EUROPEAN CENTRAL BANK

Background Studies for the ECB's Evaluation of its Monetary Policy Strategy

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Contents

Foreword

This book brings together, in slightly edited form, the technical studies submitted to the Governing Council in May 2003 in the context of its evaluation of the ECB's monetary policy strategy.

The Governing Council first announced its monetary policy strategy in October 1998, three months before the euro was introduced and the single European monetary policy was first implemented. The strategy adopted was a novel one, suited for the special characteristics of the euro area and its central bank. It is therefore not surprising that in the first years of its existence the ECB's strategy has been the subject of intense scrutiny and debate on the part of scholars, market participants and other observers.

The basis for the strategy is the Treaty mandating that the primary objective of the ECB is to maintain price stability. This mandate reflects the broad consensus that, in the long run, both inflation and deflation have negative effects on economic growth and overall welfare. Maintaining price stability is therefore the best contribution that monetary policy can make to economic welfare. In 1998, in order to make the Treaty mandate operational, the Governing Council provided a quantitative definition of price stability as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area as a whole of below 2%.

In the context of this definition, the Governing Council emphasised the medium-term orientation of the ECB's policy. Monetary policy can only have an effect on the price level with long and uncertain lags, and cannot steer price developments with high precision. The medium-term orientation of monetary policy embodies a commitment to avoid overly ambitious attempts to fine-tune inflation outcomes. The medium-term orientation cannot be reduced to a fixed time horizon. Since the time lags of monetary policy are long and variable, they can only be estimated with a high degree of uncertainty. Moreover, the appropriate forward-looking horizon for maintaining price stability depends on the nature of the shocks driving price developments at any given juncture.

The most distinctive feature of the strategy has become known as the two-pillar framework for the analysis of the risks to price stability. One pillar attaches a prominent role to money, reflecting the fundamental tenet that over the longer term both inflation and deflation are monetary phenomena. Within the monetary pillar a reference value for the growth of a broad monetary aggregate was announced in October 1998. In parallel with the analysis of monetary growth the ECB has used as a second pillar a broadly based assessment of other indicators relevant for the outlook for price stability in the euro area, drawing on a wide range of economic and financial variables. Regular staff projection exercises are used to systematically combine much of the information analysed under this pillar. The two-pillar framework makes explicit the complexity and uncertainty confronting monetary policy-makers and facilitates the cross-checking of information and complementary analytical perspectives.

In the nearly five years of experience with the ECB's monetary policy the strategy has served its functions well. It has provided from the outset a robust basis for internal decision-making and a consistent framework for external communication, thereby fostering accountability to the general public. Indeed, all evidence shows that the ECB has firmly established its credibility vis-à-vis the public. Since 1999, medium and long-term inflation expectations – as measured by survey data or financial market indicators – have remained consistent with the ECB's definition of price stability. This is all the more remarkable given that the ECB started without a track record of its own and that it has experienced a number of sizeable adverse price shocks. As a result of these shocks, HICP inflation was above (and sometimes significantly above) 2% for quite some time. But, as the shocks gradually unwound, so inflation has returned towards levels compatible with price stability. Medium and long-term inflation expectations remained well anchored throughout this period.

In December 2002 the Governing Council announced its decision to undertake a comprehensive evaluation of the strategy. After four years of conducting monetary policy for a new currency in a new economic entity, the euro area, it was only natural to take stock of experience and reassure ourselves that we were on the right track.

From the beginning of the evaluation exercise, it was clear that one of the key issues would be communication, an area where the institutional and multilingual context of the euro area poses particular challenges. We considered a wide range of views, including those expressed by market participants, academics and the press. Indeed, one of the main purposes of our announcement on 8 May 2003 was to address certain misunderstandings that had emerged in our communication with the public.

Moreover, in the preparation of the strategy evaluation by the Governing Council, the main relevant technical issues were revisited, resulting in a series of new studies and surveys that were published on 8 May and that are now brought together in this volume. Staff of both the ECB and the NCBs took part in the technical exercise and preparatory discussions. The issues investigated included the choice of the specific index and format used to define price stability; the preference accorded to headline as opposed to core inflation; the question of how to deal with inflation differentials within the euro area; the indicator properties of monetary aggregates, the stability of the euro area money demand function, and many others.

Taking the results in the background studies as a basis for its reflections on the strategy, on 8 May 2003 the ECB Governing Council announced the results of the strategy review. These focused on two main aspects: the definition of price stability and the two-pillar structure of the strategy.

Regarding the definition of price stability, the Governing Council confirmed the quantitative definition already announced in October 1998, based on an objective and transparent measure, the HICP, which provides a clear benchmark for accountability. The Governing Council noted that this quantitative definition was a successful contribution to anchoring medium and long-term inflation expectations.

At the same time, the Governing Council clarified that, in the pursuit of price stability, it aims to maintain inflation rates below, but close to, 2% over the medium term. There are a number of well-grounded arguments for tolerating a low rate of inflation, and not aiming at zero inflation. The major concern is the need for a safety margin against potential risks of deflation. In a context of strong deflationary pressures, monetary policy may become less effective if central bank interest rate management is constrained by a liquidity trap or a "zero bound" problem. ECB analyses (reflected by some of the studies in this volume) show that such constraints should not pose a significant threat if inflation remains sufficiently above zero. To aim at inflation rates below, but close to, 2% offers a safeguard in this respect and, at the same time, takes into account both the potential presence of a measurement bias in the HICP and the implications of inflation differentials of a structural nature within the euro area.

The Governing Council also confirmed the use of the two-pillar framework of the strategy as a tool to organise the information relevant for assessing the different risks to price stability. Integrating monetary analysis with economic analysis in a unified framework, in a satisfactory manner, remains an elusive challenge, both in theory and in practice. Moreover, different types of analysis provide information relevant for price developments at different time horizons. The economic analysis – focusing on the most immediate causes of inflation, such as cost developments and demand-supply imbalances – helps primarily to assess short to medium-term economic developments and, consequently, risks to price stability at that horizon. The monetary analysis – focusing on the ultimate monetary determinants of inflation – contains mainly information for assessing price trends at medium to long-term horizons. Monitoring money and credit can also offer useful indications for the interpretation of asset price developments. The Governing Council emphasised that the monetary analysis serves mainly as a means of cross-checking, from a medium to long-term perspective, the short to medium-term indications from the economic analysis. To underscore the longer-term nature of the reference value for monetary growth, the Governing Council decided to discontinue the practice of an annual review.

To summarise, while the Governing Council confirmed the main elements of the strategy, several clarifications were made, aimed primarily to enhance the effectiveness of communication. Overall, the ECB's strategy has proven to be a sound – and, by now, tested – framework for conducting monetary policy in the euro area. It combines a clear focus on the ECB's primary objective of price stability with an open and transparent view about the presence of uncertainty surrounding the functioning of the economy and the reliability of key economic relationships, which require a diversified approach. Moreover, the attention given to monetary analysis helps to underpin the medium-term orientation of the ECB's monetary policy and to avoid excessive policy activism and overly ambitious attempts to fine-tune economic developments. Looking ahead, I am convinced that the ECB's monetary policy strategy will continue to provide a solid basis for dealing with future challenges.

This book brings together the background studies that were made available to the Governing Council of the ECB in the context of its review of the ECB's monetary policy strategy. It also includes an overview paper summarising the main implications of the background studies from a policy perspective. All these papers were published on the ECB's website when the strategy review was announced on 8 May 2003. Since then, they have received close attention from the general public, academics and other central banks. The purpose of this volume is to make them more accessible for the interested reader. To this end, they have been edited slightly for the new format.

In conclusion, I would like to thank all the ECB and NCB staff who helped to prepare the Governing Council discussions on the evaluation of the ECB strategy. Many of those who took part in this effort appear as authors of the papers included in this volume. I. Angeloni, V. Gaspar, H.J. Klöckers, K. Masuch, S. Nicoletti-Altimari, M. Rostagno and F. Smets, who all among many others provided invaluable input throughout the evaluation exercise, have helped to prepare this volume. D. Rodríguez Palenzuela, A. Jung and B. Winkler also contributed in various forms to this process. To all the staff involved, I convey my deepest gratitude for the outstanding contribution they have made.

Otmar Issing
Member of the Executive Board of the European Central Bank

1

Overview of the background studies for the evaluation of the ECB’s monetary policy strategy

1. Introduction

In October 1998, the Governing Council of the ECB announced the ECB's monetary policy strategy.[1] A key element of this strategy is the ECB's quantitative definition of price stability. Furthermore, in order to assess risks to price stability, the ECB makes use of two pillars. First, it attributes a prominent role to monetary indicators, as signalled by the announcement of a quantitative reference value for the growth of a broad monetary aggregate.[2] Second, it undertakes a comprehensive analysis of a wide range of other economic and financial variables as indicators of price developments.

More than four years have elapsed since the announcement of the ECB's monetary policy strategy. In this time the ECB has rapidly built up a high level of credibility. The last few years have produced a wealth of information, in terms of direct experience, views expressed by external observers and relevant economic developments. All this can be used to carry out a thorough evaluation of the current strategic framework.

This chapter reviews the main elements of the ECB's strategy, namely the definition of price stability and the two pillars used to identify risks to price stability. It provides a guide to, and should be seen in conjunction with, the technical background studies prepared by the ECB's staff for the Governing Council's discussion on the strategy. These studies were conducted over an extended period. They reflect the ECB's own experience and they also discuss aspects raised by external observers such as academics and other outside experts.

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[1] See ECB (1998), ECB (1999), ECB (2000) and ECB (2001d). See also Issing, Gaspar, Angeloni and Tristani (2001).

[2] In December 1998 the Governing Council decided that the reference value would refer to M3, and specified the details of the derivation of the reference value.

2. The ECB's definition of price stability

The Treaty establishing the European Community (Article 105.1) assigns to the ECB its overriding objective of maintaining price stability in the euro area. However, the Treaty does not give a precise definition of what is meant by price stability. In order to specify this objective more precisely, the Governing Council announced, on 13 October 1998, the quantitative definition of price stability as a core element of the ECB's monetary policy strategy. Price stability was defined as "a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%". It was also specified that "price stability is to be maintained over the medium term". The announcement of a quantitative definition of price stability enhances the transparency of the overall monetary policy framework and provides a clear and measurable benchmark against which the public can hold the ECB accountable. Furthermore, it gives guidance to expectations of future price developments, thereby helping to stabilise the economy.

The definition of price stability has been conducive to a firm anchoring of inflation expectations in the euro area at levels compatible with the definition, thereby helping to contain the inflationary effects of the substantial price shocks which have occurred over the past three years.

While the announcement of a quantitative numerical value for the price stability objective of the ECB has been praised unanimously by external observers, there have also been some criticisms regarding specific features of the definition. Various, albeit partly conflicting, proposals for improvements or clarifications have been put forward in the debate among academics, watchers and policy-making circles.

First, regarding the choice of the price measure used in the definition, it has on occasion been argued that the ECB should put more emphasis on measures of "core" or "underlying" inflation, or even specify its objective in terms of a measure of core inflation.[3] Such measures, it was argued, could help to avoid the risk of monetary policy-makers focusing excessively on temporary price fluctuations.

Second, it has been sometimes said that the ECB's definition of price stability, in particular its 2% ceiling, may be too ambitious.[4] In this respect, the following aspects have often been mentioned: a) the presence of a positive measurement bias in the HICP; b) the presence of downward nominal rigidities, which could hamper the necessary adjustment process in the euro area at low levels of inflation; c) the existence of substantial divergences in inflation rates across countries in the euro area, which could for some countries imply "too low" a level of inflation and possibly frequent deflationary situations; and d) the presence of a zero lower bound on nominal interest rates, which could hamper the effectiveness of monetary policy in the face of large negative demand shocks and expose the euro area to the risks associated with deflation and deflationary spirals.

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[3] See, among others, Gros, Jimeno, Monticelli, Tabellini and Thygesen (2001) and Alesina, Blanchard, Galì, Giavazzi and Ulhig (2001).

[4] See for instance European Economic Advisory Group (2003), Fitoussi and Creel (2002), De Grauwe, (2002), Chapter 8. See also the recent briefing papers produced by academics for the Committee on Economic and Monetary Affairs of the European Parliament for the quarterly testimony by the President of the European Central Bank, notably Svensson (2003), Fitoussi (2003), and Wyplosz (2003).

Finally, it has been also argued that the ECB's definition of price stability is imprecise and asymmetric as it specifies precisely the upper bound for price developments but leaves the lower bound undefined.[5] This may make it less effective in anchoring inflation expectations and possibly hinder the clarity of explanations of policy moves. It has been suggested that the ECB should make its objective more precise, e.g. by officially announcing a lower bound in the definition or by specifying the objective in terms of a point inflation rate in order to more effectively anchor inflation expectations.

At the same time, other observers have expressed broad support for the ECB's definition of price stability, arguing that it is flexible enough and imposes no deflation risk on euro area countries.[6]

To assess the merits of the various arguments put forward in this discussion, and in any case after four and a half years of experience, it seems useful to evaluate in the light of the experience both in the euro area and outside, the main aspects of the ECB's definition of price stability: the choice of an appropriate price measure, the choice of the quantitative value for the objective, and the specific format and features of the announced objective.

2.1 The choice of the price index

For the purpose of setting a quantitative objective for monetary policy, a price index should embody a number of essential properties. These include the credibility of the index as perceived by the general public, a high level of reliability (e.g. revisions should be infrequent) and the availability of the index with sufficient timeliness and frequency.[7] To fulfil these conditions, it is natural for central banks to give a high prominence to the headline consumer price index when defining their final objective. The ECB decided in 1998 to define price stability using Eurostat's headline HICP, i.e. the consumer price index which has been harmonised across the countries of the EU.[8] Regarding the HICP, Eurostat implements a modern concept and provides a high quality price index at international standards. Also, importantly, the HICP benefits from frequent statistical improvements aimed at enhancing its accuracy, reliability and timeliness.

The choice of the headline measure has the advantage of transparency, as it provides the measure that most closely approximates the price of a representative basket of consumption goods and services purchased by euro area households (with no exclusion of some specific components, which might be seen as arbitrary). The use of this index makes clear that monetary policy aims to provide full and effective protection against losses in the purchasing power of money, which should foster its acceptance among the general public.

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[5] See in particular Svensson (2003 and 2002). See also IMF (2002a), and Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2002).

[6] See for instance Fels and Bartsch (2003), Deutsche Bank (2003), Belke, Kösters, Leschke, and Polleit (2003).

[7] See the background study by Camba-Mendez (2003), chapter 2, this volume.

[8] The HICP is released monthly by Eurostat, the Statistical Office of the European Union. See Astin (1999).

At the same time, the choice of the headline consumer price index has not been devoid of controversy. Some observers have argued that central banks should instead use a measure of so-called "core" or "underlying" inflation to define their objective. Such measures are credited with filtering out of headline inflation the more volatile components and/or temporary factors, which are unrelated to fundamental price trends.[9]

However, choosing a measure of underlying inflation to define price stability would not meet the above criteria for adequate price indices for monetary policy. Furthermore, it would invite considerable criticism of arbitrariness, as there is no unique or uncontroversial method of deriving such measures.

Obviously, it should be clear that by defining its primary objective in terms of headline inflation, the ECB does not in any way impart an inappropriate short-term focus in its assessment. Rather, the medium-term orientation of the ECB's monetary policy strategy ensures that the Governing Council duly discounts short-term price volatility in its deliberations.

The above reasons combine to argue that headline HICP is the appropriate measure to define the primary *objective* of the ECB. At the same time, it is also important to continue to look at various measures of "underlying inflation" as *indicator* variables in the context of the regular analysis, as this may help, on occasion, in identifying longer-trend price dynamics.

2.2 The choice of the quantitative value for the objective

The announcement by the Governing Council in October 1998 that price stability would be defined as a year-on-year increase in the HICP below 2% reflects broad consensus on the desirability of low inflation (and the absence of deflation). The choice of the specific quantitative objective to be pursued by the central bank on a permanent basis requires a balance to be struck between the costs of inflation and possible rationales for tolerating small positive inflation rates. In this respect, as mentioned above, some observers have raised the question of whether the ECB's definition is "too ambitious". In the following paragraphs, the various aspects are reviewed in turn.

2.2.1 Costs of inflation[10]

The costs of inflation relate primarily to the misallocation of resources caused by the distortions induced in relative prices, the inflation tax on real balances, the effects of inflation on income distribution, the effect of the inflation level on inflation uncertainty and associated risk premia, the costs of changing prices and costs stemming from the interaction of inflation with the tax system. The most recent studies suggest that the costs of inflation may be higher than previously thought and indicate that even moderate

9 See ECB (2001c).

10 See the background study by Rodríguez Palenzuela, Camba-Mendez and García (2003), chapter 4, this volume, and references therein.

rates of inflation could entail significant costs.[11] In this respect, there is broad consensus in that, barring the factors which caution against maintaining inflation close to zero (see below), there would be a strong case for literal price stability (i.e. zero inflation).

2.2.2 Rationales for tolerating small positive rates of inflation:

However, a number of considerations suggest that maintaining a moderate positive rate of inflation is desirable. Four main arguments are generally considered:

a) Measurement bias in the price index[12]

Inflation may be subject to a positive measurement error, which would imply that strict price stability (zero inflation) as measured by the price index would *de facto* imply a declining price level. In the specific case of the HICP, while the precise estimation of such measurement bias continues to be surrounded by uncertainty, taking into account the continuous improvements implemented by Eurostat on the index, the bias is likely to be small and to further decline in the future.

b) Downward nominal rigidities[13]

It is sometimes argued that the economic adjustment of relative prices to shocks can become sluggish in the presence of downward nominal rigidities in wages and prices, i.e. due to economic agents' aversion to nominal cuts.[14] In this respect, it has been argued that some inflation may "grease" the real adjustment of the economy to various shocks, since it would allow real wages to adjust downwards even if nominal wage movements are stalled.

However, the importance in practice of downward nominal rigidities is highly uncertain and the empirical evidence is not conclusive, particularly for the euro area. On the price-setting side, evidence based on the distribution of changes in the euro area price indices indicates that nominal price cuts are not as uncommon as often believed.[15] As far as wage-setting behaviour is concerned, the evidence for the presence of downward nominal rigidities is based both on micro surveys of households or employers and on aggregate data. At the micro level, the studies have generally found some concentration of wage changes around the zero mark but also a substantial proportion of

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[11] The most recent studies also benefit from improvements in computation and simulation methods to estimate or calibrate general equilibrium models. This allows key interactions to be captured between the prevailing rate of inflation, the fiscal regime and key economic decisions, such as wage and price-setting, saving/consumption or labour/leisure choices.

[12] See the background study by Camba-Mendez (2003), chapter 2, this volume, and Wynne and Rodríguez Palenzuela (2002).

[13] See the background studies by Rodríguez Palenzuela, Camba-Mendez and García (2003), chapter 4, this volume and the background study by Coenen (2003a), chapter 5, this volume. For a survey see Yates (1998), and references therein.

[14] For the general argument see Akerlof, Dickens and Perry (1996).

[15] In particular, there is little evidence that low inflation in the euro area affected the skewness of the distribution of those changes, as would be expected in presence of downward rigidities. See Yates (1998).

wage earners having experienced wage cuts.[16] At the macro level, the presence of downward nominal rigidities has been usually associated with non-linearities in the Phillips curve relationship at low inflation, implying that shifts in unemployment produce a smaller change in the rate of inflation.[17] Here too, however, the empirical evidence is quite mixed.[18]

The analysis is considerably clouded by several factors, notably the scarcity of evidence due to the rarity of prolonged periods of very low inflation in any country. In addition, it would seem difficult to rule out the possibility that such rigidities would decline and even vanish in the context of a permanent and fully credible move to a low inflation environment. In this regard, it should be noted that recent experience points to an increasing importance of flexible components in workers' compensation (e.g. a more widespread use of performance-based systems of compensation) and, more generally, to a greater flexibility in firm-worker relationships, which should weaken downward nominal rigidities. Moreover, it should be considered that a positive trend in productivity growth permits firms to reduce labour costs per unit of output without necessarily cutting nominal wages. Finally, even if downward nominal rigidities were pervasive, "accommodating" them with a higher inflation rate could risk making this undesirable structural feature of some economies even more "entrenched". Instead, it is crucial that structural reforms are set in place to increase the flexibility of product and labour markets and to make it possible for the benefits of price stability in euro area countries to be reaped in full.

c) Sustained inflation differentials in a monetary union[19]

It is also often said that the presence of sizeable and persistent differences in average inflation between different regions in the euro area could exacerbate the cost of downward nominal rigidities in countries with inflation rates lower than the euro area average, or push some countries into periods of protracted deflation.

Inflation differentials are and should be considered a normal feature of any currency area and an integral part of the adjustment mechanism resulting from demand and supply shocks in the economies. The single monetary policy cannot address such differentials, very much in the same way that in a single country monetary policy cannot reduce inflation differentials across regions or cities.[20]

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[16] See Card and Hyslop (1997), for the United States and Nickell and Quintini (2001), for the United Kingdom. Altonji and Devereux (1999) claim that the large proportion of wage cuts reported in the survey data can be attributed to measurement error and misreporting.

[17] A classic reference on the argument is Ball, Mankiw and Romer (1988).

[18] For example Wyplosz (2001) finds evidence for a non-linear relationship between inflation and unemployment in the euro area but Svensson (2001) points out that the findings do not seem to be robust.

[19] See the background study by Rodríguez Palenzuela, Camba-Mendez and García (2003), chapter 4, this volume.

[20] The current dispersion of inflation across countries in the euro area is not larger than that observed across macro regions in the United States; see the box entitled "The dispersion of inflation across the euro area countries and the US metropolitan areas", in ECB (2003b), pp. 22-24.

Inflation differentials can be the result of both temporary and structural factors.[21] Temporary factors include diverse dynamics in the more erratic components of the price index, differences in national fiscal policies, differences in pass-through patterns of external price and costs shocks and different cyclical positions of the various economies. Depending on the sources and causes of temporary differentials, national remedies may be needed in order to prevent them from resulting in developments which are harmful for the country, e.g. a loss of competitiveness. As mentioned above, it is crucial that product markets and wages in the euro area are sufficiently flexible to respond efficiently to supply and demand shocks.

Among the structural factors, the so-called Balassa-Samuelson effect, which relates inflation differentials to differences across economies in the relative sectoral productivity trends between the tradable and non-tradable sectors, has been often singled out as the main factor underlying sustained inflation differentials. Such differentials in sectoral productivity growth may result from a process of catching-up and convergence of living standards across countries and to this extent are an "equilibrium phenomenon" which does not require corrective policy actions.[22] In this regard, empirical studies suggest that the magnitude of the Balassa-Samuelson effect is plausibly limited in the euro area.[23] Furthermore, the size of the Balassa-Samuelson effect for countries currently in the euro area is likely to diminish in the future, given that there has been substantial convergence among countries in terms of per-capita GDP.

The size of the Balassa-Samuelson effect may be more important for the acceding countries. However, its overall impact on the euro area should be limited, given the relatively small size of these economies.[24] Moreover, it should be recalled that, in order to adopt the euro, acceding countries will have to fulfil the Treaty convergence criteria, which in particular require the sustainability of a low inflation environment. All this points to a more limited impact than sometimes claimed.

Finally, the possibility that an individual country in the euro area could fall into a "deflationary spiral" (see below), while the euro area is on average at price stability appears to be an unlikely event. Should such a situation start to emerge, significant gains in competitiveness for the countries experiencing deflation would lead to strong demand pressures for their products, which would counteract the deflationary pressures.

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[21] Differences across countries in the weighting of the items in the price index, reflecting different compositions of aggregate demand, has been indicated as an extra source of inflation differentials, see Alberola (2000).

[22] However, other sources of these productivity differentials, for example distortions in the underlying production structures (e.g. non-competitive or monopolistic structures which hamper productivity growth in the non-tradable sector), may require structural policies to eliminate them.

[23] See the background study by Rodríguez Palenzuela, Camba-Mendez and García (2003), chapter 4, this volume, and references therein. The bulk of empirical estimates of the Balassa-Samuelson effect would indicate that average inflation of, say, 1.5% for the euro area would imply an average inflation rate in lower inflation countries at values very close to 1%.

[24] See the background study by Rodríguez Palenzuela, Camba-Mendez and García (2003), chapter 4, this volume. See also IMF (2002b).

d) The zero lower bound of nominal interest rates and the risk of protracted deflation or a deflationary spiral in the euro area as a whole[25]

Many of the costs related to inflation are also incurred in a situation of deflation. This refers in particular to the following costs of deflation: the misallocation of resources caused by the distortions induced in relative prices, the effects on income distribution, the effects of uncertainty about future price developments and associated risk premia, and the "menu" costs of changing prices.

However, there are also problems which are specific to deflation and which suggest that maintaining a small safety margin in the form of a positive rate of inflation may be desirable. Most notably, maintaining a small positive inflation rate rather than zero inflation reduces the probability that nominal interest rates will approach the zero lower bound, and thus effectively constraining the central bank in its ability to respond appropriately to deflationary shocks.[26] Such a safety margin may be appropriate, as the event of nominal interest rates hitting the zero lower bound is inextricably linked to a diminished effectiveness of monetary policy and a higher risk of a deflationary spiral. Although various monetary policy actions are possible even at zero nominal interest rates and different solutions for escaping from a deflationary trap have been proposed, the effectiveness of these alternative policies is uncertain.[27]

Against this background, several studies have tried to assess the likelihood of nominal interest rates hitting the zero lower bound and/or a deflationary spiral being triggered for various levels of inflation objectives using small macro models.[28] While results in this area are highly uncertain and depend on a number of specific assumptions, most available studies indicate that the likelihood decreases to very low levels when the objective of the central bank is set at an inflation rate above 1%.[29]

All in all, the technical review of the costs and "benefits" of moderate inflation rates does not allow the optimal rate of inflation to be pinned down. However, there is broad consensus on the need for a) the inflation rate to be maintained sufficiently low to reap the benefits of price stability (i.e. to minimise the costs of inflation), and b) an inflation objective embodying a sufficient safety margin against deflation. With respect to this

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[25] See the background studies by Coenen (2003b), chapter 6, this volume and Klaeffling and Lopez-Perez (2003), chapter 7, this volume. For a survey see Yates (2002).

[26] Other problems specific to a deflationary situation which are sometimes referred to are: a) the contractionary redistributive effects of deflation in a debt-deflation scenario and the associated risks of financial instability; and b) the deferral of demand, and thus production, when prices are expected to fall.

[27] See Yates (2002).

[28] For the euro area see the background studies by Coenen (2003b), chapter 6, this volume and Klaeffling and Lopez-Perez (2003), chapter 7, this volume. Estimates for the United States are provided by, among others, Orphanides and Wieland (1998), and by Reifschneider and Williams (2000).

[29] In some studies these risks remain non-negligible also for rates of inflation above 1%. However, these studies should be taken with particular caution, since they are sometimes based on restrictive assumptions. Two of the assumptions made in most available studies would seem particularly restrictive. First, they characterise monetary policy as bound to a simple linear rule, such as a simple Taylor rule, which for example does not allow for a monetary policy conducted in such a way as to explicitly take into account the zero lower bound. Second, they are frequently based on the assumption that the equilibrium real interest rate stands at 2%, which seems to be at the lower end of plausible figures. A higher assumption for the equilibrium real interest rate would imply that the safety margin for the inflation objective could be lower.

latter aspect, it would seem that the dominant consideration in the determination of such a safety margin should be the need to limit the likelihood of the zero lower bound of nominal interest rates effectively constraining the central bank in its ability to respond appropriately to deflationary shocks to avert the emergence of destabilising expectations of protracted deflation. In this regard, the available evidence suggests that inflation objectives above 1% provide sufficient safety margins to ensure against these risks.[30]

2.3 The format of the price stability objective

A third aspect of the discussion relates to the specific features of the quantitative objective. The elements of the discussion concern two separate aspects: the issue of *symmetry* in the objective and whether it is preferable to specify the objective more precisely, e.g. in the form of *a range for allowable inflation rates* or in terms of *a specific rate of inflation.*[31]

Regarding *symmetry*, the ECB has clarified that a) the use of the word “increase” excludes deflation from the definition and b) the absence of an explicit lower bound acknowledges the existence of an unknown and possibly time-varying measurement bias in the HICP. This notwithstanding, there has sometimes been a perception of a lack of precision and symmetry in the ECB’s definition of price stability, as it clearly defines an upper bound at 2% but does not explicitly mention a lower bound. In this regard, it should be noted that the technical review revealed that the ECB’s performance in maintaining low volatility of long-term inflation expectations in the euro area is comparable to that of the best-performing countries.[32]

Regarding the choice between setting the objective of price stability in the form of *a range or a more specific rate* of inflation, there are certain trade-offs to be considered.

One advantage of a range, is that it signals the uncertainty which surrounds the optimal inflation rate and conveys to the public the important message that the control of inflation is inherently imperfect. Moreover, a range may give more flexibility to accommodate moderate and gradual variations of the “optimal” inflation rate over time. However, a range may cause public attention to focus too narrowly on whether inflation is just inside or outside the range. The main advantage of referring to a specific rate of inflation as the objective would be that, in principle, it would provide a more precise focal point for forming inflation expectations and taking forward-looking decisions.

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[30] This is also in line with the practice followed by all of the central banks of the major developed countries that have specified numerical values for their objectives; all have a midpoint above 1%. For example: the Bank of England: $2\frac{1}{2}$% (RPIX index, approximately $1\frac{3}{4}$ on average in HICP terms); Sveriges Riksbank: 2±1% (CPI); Norges Bank: 2±1% (CPI); Bank of Canada: 1-3% (CPI); Bank of Australia: 1-3% (CPI); Reserve Bank of New Zealand: 1-3% (CPI). The Federal Reserve System and the Bank of Japan have not specified a quantitative definition of their price stability objectives. The Swiss National Bank has adopted a definition of price stability which is equivalent to that of the ECB. See the background study by Castelnuovo, Nicoletti-Altimari and Rodríguez Palenzuela (2003), chapter 3, this volume.

[31] See the background study by Castelnuovo, Nicoletti-Altimari and Rodríguez Palenzuela (2003), chapter 3, this volume.

[32] See the background study by Castelnuovo, Nicoletti-Altimari and Rodríguez Palenzuela (2003), chapter 3, this volume.

Looking at experiences in various countries, while the announcement of quantitative targets is common to many central banks of major developed countries, the specific features of the announced objectives vary somewhat. The different choices appear to be linked inextricably to the overall policy frameworks and monetary policy strategies followed by the different central banks, in particular to the specific mandates and the chosen horizons for the conduct of monetary policy. Above all, the available international evidence suggests that there is no unique or best way to firmly anchor inflation expectations. The crucial aspect appears to be a credible and consistent conduct of monetary policy, while the specific features of the objective tend to be of secondary importance.[33]

2.4 Conclusions on the definition of price stability

Overall, the technical review has shown that the definition of price stability has been a fundamental element in the overall successful performance of the ECB's strategic framework.

However, a conclusion from the previous discussion is that the presence of specific risks that seem intrinsic to maintaining inflation very close to zero may argue for keeping in the conduct of monetary policy a sufficient safety margin above zero for admissible rates of inflation. Such a margin should help to substantially reduce the probability of a series of negative shocks eventually leading to a situation in which monetary policy can no longer adequately respond with its policy rates because of the zero lower bound of nominal interest rates. A sufficient safety margin against the risks of deflation would also cover other reasons – such as the existence of a measurement bias and the implications of inflation differentials in the euro area – for aiming at small positive rates of inflation.

Obviously, these considerations were already taken into account in the original formulation of the definition of price stability, particularly in the decision to set the upper bound of the definition to well above zero.[34] Furthermore, in practice, markets have understood that these considerations are fully reflected in the ECB's monetary policy decisions. Clarifications in communication should overcome remaining uncertainties.

3. The two pillars

In the course of the last four years, the ECB has explained the role that money plays in its monetary policy strategy, alongside a comprehensive set of other economic and financial analyses and models, as reflecting a two-pillar approach to the organisation, assessment and cross-checking of the information relevant for policy. The two-pillar framework has over time become the hallmark of the strategy in conjunction with the medium-term orientation of the ECB's policy framework.

[33] See the background study by Castelnuovo, Nicoletti-Altimari and Rodríguez Palenzuela (2003), chapter 3, this volume.

[34] See, for example, ECB (1999).

The public's understanding of the ECB's two-pronged strategy has improved significantly over time and support for its economic foundations has widened, notably among professional market participants.[35] However, the role of money and monetary analysis, in particular, has generated controversy among observers. Some observers, in particular, have questioned the robustness of money's leading indicator properties with respect to price developments on the grounds that the correlation between money growth and inflation appears to have declined over time in parallel with restored conditions of price stability.[36] In this context, these observers also doubted that the necessary condition for announcing a reference value for money growth – long-run stability in the demand for money – continued to be fulfilled in the euro area.

Some commentators have also questioned the usefulness of a separate "money" pillar. These commentators generally maintain that inflation forecasts – often constructed on the basis of macroeconomic models with a primary focus on the real side of the economy – include all the relevant information about the evolution of prices and the state of the economy that monetary authorities need to build a full-information judgement about the risks to price stability. To the extent that money has indicator properties for future inflation, these observers maintain that this information should simply be included in the forecasts.[37]

However, there are also other observers who have called for a strengthening of the role of money and the reference value for money growth.[38] These observers point to the wealth of studies showing a close relationship between money and prices.

Finally, it has occasionally been said that the two-pillar structure may induce confusion, in that different sources of information may be seen as entailing different policy prescriptions, or a partitioning of data, whereas the risks to overall price stability should be assessed on the basis of a comprehensive judgement encompassing all evidence.

The following reviews a number of issues concerning these aspects of the strategy.

3.1 The prominent role of money

In 1998 the decision to assign a prominent role to money was made in recognition of the fact that inflation is a monetary phenomenon in the medium- to long-term.[39] Thus, a firm focus on money can lengthen a central bank's horizon and bolster a medium-term oriented policy course.

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[35] See, for example, Commerzbank (2003), Lehman Brothers (2003), Fels and Bartsch (2003), Deutsche Bank (2003), Credit Suisse / First Boston (2002).

[36] See for example Begg, Canova, De Grauwe, Fatás and Lane (2002).

[37] See for example Svensson (2003).

[38] See von Hagen, and Brückner (2001), and Hayo, Neumann and von Hagen (1998). See also Belke, Kösters, Leschke, and Polleit (2003).

[39] For a detailed overview of the theory and the evidence for money neutrality, see Issing, Gaspar, Angeloni and Tristani (2001).

Two properties were identified by the Governing Council as relevant for the purpose of making a monetary aggregate a prominent information variable for a central bank which aims at price stability in the medium term:

- *Indicator properties:* the monetary aggregate should contain information that helps to predict future developments in the price level.
- *Stability:* the aggregate should exhibit a stable (or, at a minimum, predictable) relationship with its long-run determinants, such as real income, interest rates, and most importantly the price level.

Four years after the strategy was first announced, it is important to evaluate whether the conditions which in 1998 determined the assignment of a prominent role to money are still satisfied.

As regards the indicator properties of money, recent evidence continues to support the notion that broad monetary aggregates provide key information on inflation, notably at time horizons stretching beyond those usually adopted for the construction of central bank inflation projections.[40] This is consistent with a fundamental feature of virtually all monetary models, namely the long-run neutrality of money.[41]

There is also evidence that various monetary indicators can offer incremental information on other key macroeconomic variables, which in due course may impact on price developments. For example, narrow monetary aggregates have leading indicator properties for cyclical developments.[42] Moreover, growth rates of money and credit in excess of those needed to sustain economic growth at a non-inflationary pace may, under certain circumstances, provide early information – in addition to more standard indicators – on developing financial instability. Such information is of relevance for monetary policy because the emergence of financial imbalances or asset price bubbles could have a de-stabilising effect on activity and, ultimately, prices in the medium term.[43]

As regards money demand stability, it is important to distinguish the long-run stability of money demand from the shorter-term properties of money demand equations. As regards the latter, tests conducted in the context of the ECB's 2002 review of the reference value for the growth rate of M3 detected the emergence in 2002 of signs of

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[40] See Jaeger (2003), Gerlach (2003), Neumann (2003) and Nicoletti-Altimari (2001). On the shorter term indicator properties of the gap between real money balances and their long-run equilibrium levels for inflation, see Gerlach and Svensson (2003) and Trecroci and Vega (2000).

[41] Against this background, empirical results detecting a diminished connection between money growth and inflation in an environment of price stability should be taken with extreme caution. Leaving aside the technical problems from which these exercises often suffer, as argued in Nelson (2002b), these findings do not challenge the relevance of the long-run money growth/inflation association in signalling to central banks whether the stance of policy is consistent with maintaining the steady state rate of inflation in line with their declared objective.

[42] See the background study by Brand, Reimers and Seitz (2003) chapter 11, this volume. See also Nelson (2002b) and Meltzer (1999).

[43] See Borio and Lowe (2002). See also the background study by Masuch, Nicoletti-Altimari, Pill and Rostagno (2003), chapter 8, this volume.

instability in the short-term mechanism by which deviations of the demand for M3 from its long-term equilibrium are corrected.[44] However, despite these signs of short-term instability, the long-run equilibrium for money demand has so far not changed significantly in the euro area.[45] According to the available information, recent developments in the demand for M3 seem to be linked to a heightened preference for liquidity induced by an exceptionally prolonged period of asset price volatility. Financial anxiety appears to have led to portfolio shifts from less liquid components of wealth to instruments included in the definition of M3, which are perceived as a more secure store of value.[46]

However, there are good reasons to expect that the shorter-run instability detected in M3 velocity in the euro area will be of a temporary nature only. In fact, so far there is little evidence of structural changes in the euro area economy which would suggest that the relative attractiveness of holding instruments included in M3 versus other financial instruments has been fundamentally altered in recent years. Historically, when money demand instability occurred over longer periods of time, this was primarily due to financial innovation or tax changes affecting the opportunity cost of holding money assets. However, there have been no significant changes in any of these factors recently, which would justify expectations of continued instability in euro area money demand.[47]

Nevertheless, looking ahead, two issues will require careful monitoring. One concerns the duration of the current period of volatility in the financial markets. A second source of uncertainty concerns possible future structural changes in financial markets and in the composition of wealth due to the increased sophistication of private investors. Both issues make it necessary to closely monitor the stability properties of money demand and the appropriate definition of the broad monetary aggregate. This, in turn, means using appropriate statistical tools to identify and model such developments, as well as utilising the Eurosystem's detailed knowledge of the institutional features of the euro-area financial and monetary sector.

3.2 Monetary analysis and the reference value (the "first pillar")

Detailed monetary analysis is a key task for all the world's major central banks.[48] In view of the robust relationship between money and prices over extended horizons, monetary analysis focuses mainly on the assessment of medium to long-term price trends and the related risks to price stability.

The scope of the monetary analysis conducted at the ECB has been enriched over time. It consists of a comprehensive assessment of the liquidity situation based on information from trends in the components and counterparts of M3, in particular loans to

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[44] See ECB (2002). See also Brand, Gerdesmeier and Roffia (2002).

[45] See the background study by Bruggeman, Donati and Warne (2003), chapter 10, this volume.

[46] See, for example, the box entitled "Financial investment of the non-financial sectors in the euro area up to the third quarter of 2002" in ECB (2003a), p. 9.

[47] See the background study by Calza and Sousa (2003), chapter 9, this volume.

[48] For the importance of monetary analysis from the point of view of a central bank, see the contributions in Klöckers and Willeke (2001). See also King (2002).

the private sector, as well as narrower definitions of money such as M1, and from various money gap measures and concepts of excess liquidity.[49] The framework for monetary analysis builds on the ECB's detailed knowledge of the institutional features of the financial and monetary sector as well as a suite of small-scale money demand and monetary indicator models which have been developed and published by ECB staff and academics.[50] On the basis of these tools, monetary analysis has the main purpose of identifying the factors driving developments in monetary and credit aggregates and extracting the information contained in money for predicting longer-term price developments. This framework of analysis has proven particularly important, for example, in identifying the portfolio shifts that have affected monetary developments since mid-2001. An increasingly sophisticated analysis of monetary developments means that similar money growth figures can lead to quite different assessments, depending on the prevailing macroeconomic conditions and on the underlying factors which are estimated to have determined money growth.

In order to signal money's prominent status within its set of information variables, the ECB has announced a quantitative reference value for the growth rate of M3, as a benchmark against which monetary developments can be assessed and described to the public. The reference value is derived in a manner that is consistent with – and serves the attainment and maintenance of – the primary objective of price stability. The ECB has always emphasised the medium- to long-term nature of the reference value. The reference value is intended to provide monetary policy with a quantitative benchmark which ensures that the central bank, while responding to the variety of shocks affecting the economy over time, does not lose sight of the fact that over a sufficiently extended horizon the rate of growth of money must be consistent with the price stability objective.[51] The reference value has also offered a simple quantitative instrument for the construction of indices of monetary imbalances (e.g. the "money gaps" published by the ECB).[52]

In the first few years of the ECB's monetary policy, monetary analysis has indeed played a prominent role. In the course of 1999 and in early 2000, continued upward deviations of M3 growth from the reference value were important factors in dispelling the uncertainty about possible deflationary risks and, subsequently, in formulating an assessment of the need to increase interest rates in order to contain inflationary pressures. The continued accumulation of excess liquidity supported the interest rate increases until October 2000, and the gradual reversal of the monetary trend then contributed to the decision to lower interest rates in the spring of 2001. While the interpretation of monetary data was complicated after mid-2001 by the significant portfolio shifts, it should be recalled that it was possible for the ECB to broadly identify

49 See ECB (2001b). See also Masuch, Pill and Willeke (2001).

50 See Coenen and Vega (2001), Brand and Cassola (2000), Calza, Gerdesmeier and Levy (2001), Calza, Manrique and Sousa (2003), Stracca (2001a), Stracca (2001b). See also Gerlach (2003c) and Gerlach and Svensson (2003).

51 The usefulness of a reference value for money growth as a "check that might help avoid significant and persistent errors" is acknowledged in Mayer (2001). See also Christiano and Rostagno (2001).

52 See, for example, ECB (2003a), pp. 8-9.

relevant distortions in headline money growth figures in real time. Furthermore, strong longer-term monetary growth has played an important role in the considerations of the ECB in relation to a more cautious monetary policy stance.

While some commentators initially confused the reference value with a “monetary target”, such misinterpretations have become less frequent over recent years. It seems now to be reasonably well understood that the ECB does not mechanistically react to deviations of M3 growth from its reference value, as was already announced when the strategy was presented four and a half years ago. Obviously, the relevance of a reference value for the growth rate of a particular monetary aggregate hinges on the long-run stability of the demand for that aggregate. Stability properties of money demand are monitored carefully by the ECB not only to determine the stability of the corresponding equations but also to assess the relative properties of alternative monetary aggregates. As argued above, there are at present no signs of structural breaks in the long-run fundamental relationship between M3 and prices in the euro area which underlies the derivation of the reference value. Nevertheless, it is necessary to continue monitoring closely the stability of money demand in the future and studying the definition of “money” which is most appropriate for monetary policy purposes.

However, there are two aspects related to the reference value, which may require reflection. First, the practice followed thus far by the Governing Council of annually reviewing the reference value may have contributed to the occasional misperception that the reference value is announced “for a specific year”, similar to the past practice of some monetary targeting central banks. Since the reference value is based on medium-term assumptions for real GDP growth and the income velocity of money – and since experience has shown that these assumptions change only gradually – there may in fact be no need for an annual review of the technical assumptions underlying the computation of the reference value.

Second, the Governing Council stated in 1998 that it would use a three-month moving average of annual rates as its main tool to assess the deviations between observed M3 growth and the reference value. This was meant as a simple device to filter out very short-run variations in monetary figures, which are uninformative about future risks to price stability. However, since the start of Stage Three of Economic and Monetary Union a number of tools have become available to better identify medium-term trends in monetary growth. These are more in line with the medium to long-run association between money growth and prices. Therefore, an “official” focus on the three-month moving average of annual growth rates might be discontinued. Various other measures of M3 trends can be employed to assess risks to price stability as already done in the ECB’s Monthly Bulletin.

3.3 The broadly based economic analysis (the “second pillar”)

The broadly based economic analysis focuses mainly on the assessment of current economic and financial developments and the implied short to medium-term risks to price stability from the perspective of the interplay between supply and demand at those horizons. In this respect due attention is paid to the need to identify shocks hitting the economy. To this end, the developments analysed include a broad range of information on, for example, wages, commodity prices and exchange rates, asset prices, wealth, external demand, fiscal policy, and domestic financing conditions and costs.

In this context, the macroeconomic projection exercises conducted by Eurosystem staff provide an instrument to synthesise information and ensure consistency across different sources of economic evidence.[53] They play an important role in fostering a forward-looking orientation of policy and sharpening the assessment of economic prospects. However, the ECB has taken the position that its policy-making should not rely exclusively on such tools.[54]

Arguments against an all-encompassing role for macroeconomic projections in monetary policy-making are to some extent related to the notion that monetary policy should not react mechanically to a forecast at a fixed horizon but should rather tailor policy to the nature of shocks hitting the economy. Moreover, an essential element of the policy process is to evaluate and compare the robustness of the information stemming from various sources. To fully assess the outlook for price stability, it is necessary to employ a variety of techniques as well as a great deal of judgement, *inter alia* with regard to the likelihood that certain scenarios will occur. In this respect, the argument can be made that a strong focus on a single inflation forecast would not do justice to the complexity of the decision-making process and would also not provide a transparent means to communicate this complexity.

The broadly based economic analysis has been extended and enriched in line with improved availability of data and tools. Several tools have been developed to better assess and understand past and ongoing developments, to make short-term analyses more reliable and to underpin the regular macroeconomic projection exercises for the euro area economy. In addition, forecasts from other institutions as well as private-sector forecasts and the expectations embedded in financial market prices have also been usefully employed to cross-evaluate the Eurosystem staff projections.

Overall, while the macroeconomic projection exercises provide a major element of the broadly based economic analysis, they are not an all-inclusive summary device and should continue to be used in conjunction with alternative sources of information.

3.4 The two-pillar approach

Monetary policy faces uncertainties about the functioning of the economy. The ECB's monetary policy strategy was designed with the aim of ensuring that no information is lost and that appropriate attention is paid to different analytical perspectives in a transparent manner. The two-pillar approach is a means to convey the notion of diversification of analysis to the public and to ensure robust decision-making on the basis of different analytical perspectives.

One aspect of this approach relates to the different time perspectives relevant to the analyses under the two pillars. This builds on the well-documented findings that long-term price movements are driven by trend money growth, while higher frequency inflation developments appear to reflect the interplay between supply and demand conditions at shorter horizons. Against this background, the broadly based economic analysis gives higher-frequency indications for policy decisions based on the assessment of non-monetary shocks to price developments and the likely evolution of prices over

53 See ECB (2001a).
54 See Duisenberg (2001).

short to medium-term horizons. Monetary analysis and indices of monetary imbalances, on the other hand, provide information against which these indications can be evaluated and the stance of policy can be cross-checked from a longer-term perspective.[55] The medium to long-term focus of the monetary analysis implies that there is no direct link between short-term monetary developments and monetary policy decisions.

Another aspect of the two pillars is their use as an instrument to organise and convey information to the Governing Council and the public. As conventional macroeconomic analysis is not yet far advanced in combining the analysis of real economic trends with that of phenomena that are broadly "monetary" in nature, the two-pillar approach represents a commitment on the part of the ECB to ensure that these latter phenomena – likely to be overlooked within a framework centred on short-term inflation forecast procedures – are sufficiently considered in policy deliberations.[56]

Overall, the two-pillar approach provides a framework for cross-checking indications stemming from the shorter-term economic analysis with those from the monetary analysis, which provides information about the medium to long-term determinants of inflation. This cross-check helps to understand whether the monetary policy course is broadly pointing in the right direction, thereby ensuring that monetary policy has a nominal anchor beyond the conventional projection horizon.[57] Assigning a prominent role to money is therefore also aimed at underpinning the medium-term orientation of monetary policy and ruling out attempts to "fine-tune" economic developments. Taking policy decisions and evaluating their consequences on the basis not only of a short-term-oriented analysis of economic and financial shocks and macroeconomic projections but also of money and liquidity considerations allows a central bank to see beyond the transient impact of the various shocks and maintain a firm medium-term orientation.

To conclude, the two-pillar structure does not entail a partitioning of the information set, or a rigid allocation of indicators to one pillar or another. It is rather a direct way of conveying the notion of robustness and diversification of analysis, and provides information which helps the Governing Council to form a unified assessment.

Against this background, the cross-checking role of monetary analysis within the strategy could be better highlighted in the ECB's communications than it has been so far. There may be scope to better clarify the existence of "a bridge" between the two pillars which ensures the use of all the information provided by the monetary and non-monetary analyses. Indeed, more flexible formats of communication are conceivable and could be fruitfully employed in the future.

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[55] See Issing (2002) and also IMF (2002a and 2002b).

[56] See Gerdesmeier, Motto and Pill (2002), and Masuch, Nicoletti-Altimari, Pill and Rostagno (2003), chapter 8, this volume.

[57] See Christiano and Rostagno (2001).

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2

The definition of price stability: choosing a price measure*

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1. Introduction

Following the announcement of the stability-orientated monetary policy strategy on the 13th of October 1998, the Governing Council decided to provide a quantitative definition of price stability in the euro area as *"a year-on-year increase in the Harmonised Index of Consumer Prices of below 2 percent"*. The purpose of this note is to review the choice of the Harmonised Index of Consumer Prices (HICP) as the appropriate yardstick for judging price stability.

This note provides a general assessment of the characteristics that a price measure must display if it is to to be used as a target for monetary policy. Some of these characteristics are of a practical nature such as credibility, reliability and comparability. Others are of a more technical nature, including the coverage of the index, the valuation principle and the index number formula. Two further issues are then given specific attention. First, the role that asset prices should play in such measures and, second, the potential role for measures of underlying inflation.[1] The note concludes with a final assessment that, whilst recognising the continuing suitability of the HICP as an appropriate measure to be used for the definition of price stability, nevertheless identifies some areas for improvement. In particular, there may be a need for more frequent re-basing of the index in some countries and the cross-country comparability of the index would be improved by the inclusion of owner-occupied housing services.

2. Practical issues for the adoption of a price index

2.1 Credibility

A price index should be credible. By this it is meant that households should regard changes to this price index as linked to their own welfare. Otherwise, the actions of a central bank that achieves its definition of price stability, would count for little. In addition, in order to be credible, the price index should be viewed by households as providing an independent and reliable measure of prices. For example, a price measure constructed by the central bank itself may well lack credibility with households, as they would not necessarily trust the central bank not to manipulate that measure to achieve its target. Price indices that are subject to major revisions may also lack credibility.

This brings us to a first summary statement:

A price index should be credible and widely recognised as reflecting changes in all the prices paid by consumers.

[1] Discussions on measures of underlying inflation in the present note will be limited to their potential role as a target for monetary policy.

2.2 Reliability

A related consideration is that of reliability, in the sense that a price index should be as accurate as possible in its measurement of price movements and should not be subject to significant biases. There are four major sources of measurement bias in price indices: substitution bias, quality bias, outlet bias and new good bias. *Substitution* bias results from failing to take into account the fact that agents can modify the composition of the goods purchased when the prices of goods change. Discussion on substitution bias is pursued in more detail in section 3.3 below. *Quality* bias results from comparing prices of two non-identical goods. The quality of goods typically increases over time, and this, for example, makes television sets bought in period 1 and period 2 not directly comparable. Ignoring altogether the change in the quality of the good will induce a measurement error in the price index. National Statistical Institutes (NSIs) adopt a variety of methods to account for the changes in quality. The simplest way of dealing with this problem is to remove from the sample items that are not comparable, and use only those that can be identically "matched". Other methods rely on quality corrections that in effect amount to computing a quantity equivalent of the item offered in period 2 that takes into account the change in quality (for example using Hedonic methods). *Outlet bias* results from shifts in market shares among retailers that are not reflected in the composition of the sample outlets used in the survey. This may be larger for example, in countries where low-price retailers are gaining market share. *New good bias* results when a new good is introduced but is only included in the price index with a (sometimes considerable) lag. The problem of handling new goods is that there is no price in the base year that serves as a reference. Economic theory provides some techniques to deal with this problem, but their implementation is not straightforward.

A report by the Boskin Commission (see Boskin, 1996) suggested that the main source of bias in consumer price indices in the US was due to changes in quality. In Europe, some economists suggested that during years of rapid technological developments, like those observed during the 1990s, quality bias in price indices could have been even larger, partly as a result of a reluctance by NSIs to introduce methods for quality adjustment.

Measurement biases in price indices bring challenges for monetary policy. Large errors in measuring prices in an environment of low inflation may, for example, hide a situation of "de facto" deflation. Therefore setting a quantitative definition of price stability that is consistent with a small rate of increase in measured prices may actually be consistent with no change in the "true" price level. Despite recent research efforts to study the potential bias in the HICP (see Camba-Mendez, Gaspar and Wynne, 2002, and Wynne and Rodriguez-Palenzuela, 2002), any estimates of measurement bias are subject to a large degree of uncertainty. Work reviewed in Camba-Mendez, Gaspar and Wynne (2002) suggests that the measurement bias for some items is actually downward rather than upward. It is important to note that the empirical evidence also points to the fact that both the size and sign of any resulting biases depend crucially on the structure of the markets.

This brings us to a second summary statement:
At the present time, not enough is known to estimate with any degree of precision the magnitude of measurement biases in European consumer price indices.

2.3 Comparability

One of the principle objectives of the European Union is to promote economic and social progress, and in order to conduct its policies, there is a need for monitoring the economic performance across countries. This can only be achieved if the available statistical information is comparable. The comparability of price indices depends mainly on five factors: a) their coverage, b) the index number concept used, c) sampling techniques, d) use of imputations for certain items, and e) handling of the introduction of new goods and quality changes. Work on the harmonisation of consumer price indices across EU countries started in 1993, and by March 1997 the first figures of a harmonised index of consumer prices for each member state were being published. Considerable effort has been devoted to achieve a high degree of comparability in the HICPs across countries, but work is still ongoing with respect to sampling and quality adjustment procedures.

This brings us to a third summary statement:
The HICP has been designed to ensure the comparability of consumer price indices across EU countries. The harmonisation process is largely completed except for sampling practices, quality adjustment and the frequency at which weights are revised.

2.4 Periodicity and timeliness

For policy purposes it would be ideal to have accurate information on the state of the economy at every point in time. This is, of course, an impossible task, but nevertheless price indicators with the greatest frequency should be preferred for policy purposes. Such a consideration counts against the GDP deflator and the consumers' expenditure deflator due to its quarterly periodicity as compared with the monthly frequency of the HICP. In addition, the timeliness of the GDP deflator and the consumers' expenditure deflator is also worse as the publication lags are longer than for the HICP.

2.5 Consistency with the European Union Treaty

Gaspar (2002) pointed to an argument of an institutional nature that is key in the adoption of a definition of price stability by the ECB. In his view, the Protocol annexed to the European Union Treaty (EUT) dealing with the specific issues related to the application of the price stability convergence criterion, *"shows that the drafters of the EUT had consumer price inflation as the yardstick to assess price stability"*. The mandate of the ECB does not make a direct reference to consumption expenditure as the required domain for defining price stability. But it is clear that a different domain would be at odds with the convergence criteria requirements set in the Treaty.

3. Conceptual issues I: The relevant price measure for monetary policy purposes

A price index can be described along the following three dimensions: a) the scope, or coverage of the measure, b) the valuation principle and c) the index number concept.

3.1 The coverage of the price measure

A useful starting point for the analysis of the coverage of the price measure is the quantity theory of money. As originally formulated by Fisher (1911), the quantity theory highlighted the identity between the monetary value of all transactions in the economy (PxT, where P is the price level and T the volume of transactions) and the product of the rate at which a unit of money changes hands with the number of units of money (V x M). This identity can be used as an explanation for the price level, and on this basis the scope of the price measure should extend to all monetary transactions (including goods bought for intermediate consumption). However, such a broad coverage is unsuitable for three main reasons. First, even if possible, it would be extremely costly to obtain data for all economic transactions. Second, in all likelihood, the large bulk of those transactions would relate to purchases of shares and foreign currency. Such a measure would therefore be far removed from developments in the prices actually paid by consumers and producers in the economy. Third, subsequent versions of the quantity theory of money adopted a measure of income in preference of all transactions. This would suggest ignoring intermediate transactions and focusing instead in the scope of the deflator of GDP.

However, the use of the GDP price deflator has one drawback from an empirical viewpoint. In particular, the GDP deflator might on impact decrease when import prices increase, if prices of final demand are sticky in the short run. This effect, which may be regarded as perverse and undesirable, highlights the potential interest in focussing on the domain of GDP plus imports, i.e. to choose the deflator of what some have referred to as "total domestic final expenditure", see Hill (1996). Exports refer to expenditures made by the rest of the world, and therefore changes in the price of exports do not have a direct effect on domestic households. This leaves the price deflator of domestic demand (Private Consumption, Government Expenditure and Investment) as a possible choice. However, there are recognised difficulties in measuring prices of government services such as health and education, and on practical grounds, so there may be benefits in removing government expenditure from the domain. With regard to investment, Diewert (2002) argues that it should also be excluded as it is not linked to current period household expenditures, but rather represents claims on future consumption. This leaves the coverage of the measure in the domain of consumption expenditures.

The arguments presented above provide support to the choice of consumption as the correct domain by ruling out other alternatives. But this is not to say that this choice is second best. The choice of consumption as the correct domain is justified on its own by the fact that consumption is the ultimate source of welfare. Modern macroeconomic theory built on micro-foundations takes the maximisation of the discounted value of the utility provided by consumption flows as the ultimate goal behind household's decisions.

Regarding specifically Eurostat's HICP and in connection with the problem of the coverage of the index, one issue that remains relatively open is the approach taken to include the price of shelter services for owner occupied housing. Specifically, the HICP currently includes housing rents but not owner occupied housing. The inclusion of owner occupied housing services seems indeed important because ignoring them complicates the comparison of the HICP across countries given that the percentage of people who live in rented accommodation varies substantially within the euro area. In this respect, Eurostat is currently conducting a pilot study to assess the merit of approximating such costs through a net acquisition cost of housing purchases in the future. Such approach entails both advantages and disadvantages. It is on the one hand simple, as it avoids deriving imputed prices for the rental value for owner occupied housing. On the other hand, it presents some of the drawbacks of using asset prices in a price index for monetary policy (see the discussion below in Section 4) and the measure may be subject to small sample problems in the smaller countries, which could jeopardise the comparability across countries in this respect.

All this brings us to a fourth summary statement:
Household consumption expenditure is the correct domain of definition of a price measure. The inclusion of owner occupied housing services in the HICP is desirable because it improves the comparability of the HICP across countries.

3.2 Valuation principle

The second parameter in the definition of a price index refers to its valuation. The key issue here is whether the price should refer to the amount of money paid by the buyer (and therefore includes any indirect taxes and excludes any subsidies), or whether the price should refer to the amount received by the seller (and thus excludes taxes but includes subsidies). At first sight, there may appear to be some merit in adopting the seller's perspective. It more closely represents the economic cost of producing the good or service and excludes the effects of indirect taxation and subsidies which, being imposed by government, are beyond the control of a monetary authority. However, except in the case where the price elasticity of demand is highly inelastic, the effects of changes in indirect taxes and subsidies will also be reflected in the seller's price. Therefore, neither the buyer's nor the seller's prices are immune from changes in taxes or subsidies, and hence there are no clear theoretical grounds for choosing one over the other. However, as discussed later in this note, there are practical reasons for favouring the buyer's price on the grounds of credibility of the measure chosen.

3.3 Index number concept and substitution biases

There are two major approaches to formulating a price index: the fixed basket approach, and the cost of living approach. The fixed basket approach defines the price change between period 1 and 2 as the ratio between the cost of a representative basket of goods at period 2 and 1. The Laspeyres index selects that representative basket on the basis of consumption patterns observed at period 1, while the Paasche index does so on the basis of those observed at period 2. Most NSIs have adopted a Laspeyres index in the construction of consumer price indices (CPI). The cost of living approach on the other hand defines the price change between period 1 and 2 as the ratio of the minimum cost in periods 1 and 2 required to achieve the same level of utility provided by a representative basket at given changes in prices. Note that the same decision as before needs to be made to select the representative basket, but contrary to the previous method, the theoretical approach does not assume that the quantities consumed of every item in the basket are independent of their prices. It follows that a price index computed with the Laspeyres formula overstates the true cost of living because as the price of certain items rises, the index ignores the possibility individuals might substitute the more expensive goods for cheaper ones, and still achieve the same level of utility. This is known as the "substitution bias" effect.[2] The report of the Boskin Commission suggested that, in the US, substitution bias was around 0.15%.

A problem with the fixed basket index is that the composition of the basket may well gradually become unrepresentative of expenditure patterns. To avoid this, rather than keeping the base year fixed, NSIs change it over time and produce a chained index. Sufficiently frequent re-basing in effect reduces substitution bias. Moreover, an appropriate choice of aggregation formula at elementary index level (e.g. the geometric mean) alleviates substitution bias at this level.

An alternative approach to formulate the index relies on the computation of symmetric averages of the Laspeyres and the Paasche indices. Examples include the Fisher, Walsh and Tornqvist index.[3] These three indices are said to be *superlative indices*. This means that, under certain assumptions, they provide an exact approximation to a true cost of living index.[4] In addition, under those same assumptions, superlative indices account for consumers' substitution of goods in response to changes in their relative prices, and as a result are less subject to substitution bias. Nevertheless, the assumptions required for these indices to be considered as "superlative" are not uncontroversial.

In August 2002, the US Bureau of Labor Statistics (BLS) began publishing the Chained Consumer Price Index (C-CPI) that adopts a Tornqvist index number concept. Contrary to other CPI measures, which use a single expenditure base period, the C-CPI uses expenditure data for both the base and current periods. Data on current period expenditure is only available with a time lag. Rather than waiting for the data, a first release of the C-CPI is published with preliminary data, and is subsequently revised. The US CPI is chained (that is, they use updated expenditure weights) every two years, the C-CPI is chained monthly. The gap between the CPI and C-CPI series published by the BLS is explained by substitution bias. This gap points to a figure much larger than that reported in the Boskin's report with an average bias of 0.6% (ranging from 0.3% to 0.9%).

Camba-Mendez, Gaspar and Wynne (2002) argue that it should not be automatically assumed that substitution bias is of a similar magnitude in Europe. Unfortunately not enough is currently known to provide a comparison. Many European NSIs frequently update weights in price indices and carefully ensure that the sample basket of goods is representative of current consumption patterns. Currently six euro area countries (Germany, Greece, Spain, Ireland, Austria and Finland) re-base the index every five

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[2] It is easy to show that the true cost of living index should lie in between a Laspeyres fixed basket index and a Paasche price index, see Diewert (2002).

[3] The three approximate each other closely, therefore it does not matter much which is chosen. In fact, Diewert (1978) has shown that the three formulas will approximate each other to the second order.

[4] For example under the assumption that the household's utility function is a homogeneous quadratic function, the Fisher price index is equal to the true cost of living index.

years. The other countries do so at one to three year intervals. It has long been acknowledged by those responsible for the development of the HICP that differences in the frequencies of updating might lead to non-comparability. This concern prompted the setting of minimum standards whereby adjustments need to be made more frequently when there is evidence of significant changes in expenditure patterns. This in effect translates into checking the weights of those components judged to be most critical for the reliability of the HICP. Notwithstanding, whether this strategy to update the weights compares favourably to the US case of two years is still open to question. Furthermore, the estimates for the US highlight the need for a thorough investigation of substitution bias in the euro area.

The publication of a Tornqvist price index by NSIs of the euro area would provide some interesting additional information to assess inflation developments. Notwithstanding, the practical use of a Tornqvist price index (e.g. for monetary policy) also creates difficulties for the analysis of short-term inflation developments. For example, the formulae for the computation of sub-indices and aggregates, and the formula for the computation of monthly changes become less straightforward. Also, the Tornqvist price index is subject to major revision, and as noted above, such indices may lack credibility with the public.

This brings us to a fifth summary statement:
Sufficiently frequent re-basing of the consumption basket by all countries is important to ensure the accuracy and comparability of the HICP, and as a way of reducing the substitution bias.

4. Conceptual issues II: Inclusion of asset prices

There has been considerable debate in the economic literature on the potential role that asset price movements should play in measures of prices used for monetary policy purposes. Alchian and Klein (1973) suggested that a price index to measure inflation should be based in the Fisher tradition of intertemporal consumption, contrary to a standard cost of living index that is static in nature. However, formulating such index would require observing at two points in time price vectors for present and future prices. For most goods and services future prices do not exist. This makes the construction of a cost of living index based on intertemporal consumption theory intractable. Although this problem was originally acknowledged by Alchian and Klein, on the basis of their theoretical developments, they suggested that *"the current prices of assets of different life lengths provide a theoretical substitute since they embody present prices of expected future flows"*. But this is not free from controversy. With the exception of physical assets such as owner occupied housing and consumer durables, households' holdings of financial assets are claims to the capital owned by firms and are in no way directly related to the intertemporal consumption prices faced by the household. As pointed by Gilchrist and Leahy (2002) asset prices change for many reasons, not all related to the cost of future consumption. Asset prices may rise when expected profits rise while interest rates may remain unchanged. This implies that changes in asset prices reflect changes in the quantity of future consumption rather than changes in the price of future consumption. This argument also highlights a further concern with the inclusion of asset prices, namely whether they are controllable by the central bank given that they depend on real factors.

The inclusion of equity prices in particular, has some other major drawbacks of an empirical nature. First, the large volatility and/or potential for bubbles in equity prices may add too much noise to a measure of inflation, thereby making it more difficult to extract the true signal from price developments. Second, it could be very risky for a Central Bank to try to smooth large changes in asset prices. If, for example, a Central Bank tried to correct for sharp falls in asset prices this could ultimately lead to larger asset price bubbles, as investors may begin to count on the central bank to come to the rescue. Third, the empirical evidence supports a link between real estate prices and output, but this link is much weaker for equity prices, see Cecchetti et al (2000) and Goodhart and Hofmann (2000). This led Goodhart (2001) to suggest that, in so far as the welfare effects of inflation relate ultimately to its impact on output and on consumption, a measure of inflation should accord some weight to housing prices, although none to equity prices.

The above discussion brings us to a sixth summary statement:
There are both theoretical and empirical concerns against including asset prices in the index used for quantifying the price stability objective

5. Conceptual issues III: Measures of underlying inflation

The ECB's stability oriented monetary policy strategy states that price stability shall be maintained over the medium term. The problem with standard price measures is that they are often contaminated by three main types of transitory shocks: i) unsystematic measurement errors, ii) regular seasonal fluctuations, and iii) other non-monetary factors, such as for example a good or bad harvest. This has prompted economists to suggest the use of a "filtered" version of the published price index, that removes those short run disturbances, as a measure of underlying inflation. Two major approaches for filtering a price index have been adopted. The first approach exploits the cross section dimension, and in effect acts upon the original series by modifying the weights attached to its different components. An example in this vein is a study conducted for the euro area HICP by Vega and Wynne (2001) which suggested that a trimmed mean measure of underlying inflation outperforms a measure computed by excluding unprocessed food and energy prices. By better performance Vega and Wynne (2001) meant the power of a certain measure to forecast headline inflation over a long horizon. The second approach exploits the time series dimension of the price index series, and builds a measure of underlying inflation at a point in time as the weighted sum of observations from the past and the future. The justification for this approach follows Blinder's (1997) suggestion to identify the persistent component of aggregate inflation as an underlying measure of inflation, i.e. that component that does not vanish in future periods but leaves a permanent mark on the level of inflation.

A measure of underlying inflation removes those fluctuations associated with short run developments that should be disregarded for monetary policy purposes. In that sense it represents an appealing concept for monitoring price developments. Notwithstanding, it is difficult to discriminate between alternative measures of underlying inflation and different measures often provide very different figures. The power to forecast headline inflation over a long horizon is usually adopted as a valid criteria. An alternative criteria could also be whether a measure is or is not well grounded in economic theory. Some measures of euro area underlying inflation in December 2000 reported in ECB (2001) ranged from values of 1.4% to 2%. It is also important to note that underlying measures of inflation are transformations of an original series extracted from sampling, and may lack credibility with the public.

Moreover, it should be kept in mind that in defining its primary objective in terms of headline inflation, the ECB does not impart in any way an inappropriate short-term focus in its assessment. Rather, the medium-term orientation of the ECB's monetary policy strategy ensures that the Governing Council will duly discount short-term price volatility in its deliberations.

This brings us to a seventh summary statement:
Underlying measures of inflation represent an appealing concept, but the large degree of uncertainty behind its computation is a deterring factor for its use in the ECB definition of price stability. Also, these measures may very well lack credibility with the public. However, they are useful indicators for monetary policy.

6. Final assessment

On the basis of the preceding discussion, it seems reasonable to confirm that the HICP is the best available measure of prices for the euro area. In broad terms, the HICP is described as a Laspeyres type index defined over the domain of consumption expenditure which is published monthly and in a timely manner, is very rarely subject to revisions and is possible to aggregate across countries. These characteristics make it unique. Any other choice would invariably compromise at least one of these important properties.

In addition, the domain of the definition for price stability and the need for comparability are specifically stated in the Protocol on the convergence criteria annexed to the EUT: *"Inflation shall be measured by means of the consumer price index on a comparable basis, taking into account differences in national definitions"*. The choice of a different domain in the definition of price stability of the ECB would thus appear to be at odds with that in the convergence criteria.

The definition of price stability currently adopted by the ECB, which encompasses price increases up to 2%, has been partly justified with respect to a potential upward bias in measured price increases. On the basis of the most recent evidence the measurement bias does not appear to be an argument for changing this assessment.

Whilst being supportive of the continuing validity of the HICP as a yardstick for prices, this note has identified two potentially sensitive issues associated with the HICP. First, frequent rebasing of the national indices is very important. Currently six euro area countries (Germany, Greece, Spain, Ireland, Austria and Finland) re-base the index every five years. The other countries do so at one to three year intervals. Whether this compares favourably to the US case of two years is open to question. Sufficiently frequent re-basing of the basket by all countries is important to ensure the accuracy and comparability of the HICP. Second, inclusion of owner occupied housing would allow for the HICP to be more comparable across countries.

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3

Definition of price stability, range and point inflation targets: The anchoring of long-term inflation expectations*

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1. Introduction

As a result of the widely shared consensus that price stability is the ultimate objective of monetary policy, over the past fifteen years there has been a growing tendency among central banks to explicitly announce numerical targets for their objective of price stability. This trend is part of a wider process of transformation of the overall monetary policy framework, which has witnessed the acquisition by central banks of a high degree of independence and, in parallel, the adoption of a more open approach in the conduct of monetary policy. In this context, the announcement of quantitative definitions of price stability and explicit numerical targets for inflation is seen to be instrumental for a higher transparency of the policy framework and thereby for the accountability of the central banks. Moreover, the announcement of a quantitative target is believed to be a powerful instrument for anchoring inflation expectations, providing a device for co-ordinating price and wage setting behaviours and thus for facilitating the conduct of monetary policy by the central bank.

This paper reviews the different practices and operational concepts which are used to define the objective of maintaining price stability in 15 major developed countries and the performance of these countries in anchoring long-term inflation.[1] While the announcement of quantitative targets is common to many central banks, the specific features of the announced targets vary across the different countries. The various practices include the announcement of a quantitative definition of price stability and inflation targets in the form of point or ranges for admissible inflation outcomes. Moreover, central banks in some countries have chosen not to announce quantitative objectives but have defined price stability only in qualitative terms.

When looking at the debate on the pros and cons of the different choices – in particular with a view to the arguments for specifying a range or a point objective for inflation – the following points seem to emerge. The announcement of a range (rather than a point) permits the central bank to clearly signal the uncertainty surrounding future price developments and the imperfect controllability of inflation, particularly at short horizons. Moreover, a range may give more flexibility to accommodate possible moderate and gradual variations in the optimal inflation rate over time. On the other hand, a possible drawback of a range objective is that the bounds of the range may be seen as implying "hard edges", i.e. thresholds values which trigger actions in a quasi-automatic fashion. A point objective may be preferable in this respect. Moreover, a point objective probably increases the signalling properties of the announcement, as it may provide a more precise focal point for the expectation formation mechanism of agents in the economy.

Overall, the choice of the specific features of the announced objectives reflects the above trade-offs and appears to be inextricably linked to the overall policy framework and monetary policy strategy followed by the different central banks, in particular with regard to the specific mandates and the chosen horizon for the conduct of monetary policy. Using survey data on long-term inflation expectations, we evaluate the empirical evidence regarding the capability of the various countries in tightly anchoring inflation expectations since the early nineties. The results show that in all countries, with the exception of Japan, long-term inflation expectations are well anchored and, generally,

[1] The review also includes countries currently in the euro area for the period prior to 1999.

increasingly so over the past 15 years. This is indicated by both a low and generally decreasing volatility of expectations and a low and generally decreasing degree of correlation between revisions in short-term and long-term inflation expectations. When comparing this evidence across types of announcement of the inflation objective, we find that the specific features of such objectives have no visible effect on the performance at anchoring inflation expectations. In particular, there does not seem to be evidence that the announcement of a quantitative objective in the form of a point or of a range for admissible inflation rates makes any appreciable difference. As regards the euro area, indicators point at a very low volatility of long-term inflation expectations since 1999, at levels which are comparable to those of the best performing countries. Finally, the two countries in our review where no numerical value for the inflation objective was announced, the United States and Japan, represent two extreme cases. While in the former country the tightness of inflation expectations is comparable to that of the best performing countries, in the latter expectations exhibit a relatively high volatility.

The rest of the paper is organised as follows. Section 2 briefly reviews the different practices and operational concepts adopted by major central banks in defining their primary objective of maintaining price stability. Section 3 analyses the main rationales, proposed either by the central banks or by outside observers, which may lie behind such choices, in particular with regard to the choice of specifying a range or a point objective for price developments. In Section 4, using survey data on long-term inflation expectations, we evaluate to what extent inflation expectations are well anchored in the various countries. Section 5 concludes the paper.

2. Overview of international practice

Table 1 below presents an overview of the basic features of the objectives announced in major developed countries around the world. While in all countries price stability represents a primary goal for monetary policy, actual practices vary somewhat across countries, ranging from no explicit quantitative definition to explicit quantitative definitions and inflation targets in the form of point targets or ranges for admissible inflation outcomes. In terms of the announcement of objectives for price developments we can distinguish between:

- *Central Banks that have not announced a quantitative target* (the Federal Reserve System and the Bank of Japan)

In the **United States** there is a broad consensus that price stability deserves primary attention of monetary policy authorities.[2] The US Federal Reserve System (Fed), however, has not set an explicit, numerical objective for price stability. In the early

[2] In the Full Employment and Balanced Growth Act of 1978 (the Humphrey-Hawkins Act) a legal foundation is provided by stating that: “The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long-run growth of the monetary and credit aggregates commensurate with the economy’s long run potential to increase production, so as to promote the goals of maximum employment, stable prices, and moderate long-term interest rates.”

1990s, the Fed Chairman A. Greenspan clarified that price stability obtains when "households and businesses need not factor expectations of changes in the average level of prices in their decisions".[3] Later on he clarified that while price stability is the ultimate objective of the Fed, the difficulty to pin down exactly this notion (mainly due to the existence of significant measurement problems) prevents the Fed to adopt a specific numerical target.[4]

In the same vein, in **Japan** no explicit quantitative definition has been adopted by the Bank of Japan (BoJ) so far. For decades the BoJ has referred to price stability as a "prerequisite for sustainable economic growth and a primary objective for monetary policy". On 13 October 2000 the Policy Board of the BoJ made an attempt to clarify the definition of price stability for Japan "as an environment where economic agents including households and firms can make decisions regarding such economic activity as consumption and investment without being concerned about the fluctuation of the general price level". The BoJ has recently justified its unwillingness to provide a quantitative definition of price stability on the ground that the recent situation in Japan is characterised by exceptional economic conditions and unusual price developments.

- *Central Banks that have provided a quantitative definition of price stability* (the euro area and Switzerland)

For the **euro area**, the Governing Council of the ECB announced the quantitative definition of price stability on 13 October 1998 as: "Price stability shall be defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%". The ECB clarified that the use of the world "increase" excludes deflation from the definition and that moreover the lack of an explicit lower bound in the definition reflects the acknowledgement of the existence of an unknown (but likely small positive) and possibly time varying measurement bias in the HICP.[5] Price stability has therefore been defined in the form of a range for allowable inflation rates.

In **Switzerland**, the Swiss National Bank has provided an explicit quantitative definition of price stability, which is fully equivalent to that of the ECB. It has defined price stability as an increase in the CPI for Switzerland of less than 2%.

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[3] See Greenspan (1994).

[4] *"[…] the Federal Reserve can be quite explicit about its ultimate objectives – price stability and the maximum sustainable growth in output that is fostered when prices are stable. By price stability, however, I do not refer to a single number as measured by a particular price index. In fact, it has become increasingly difficult to pin down the notion of what constitutes a stable general price level". […]. "For all these conceptual uncertainties and measurement problems, a specific numerical inflation target would represent an unhelpful and false precision. Rather price stability is best thought as an environment in which inflation is so low and stable over time that it does not materially enter into the decisions of households and firms."* Remarks by Chairman A. Greenspan "transparency in monetary policy" at the Federal Reserve Bank of St. Louis, Economic Policy Conference, October 11, 2001.

[5] See ECB (1999). See also Duisenberg (2001a and 2001b).

Table 1: Inflation targets or definitions of price stability in selected industrial countries

Country	Indicator	Numerical Value Definition/Target	Ex-Ante Horizon (*)	Accountability (ex post) (*)
1. Europe:				
Euro area	HICP	Below 2% (since 1999) Definition of price stability	Medium term (not sole focus on inflation forecasts; prominent role for monetary developments, which exhibit a medium-term relation with prices)	Medium term
Memo item: Euro area countries prior to 1999 (3)				
Finland	CPI	(about) 2 % Objective for 1998	Focus on two years ahead inflation forecast	
France	CPI	Not exceeding 2% Objective for 1998		Inflation in the year concerned
Germany	Not specified	2% before 1997 1.5 – 2% for 1998 “inflation norm”	Annual monetary target	Monetary developments in the year concerned
Italy	CPI	Not exceeding 2% Objective for 1998		
Spain	CPI	3.5%-4% (Jan. 95-96:Q1) 3%-3.25 % (96:Q1-97:Q1) below 3% during 1997 below 2.5%-2.75% for late 1997 2% for 1998		Inflation in the year concerned
European countries not in the euro area:				
Norway	CPI Focus on core inflation	$2^1/_2$% with a fluctuation margin of ±1% Target	Main focus on 2 years ahead inflation forecast	Timeless with escape clauses (2)
Sweden	CPI	2% with a fluctuation margin of ±1% (Jan.95-now) Target	Main focus on 1 to 2 years ahead inflation forecast possibility of with extending horizon	Escape clauses (2)

Table 1 (cont.): Inflation targets or definitions of price stability in selected industrial countries

Country	Indicator	Numerical Value Definition/Target	Ex-Ante Horizon (*)	Accountability (ex post) (*)
Switzerland	CPI	Below 2% Definition of price stability	Medium term with a focus on three years ahead inflation forecast	Medium term
United Kingdom	RPIX (Retail Price Index excluding mortgage interest payments	1%-4% (Oct. 92-June 97) 2.5 % (1), (June 97-now) Target	Medium term (with a focus on two years ahead inflation forecasts)	Timeless with escape clauses (2)
2. Other OECD countries:				
Australia	CPI	2-3%, (Jan. 1993-now) Target	Medium term	On average over the business cycle
Canada	CPI Focus on CPI excluding food energy, and the effect of indirect taxes	Midpoint 2%-4% (Feb. 91-end-1992. Midpoint 1.5%-3.5% (end-92-mid 1994). Midpoint 1%-3% (Dec. 1993 (revised)-Feb 2001; then renewed, and valid up to end-2006). Target	Medium term with focus on six to eight quarters ahead	
Japan	CPI	No numerical value (5) Qualitative definition of price stability	(6)	
New Zealand	CPI (excluding credit services)	3%-5%, range target (Mar. 90-Dec. 90) 2.5%-4.5%, range target (Dec. 90-Dec. 91) 1.5%-3.5% (Dec. 91-Dec. 92) 0%-2% (Dec. 92-Dec. 96) 0%-3% (Dec. 96-Nov. 2002) 1%-3% (Nov. 2002-now) Target	Medium term (Prior to nov. 2002: main focus on 6 to 8 quarters ahead inflation forecast)	Medium term (future CPI between 1-3% on average over the medium term)

Table 1 (cont.): Inflation targets or definitions of price stability in selected industrial countries

Country	Indicator	Numerical Value Definition/Target	Ex-Ante Horizon (*)	Accountability (ex post) (*)
United States	Not specified Focus on several inflation measures	No numerical value (4) Qualitative definition of price stability		

Notes to Table 1: (*) Ex ante horizon: the horizon over which the central bank will seek to pursue its objective or re-establish it after a shock has occurred. Accountability ex post: the time period over which the central bank is to be held accountable. (1) If inflation as measured by the RPIX is more than one percentage point above or below the target of 2.5%, the Governor of the Bank of England needs to write an Open Letter of explanation to the Chancellor. (2) Timeless horizon implies that, in principle, the inflation target has to be maintained at all times. Escape clauses: when explicit contingencies under which a temporary deviation from price stability can be allowed are provided. (3) When adopting the broad economic policy guidelines in July 1995 the Ecofin indicated that a value of 2% would be the maximum rate of inflation compatible with price stability. This was reconfirmed in the 1998 guidelines. (4) The Chairman of the US Fed, Alan Greenspan, stated that "price stability obtains when people do not consider inflation a factor in their decisions". (5) The BoJ has defined price stability "as an environment where economic agents including households and firms can make decisions regarding such economic activity as consumption and investment without being concerned about the fluctuation of the general price level". (6) On 19 March 2001 the BoJ announced that it will continue its policy of quantitative easing "until the CPI registers stably a zero percent or an increase year on year".

- *Central banks that specified inflation targets* (all remaining non-euro area countries shown in Table 1)

Following the practice initiated by New Zealand in 1990, over the last decade a large number of countries have announced explicit inflation targets in the form of point targets or ranges, in the context of a general process of reform of their monetary policy framework.[6] It should be noted that in many cases initially a clear distinction was made between the "inflation targets" and the ultimate price stability objective. In the context of the gradual process of disinflation in many countries at the beginning of the 1990s, the former was seen as instrumental for achieving the latter. As many countries have reached and announced very low inflation targets in the meantime, these are nowadays seen more as an operational definition of the ultimate objective of price stability.[7]

Starting from non-European countries, in **Canada** an agreement between the central bank and the finance ministry sets price stability as the principal objective for monetary policy. To implement this objective, the agreement specifies a target range for CPI inflation of 1 to 3% with a focus on the midpoint of the range. In **Australia**, the central

[6] For a detailed review of the experiences with inflation targeting see Bernanke et al. (1999).

[7] Clearly, in countries (such as some Eastern Europe or Latin America countries, not reviewed in this paper) where relatively high inflation targets are announced, the distinction between the definition of price stability and the inflation target is more relevant.

bank has set an inflation target with a range of 2-3% for the CPI, which applies to the average inflation rate over a business cycle. In **New Zealand**, the numerical inflation target is set jointly by the Minister of Finance and the Governor of the central bank in the context of the Policy Target Agreement (PTA). The new PTA signed in November 2002 requires the Reserve Bank of New Zealand to keep future CPI inflation in the range 1-3% on average over the medium term (the target was previously set at 0-3% since 1996).

Turning to European (non euro area) countries, in the **United Kingdom** the Chancellor has mandated the Bank of England to pursue a point target for RPIX inflation of 2.5%.[8] This point target has remained unchanged since 1997. In **Norway**, the target for CPI inflation is set at 2.5% with a fluctuation margin (or tolerance band) of ±1%. Finally, in **Sweden** a point target for CPI inflation of 2% with a fluctuation margin of ±1% has been adopted.

Table 1 also reports (when made explicit) the horizon for the conduct of monetary policy, trying to make a distinction between an ex ante dimension (i.e. the time frame over which the central bank will seek to pursue its objective in a forward-looking manner) and the ex post dimension (i.e. the horizon over which the central bank wishes/is to be held accountable).[9] Broadly speaking all central banks recognise that, due to the occurrence of unforeseeable shocks and the existence of significant lags in the transmission of monetary policy impulses, it would be impossible to keep inflation at the desired level all times or to bring it back to the desired level in a very short time. Moreover, it is widely recognised that a gradual response of monetary policy to some specific shocks (mainly of a cost-push nature) is required in order to avoid imparting an unnecessarily high volatility in output and interest rates.

In terms of ex ante horizon some central banks that have adopted an explicit inflation targeting approach have announced a specific fixed horizon driving the conduct of their decisions. Such horizons vary in a range from 1 to 3 years ahead and often correspond to the horizons of the official published forecasts of the central banks. It should be mentioned that more recently a tendency towards de-emphasising the fixed horizon in favour of a 'medium term' notion can be noted among inflation targeting central banks. The medium term notion has been adopted by the ECB, the Bank of Australia and more recently by the Reserve Bank of New Zealand (RBNZ).[10]

[8] If inflation as measured by the RPIX is more than one percentage point above or below this target, the Governor of the Bank of England needs to write an open letter of explanation to the Chancellor. It should be noted that owing to differences in statistical methodologies and in the coverage of expenditure items, RPIX inflation has historically tended to be higher (by more than half a percentage point on average over the past decade) than HICP inflation in the UK.

[9] Given that not all countries have made an explicit distinction in this respect, our attributions in the table should be taken with particular caution.

[10] For example, in New Zealand, the new PTA has officially extended the horizon from the previous 6 to 8 quarters ahead to the "medium term". Recently the Bank of England has also referred to the notion of the medium term several times in its recent press releases on interest rates decisions. For example, on 6 February 2003 the MPC stated: "[…]. *In order to keep inflation on track to meet the target over the medium term, the Committee judged that it was necessary to reduce interest rates by 0.25%*". The recent literature has emphasised the potential problems which may arise with the adoption of a fixed (and relatively short-term) horizon, e.g. in relation with the possibility of the emergence of asset price bubbles and episodes of financial crises.

Only a few central banks have made explicit their ‘ex post’ horizon (or horizon for accountability). The Bank of England and Norges Bank and the RBNZ prior to the new Policy Targets Agreement (PTA) view their horizon as being timeless, implying that in principle the inflation target has to be maintained at all times. In these cases normally a number of escape clauses are provided, i.e. explicit contingencies under which temporary deviations from the target can be allowed (these normally relate to a number of cost-push unexpected shocks). The ECB and the RBNZ have adopted a medium term horizon. The Bank of Australia refers to the average inflation developments over the business cycle.[11]

3. Ranges or point objectives: rationales

As discussed in the preceding section, the specific features of the announced quantitative objectives for inflation developments vary somewhat across countries, including ranges of various size, ranges with an explicit focus on the range’s mid-point, point targets with fluctuations bands or point targets. In this section we review some possible motivations for these different choices that have been proposed either by central banks, academic experts or observers.

Generally, central banks that have adopted ranges have emphasised the existence of *uncertainty* related to future inflation developments and the *imperfect controllability* of inflation. The advantage of a range, in this respect, would be that it conveys to the public the important message that the control of inflation is inherently imperfect and therefore it avoids giving the impression that monetary policy is equipped to (or might attempt to) fine-tune price developments with a high degree of precision. The size of the range may thus convey information about the central bank’s assessment of the uncertainty surrounding the effects of its policies. In this respect, the motivations behind the choice of a range are similar and related to those behind the choice of a medium-term perspective in the conduct of monetary policy, as described in the previous section. In an uncertain environment, a range objective may also be seen as preferable to a point objective for credibility purposes. Over relatively short periods of time, deviations from any point objective may be substantial with potential negative effects on the credibility of the central bank, while a range enhances the likelihood that inflation developments will be very frequently within the established objective.

This latter view is not, however, uncontroversial. Bernanke et al. (1999) argue that missing a range (which may inevitably happen from time to time) may be perceived by the public as a more serious policy failure than missing a point (which happens continuously and inevitably).[12] Moreover, with a range in place the public may focus excessively on whether inflation is just inside or just outside of the range, rather than on

[11] It should be noted that the use of the word ‘average’ in the case of both Australia and New Zealand (“future CPI …on average over the medium term”) might seem to imply a price level target with drift. However, it is not straightforward (particularly in the case of New Zealand where the word ‘future’ is included) to what extent ex post deviations of the expected inflation from the policy target are bygones or not. If they are not corrected, the cumulative long-run effects on the price level of these short-run deviations may drive the CPI far away from the drift.

[12] Similar points have been made by Svensson on various occasions, e.g. in Svensson (2001a). More recently he pointed out that a relatively narrow interval (say 1% wide) would avoid the main drawbacks of ranges.

the magnitude of the deviations from the mid-point. All this may increase pressure on the central bank to act vigorously to keep inflation within the range, which may create problems of instrument instability and excessive volatility in the real economy, particularly if the horizon is short.[13] In this sense a trade-off may exist between the choice of the size of the range and the length of the horizon for the conduct of monetary policy. Moreover, careful communication may be needed on the part of the central bank to avoid the impression that the bounds of the range are seen as implying "hard edges", i.e. threshold values which trigger actions in a quasi-automatic fashion.[14]

Orphanides and Wieland (2000) point out that the presence of a range target invariably suggests a non-linearity in the policy response of central banks. Given that under the conventional linear-quadratic framework used in the analysis of optimal monetary policy, optimal policy is linear and invariant to the presence of (additive) uncertainty, the presence of a range must imply a departure from the standard framework. With this in mind, they offer two possible motivations for the adoption of a range and explore their implications for optimal monetary policy. First, they assume a zone-quadratic objective for the central bank, that is, a loss function which assigns quadratic loss to inflation outside the target zone and, implicitly, a near zero loss for inflation outcomes within the zone. Secondly, they explore the possibility of non-linearities in the short-run inflation-output trade-off, namely, the assumption that inflation is relatively stable for a range of output gaps and only increases or decreases when the output gap falls outside this range. Under both types of non-linearities, and under the assumption that the central bank assigns at least some weight to output stabilisation, monetary policy will be relatively unresponsive to inflation (and more responsive to output developments) when inflation is within the range inflation objective. However, the size of the zone of relative inaction to inflation developments depends crucially on the degree of uncertainty the central bank faces (relative to the size of the range). In particular, the higher is uncertainty the lower is the zone of inaction and in the limit optimal policy will collapse to the standard linear-quadratic case (which implies no inaction zone).

Another reason that is often quoted as a motivation for the choice of a range (rather than a point) inflation objective is the need to preserve *flexibility* in the management of monetary policy. There are two levels of arguments in this regard.

First, it is argued that a range also reflects a concern by central bank for macroeconomic stabilisation, in particular for avoiding excessive output and employment fluctuations when responding to threats to price stability.[15] In this respect, there is clearly a link between the choice of a range and the horizon for the conduct of monetary policy (see Section 2 above) and a trade-off may exist between the size of the

[13] Bernanke et al. (1999) quote the case of New Zealand as an example in this regard and argue that these problems played a role in the country's decision to finally widen the range objective in 1996, from 0-2% to 0-3%.

[14] These motivations appear to be behind the choice of the Bank of Canada to emphasise the mid-point of its range, as apparent from the following quote: "[…] *Monetary policy will therefore be directed to moving inflation to the target midpoint over a six- to eight-quarter horizon. In this way, policy aims at keeping the trend of inflation at the 2 per cent target midpoint. The target range of ±1% around the target midpoint thus encompasses the outcomes for inflation that are likely to occur most of the time. This range should be interpreted as a reflection of the short-run uncertainty of outcomes stemming from unpredictable shocks and not as a measure of the indifference of the Bank as to the outcome*". See Bank of Canada (2001).

[15] See Bernanke et al. (1999), pp. 291-293.

range and the length of the horizon adopted for the conduct of monetary policy. Moreover, a range may also be thought to give more leeway to the central bank to pursue objectives other than inflation, such as output growth, in case its mandate includes multiple objectives with no priority given to price stability.[16]

Second, it has been argued that a range might be seen as preferable if there is the possibility that the optimal inflation rate for the economy might vary (gradually and moderately) over time. There may be several reasons for this. For example, structural shocks (such as a permanent rise in productivity growth) may increase the equilibrium level of the real interest rate of the economy, permitting to balance the costs of inflation with the benefits (such as those deriving from the existence of a zero lower bound in nominal interest rates) at a permanently lower inflation rate.[17] Similarly, changes in statistical measurement methods may permit to reduce the measurement bias in observed inflation and thereby the implicit focal point within the inflation objective. In these cases, a range objective could at least theoretically accommodate mild variations in the optimal inflation rate without requiring a change or frequent changes in the inflation objective.

The two lines of argumentation above also illustrate the possibility that the higher flexibility given by a range target (relative to a point) may leave open the possibility (or raise the suspicion) of an excessive degree of discretion in the conduct of monetary policy. In this respect, the trade-off existing for the society between the benefit from granting the policy maker some flexibility in the conduct of its policy and the need to limit its discretion has been recently formalised by Athey, Atkenson and Kehoe (2002). In their model, monetary authorities have private information on the state of the economy determining the optimal inflation rate or target, which remains unknown to the public. The problem of the society is to find a well-designed rule which gives monetary policy the flexibility to react to its private information, but at the same time is able to guard against the standard time inconsistency problem arising from the temptation to stimulate the economy by creating unexpected inflation (à la Barro-Gordon). They find that the optimal rule is simply achieved by legislating an inflation cap that specifies the highest allowable inflation rate. The optimal inflation cap (or degree of discretion) is decreasing in the severity of the time inconsistency problem.

Last but not least, a crucial aspect that is referred to in the discussion on ranges and point objectives concerns the *signalling properties* of the announced target. The capability of tightly anchoring inflation expectations is in fact a crucial motivation for the announcement of a quantitative objective for inflation in the first place. In this respect, it is often claimed that the signalling properties of a point target are superior to those of a range. A single number is easier to communicate, may be remembered more

[16] In this respect, Fed officials have sometimes referred to the fact that a numerical objective for inflation would unduly constrain the Fed in view of its dual mandate of price stability and long-term output growth; e.g. see the remarks by Governor Khon (2003). In this respect, the focus of the Fed on price stability with no quantitative specification of the inflation objective, may be thought of as implying a range for allowable inflation outcomes of relatively broad size. This argument is not, however, used by central banks with a mandate which assigns price stability an overriding role.

[17] Another example could be the need of responding in an appropriate manner to episodes of asset price bubbles or financial instability, which may require in some cases a prolonged deviation from any point target inflation rate, in order to ensure that the target is met over a longer-run prospective.

easily and, especially, it provides a more precise focal point for the expectation formation mechanism of agents in the economy and for co-ordinating their actions.[18]

Orphanides and Williams (2003) analyse the effect of the announcement of an explicit numerical inflation target in a model in which agents have imperfect knowledge about the structure of the economy and rely on adaptive learning to continuously update their beliefs regarding the dynamic structure of the economy based on incoming data. In such a framework, effective communication of an explicit inflation target (and strong emphasis on the primacy of price stability objective) by the central bank can help focus inflation expectations and thereby reduce the costs associated with imperfect knowledge, thus yielding superior economic performance.

While clearly the above argument suggest that the adoption of a relatively broad range might result in lower capability of anchoring inflation expectations relative to a point target, it is less obvious what difference a relatively small size range (such as those announced by the central banks reviewed above in Section 2) would make. It seems therefore useful to investigate empirically whether there are any systematic differences in countries' ability of anchoring inflation expectations and whether these differences can be related to the specific characteristics of their announced objectives.[19] We turn to this issue in the next section.

4. Evidence on long-term inflation expectations in selected countries

Exhibiting well-anchored long-term inflation expectations is commonly seen as a desirable feature in any monetary policy framework. Well-anchored expectations would reflect that the public regards the central bank and the overall policy framework as deserving a high degree of credibility for achieving its inflation objective. By contrast, in a low credibility environment, the presence of significant fluctuations in inflation expectations would tend to hamper the smooth functioning of monetary policy.

In practice, in a given monetary policy framework, long-term inflation expectations are usually considered to be well anchored if they exhibit limited variability around an intended level. However, assessing this in practice might not always be a straightforward endeavour.[20] Two types of difficulties in this respect are relevant: those related to uncertainty about the level at which the central bank intends to settle long-term expectations and those related to gauging a threshold for volatility in observed long-term expectations which would seem compatible with well-anchored expectations.

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[18] For instance Svensson (2001b), commenting on the ECB's definition of price stability, claims: "*A range provides a less precise anchor for inflation expectations. There is a big difference between inflation expectations of 2% and 0%. For instance, wage negotiation differences are often about a few tenths of a percent, and the starting point for the negotiations (expected inflation plus expected productivity growth) are important*".

[19] Quite obviously the ability to anchor inflation expectations depends on all the features of the monetary policy frameworks, including the way of conduct of monetary policy, their credibility and effectiveness in the communication with the public, so results are not certain a priori.

[20] In the case of the euro area, the ECB monitors regularly inflation expectations in the euro area through a number of indicators, including indicators derived from financial assets, consumer surveys and surveys of professional forecasters. The ECB conducts its own survey of professional forecasters at a quarterly frequency (e.g. described in ECB Monthly Bulletin, November 2002). For comparability purposes at an international level this note makes use primarily of measures of long-term inflation expectations reported by *Consensus Forecasts*.

Regarding the first issue, two sources of uncertainty should be highlighted. First, even if the central bank announces an intended level of inflation, the public may believe that such objective could be changed in the future. For instance, the central bank might be interested in performing a one-off change in the level of desired inflation (e.g. the quest for low inflation in the 1980s and part of the 1990s in many industrial countries). In this case, the above description of well-anchored expectations as stable long-term expectations would usually not apply and it might even be reversed: a credible disinflationary process would be characterised by rapidly changing expectations toward the new equilibrium level. Second, uncertainty in the level at which the central bank intends to anchor expectations may also arise in a *stationary* environment if the central bank's strategy does not include a quantitative announcement of the inflation objective or definition of price stability or if there is a quantitative announcement which leaves some room for variability in the intended level of future inflation. In this respect, the evidence presented in the following attempts to gauge the implications of different types of quantitative announcement (or the lack thereof) for the ability to anchor long-term inflation expectations by the central bank. An obvious caveat to this approach is the fact that the stability of inflation expectations depends on the overall monetary policy framework and not only on the presence of a quantitative announcement for the inflation objective or its specific features.

A second problem that complicates the analysis of central bank's credibility relates to the possibility that measures of inflation expectations may exhibit some intrinsic volatility independently of the credibility gained by the central bank. Such volatility may result from measurement problems (e.g. due to changes in the sample of experts that provide input if expectations are measured through a survey of professional forecasters or due to shifts in the inflation or liquidity risk premia if they are measured from relative yield of inflation-indexed bonds). Given the uncertainty surrounding such measurement problems, a natural way to assess this volatility in a given country is by its relative performance with respect to best performing countries or economic areas.

As regards the implications of a low level of credibility of the central bank to keep future inflation close to a given level, recent studies (e.g. Erceg and Levin (2001) and Orphanides and Williams (2002)) have shown that as the degree of uncertainty faced by the public regarding the long-term inflation objective of the central bank increases, the degree of persistence in inflation could increase substantially, so that shocks to current inflation could have visible effects on long-term inflation expectations. This suggests that under a low degree of credibility of the central bank inflation expectations would exhibit (in addition to relatively large volatility) positive correlation between changes in short-term inflation expectations (which reflect shocks to inflation) and long-term inflation expectations.

Against this background, long-term inflation expectations in the context of a stable monetary policy framework could be considered to be well anchored if they exhibit at least two features: First, a low level of volatility around a given level (which should be compatible with the point or range target in the case where the central bank makes a quantitative announcement of the inflation objective). Second, a low degree of correlation between movements in realised inflation and short-term inflation expectations on the one hand and long-term inflation expectations on the other. These two criteria to assess the stability of inflation expectations are examined in the next two sub-sections. For this, we examine long-term inflation expectations proxied by the measures provided by Consensus Forecasts in the period 1990-2002 in a number of industrial countries (namely, Australia, New Zealand, the U.K., Canada, the U.S., Switzerland, Sweden and the euro area.[21] (See Annex I for a description of the data).

4.1 The level and volatility of long-term inflation expectations

This section highlights in the first place the patterns in the level and volatility of long-term inflation expectation from the early 1990s until 2002 in the countries considered, except that for some countries only shorter periods of observations are available (exact data availability is indicated in Table 3 and Annexes I and II). For this, Table 2 presents summary statistics with average long-term inflation expectations in a number of sub-periods; in addition, Annex II shows in Displays 1 to 14 a more comprehensive set of indicators and Charts with inflation expectations developments in each of the considered countries.

As regards the patterns in the level of inflation expectations across economic areas, and focusing primarily in the period after the disinflationary process was completed in most countries, the following conclusions may be extracted. For the U.S., where the central bank does not announce a quantitative objective for inflation, the level of expectations seems to have stabilised around an inflation rate of 2.5%. In the case of Japan it should be noted that the level of expectations broadly converges (although with significant variability, as discussed below) to a rate slightly below 1%, indicating that markets consistently believe that mild deflation will eventually come to an end. For central banks with an explicit quantitative announcement of their primary objective, it is noted from Displays 1-14 that in the majority of cases where either a point or a fully symmetric range is used as the format of the objective, that inflation expectations have converged to that point or mid-point in the range. This is indeed the case for the U.K., Sweden (where a focal point is a feature of the objective), Australia (where a symmetric range is used) and to a large extent also Canada (focal point). In the case of the euro area, Display 1 indicates that measures of inflation expectations (five years ahead in the case of the ECB Survey of Professional Forecasters and between 6 and 10 years ahead in the case of Consensus Forecasts) were close to the 2% mark at the start of Stage Three of EMU, declined somewhat in 2000 and have drifted slightly upwards since then, to remain stable at about 1.8 to 1.9%.

As regards the trends in the volatility of inflation expectations across economic areas, Table 2 and the charts and tables in Annex II show that all countries except one experienced a clear reduction in the volatility of long-term expectations starting in the early 1990s. The only exception to these broad trends is the case of Japan, where volatility of inflation expectations did not fall.[22]

The parallel decline in the volatility of long-term inflation expectations over the 1990s is confirmed in the tables within Displays 1 to 14 for all countries considered except the case of Japan, which is analysed separately. This evolution is reflected in particular in

[21] In addition, patterns in long-term inflation expectations in some of euro area countries –namely, France, Germany, Italy, the Netherlands and Spain- are examined, with particular emphasis on the period 1990-1998. Obviously, any inference on these countries for the period starting in January 1999 should be made with caution, as at that time euro area countries relinquished the independent monetary policies, which makes their experience not comparable with those of countries with an independent monetary policy.

[22] In order to avoid the difficulties in gauging the quality of the inflation expectations anchor in a context of disinflation, the analysis focuses mainly on the period after the disinflationary movement (i.e. 1995-2002).

the decline in the coefficient of variation of long-term inflation expectations in all countries except Japan. When the earliest sample (1990-1994) is considered, countries' coefficients of variation of long term inflation are in the range of 0.04 (for Germany) to 0.19 (Canada). By contrast, when the most recent sample (1999-2002) is considered, these figures are in the range of 0.03 (U.S. and Sweden) to 0.10 (New Zealand and Switzerland).

Similarly, when the ratio of the standard deviation of long-term inflation expectations to the standard deviation of realised inflation is considered, all countries are found to have experienced a gradual and considerable decline in that ratio: Whereas for the earliest sample 1990-1994 the ratio was in the range of 6.2% to 59.8%, in the most recent sample 1999-2002 the range of the ratio was between 4% and 38.1%.

Table 2: Summary statistics on long-term inflation expectations*

		1990-1994	1995-1998	1999-2002
Euro area	Average long-term inflation expectations	3.13	2.32	1.82
	Standard deviation of inflation expectations	0.18	0.27	0.09
	Coefficient of variation of inflation expectations	0.06	0.12	0.05
	Standard deviation of realised inflation	-	0.60	0.63
Memo items: euro area countries:				
France	Average long-term inflation expectations	2.96	2.18	1.63
	Standard deviation of inflation expectations	0.28	0.23	0.09
	Coefficient of variation of inflation expectations	0.10	0.11	0.05
	Standard deviation of realised inflation	0.61	0.65	0.62
Germany	Average long-term inflation expectations	2.69	2.21	1.80
	Standard deviation of inflation expectations	0.11	0.15	0.11
	Coefficient of variation of inflation expectations	0.04	0.07	0.06
	Standard deviation of realised inflation	1,78	0.48	0.81
Italy	Average long-term inflation expectations	3.94	2.43	1.66
	Standard deviation of inflation expectations	0.52	0.58	0.11
	Coefficient of variation of inflation expectations	0.13	0.24	0.06
	Standard deviation of realised inflation	0.87	1.39	0.51
Netherlands	Average long-term inflation expectations	-	1.78	1.86
	Standard deviation of inflation expectations	-	0.10	0.19
	Coefficient of variation of inflation expectations	-	0.06	0.10
	Standard deviation of realised inflation	-	0.33	1.04
Spain	Average long-term inflation expectations	-	2.61	2.33
	Standard deviation of inflation expectations	-	0.38	0.21
	Coefficient of variation of inflation expectations	-	0.15	0.09
	Standard deviation of realised inflation	-	1.25	0.56
Switzerland	Average long-term inflation expectations	-	-	1.63
	Standard deviation of inflation expectations	-	-	0.16
	Coefficient of variation of inflation expectations	-	-	0.10
	Standard deviation of realised inflation	-	-	0.41

Table 2 (cont.): Summary statistics on long-term inflation expectations**

		1990-1994	1995-1998	1999-2002
Sweden	Average long-term inflation expectations	-	2.43	1.96
	Average absolute deviation of expectations from target	-	0.18	0.04
	Standard deviation of inflation expectations	-	0.47	0.05
	Coefficient of variation of inflation expectations	-	0.20	0.03
	Standard deviation of realised inflation	-	1.36	0.95
U.K.	Average long-term inflation expectations	3.86	2.98	2.33
	Average absolute deviation of expectations from target	-	0.50	0.18
	Standard deviation of inflation expectations	0.36	0.38	0.10
	Coefficient of variation of inflation expectations	0.09	0.13	0.04
	Standard deviation of realised inflation	2.28	0.66	0.89
Australia	Average long-term inflation expectations	4.03	2.99	2.48
	Average absolute deviation of expectation from target point	-	0.27	0.05
	Standard deviation of inflation expectations	0.63	0.44	0.07
	Coefficient of variation of inflation expectations	0.16	0.15	0.03
	Standard deviation of realised inflation	1.28	1.91	1.73
Canada	Average long-term inflation expectations	2.99	1.89	1.99
	Average absolute deviation of expectation from target point	0.18	0.19	0.06
	Standard deviation of inflation expectations	0.58	0.25	0.10
	Coefficient of variation of inflation expectations	0.19	0.13	0.05
	Standard deviation of realised inflation	2.21	0.54	0.62
Japan	Average long-term inflation expectations	2.14	1.50	0.88
	Standard deviation of inflation expectations	0.43	0.44	0.34
	Coefficient of variation of inflation expectations	0.20	0.29	0.39
	Standard deviation of realised inflation	1.09	0.97	0.35
New Zealand	Average long-term inflation expectations	-	1.78	1.86
	Average absolute deviation of expectation from target point	-	0.50	0.36
	Standard deviation of inflation expectations	-	0.10	0.19
	Coefficient of variation of inflation expectations	-	0.06	0.10
	Standard deviation of realised inflation	-	1.02	1.38
U.S.	Average long-term inflation expectations	3.84	3.00	2.56
	Standard deviation of inflation expectations	0.26	0.25	0.07
	Coefficient of variation of inflation expectations	0.07	0.08	0.03
	Standard deviation of realised inflation	0.66	0.63	0.85

(*) Source: Consensus Forecasts. Long term inflation expectations reflects survey evidence relating surveyed experts' views on inflation rates in a period between six and ten years ahead. For the euro area, data are constructed by aggregating series from the five euro area countries listed under memo items in the Table, representing more than 80% of the euro area household consumption in all periods considered. Annex I provides background information on data sources and elaboration.
(**) For Australia the first year considered is 1991.

In summary, Table 2 and Displays 1 to 14 in Annex II show that the downward trend in long-term inflation expectations did tend to be levelled-off in all countries at some point in the second half of the 1990s. From this point, they also tended to exhibit lower volatility. The exception to this trend is the case of Japan. As shown in the table in

Display 12, long-term inflation expectations in Japan declined on average somewhat over the 1990s. But their volatility has seen only a limited decline, as reflected in the relatively small declines in the standard deviation and the coefficient of variation between the earliest sample 1990-1994 and the most recent sample 1999-2002. Furthermore, the average change (in absolute terms and relative to the previous observation)[23] in long-term expectations increased from 0.33 in the earliest sample (1990-1994) to 0.5 percentage point in second sample (1995-1998) to remain at that level in the latest one (1999-2002), as shown in the table within Display 12. By contrast, for all other countries considered, this same statistic saw a decline or remained broadly unchanged over the 1990s. In particular, for all countries excepting Japan this measure of volatility of expectations was in the range of 0.04 (U.S) to 0.33 (Australia) percentage point in the period 1990-1994, while in the period 1999-2002 the respective range was from 0.05 (Australia) to 0.13 (Switzerland and U.K.) percentage point.

Overall, looking at the various indicators and with particular reference to the period 1999-2002, the variability of inflation expectations has been very low in Australia, Canada, the euro area, Sweden, the UK and the US, with little perceivable differences in performance among these countries.[24] Interestingly, these countries adopted different frameworks to anchor inflation expectations: a point target in the case of Sweden and the UK, a range in the case of Australia and Canada, a range definition of price stability in the euro area, and no explicit quantitative reference in the case of the U.S.

In the same period, inflation expectations were slightly less well-anchored, according to most indicators, in New Zealand and Switzerland, although volatility of expectations in this countries remained at relatively low levels.[25]

All in all, although it is difficult to extract strong conclusions from this evidence, the previous discussion suggests that the announcement of quantitative references in terms of point targets or ranges for inflation is not a necessary condition (e.g. U.S.) for good performance at anchoring inflation expectations.

In order to more rigorously compare the degree of volatility in inflation expectations across different features of the inflation objectives, Table 4 reports the results of a simple panel-data regression of the form:

$$\frac{(E\pi^{J}{}_{t+10} - \frac{1}{T^{J}}\sum_{t=1}^{T^{J}} E\pi^{J}{}_{t+10})^{2}}{(\frac{1}{T^{J}}\sum_{t=1}^{T^{J}} E\pi^{J}{}_{t+10})^{2}} = \alpha + \sum_{I} \beta^{I} \cdot Dummy_{t}^{J}(I) + \varepsilon^{i}{}_{t} \tag{1}$$

where *I, J* and *t* index announcement strategies, countries and time periods respectively. T^J is the total number of periods in which country *J* is observed. The term in the left-hand-side in (1) is a function of long-term inflation expectations. The term *Dummy(I)* in

[23] Consensus long-term expectations are reported biannually, as explained in Annex I of this note.

[24] For euro area countries, the tables in Displays 3 to 7 indicate a considerable decline in both the level and the volatility of long term expectations in the period 1999-2002 compared to the longer periods including previous years, particularly in France and Italy, while less so in Spain and the Netherlands.

[25] In the case of Switzerland, results appear to be particularly affected by one observation in 1999, which may of course represent an outlier.

the right-hand-side is an indicator variable reflecting the type of implemented strategy (*I*) relating the announcement of a quantitative target in a given country (*J*) and year (*t*) , as reflected in Table 1, although in many cases it is not straightforward to assign precisely central bank strategies in this respect to a given regime. A baseline classification of countries' or areas' strategies in the observed years in line with Table 1 is shown in Table 3 below.

Table 3: Baseline classification of countries' strategy announcement of inflation objective

No explicit announcement	France (1990-1997) Netherlands (1995-1998) Japan (1990-2002)	Italy (1990-1998) U.S. (1990-2002) U.K. (1990-1991)
Quantitative definition of price stability (no explicit lower bound)	euro area (1999-2002) France (1998)	Switzerland (2000-2002)
Target range	Australia (1995-2002) Spain (1995-1996)	New Zealand (1995-2002) U.K. (1992-1997)
Explicit point target	U.K. (1997-2002) Sweden (1995-2002) Switzerland (1999)	Canada (1990-2002) Germany (1990-1998) Spain (1997-1998)

Obviously, any classification of announcement strategies in narrowly defined categories, as attempted in Table 3, entails some degree of oversimplification, and therefore alternative classification criteria to the borderline cases have also been used in the empirical analysis.[26]

The results of the panel estimates are reported in Table 4 below. The term "No explicit announcement" (which corresponds to the constant term in the regression) captures measured volatility in expectations in countries that did not implement a quantitative definition of the inflation objective. The other coefficients reported in Table 4 correspond to the *difference* in measured volatility in the other categories, relative to the degree of volatility in countries that did not announce a target.

Overall the results in Table 4 appear to indicate that the precise features of the quantitative announcement seem to have limited effects on the performance at anchoring long-term expectations.[27]

Table 4 also suggests that the announcement of a quantitative objective has tended to contribute to reducing volatility in long-term expectations. At the same time, volatility of expectations in the U.S., where no quantitative objective was announced, turned out

[26] In this respect, it would seem particularly difficult to classify the announcement strategies of Germany in 1990-1998 and Switzerland before 2000 in any of the narrow categories in Table 3, given the then prevailing focus on monetary targeting in these countries. For reasons of simplicity, these countries in those years are classified as implementing a point target in the baseline case.

[27] This appears to be robust also for alternative classifications to the baseline case. In particular, the finding that announcing a point target does not seem to significantly improve the performance in anchoring long-term inflation expectations is somewhat strengthened in alternative regressions where Germany (1990-1998) and Switzerland (1998-1999) are classified as "no explicit announcement".

smaller than in the control group. Obviously, these results should be seen with caution, as the analysis is limited by the size of the sample and potential endogeneity bias in the estimates.

Table 4: Volatility of long-term inflation expectations: announcement strategies*

	1995-2002	
	Coefficient	t-value
No explicit announcement (excluding Japan and US)	0.046	3.57
Quantitative definition of price stability	-0.031	-1.98*
Target range	-0.030	-1.65
Point target	-0.029	-1.56
Japan	0.119	5.48**
US	-0.036	-1.64
R-squared	0.239	
No. observations	217	

(*) Reports results of estimating equation (1):
The coefficient for "no explicit announcement (excluding Japan and U.S.) corresponds to "α" in equation (1) (i.e. the constant term). The remaining coefficients correspond to the terms "β^{l}" in equation (1).
The terms (*) (**) indicate that the coefficient is statistically significant at (5%-level)(1%-level) respectively.

Table 5 shows similar estimates across economic areas as opposed to across different types of announcements.[28] Results in Table 5 indicate that the dummy variables that proxy the volatility of long-term inflation expectations appear significant only in few countries.

[28] It should be noted that in this case a constant term is not included and thus all coefficients reflect absolute volatility of expectations in each economic area.

Table 5: Volatility of long-term inflation expectations: economic regions*

	Coefficient	t-value	p-value
Euro area (1999-2002)	0.016	0.580	0.563
Memo items: euro area countries (1995-1998)			
France	0.034	1.220	0.226
Germany	0.015	0.544	0.587
Italy	0.071	4.030	0.000
Netherlands	0.003	0.391	0.696
Spain	0.017	0.122	0.903
Other European countries			
Sweden	0.032	1.610	0.109
Switzerland	0.007	0.285	0.776
U.K.	0.025	1.260	0.208
Other OECD countries			
Australia	0.020	1.030	0.303
Canada	0.009	0.454	0.651
New Zealand	0.007	0.349	0.728
Japan	0.165	8.350	0.000
U.S.	0.010	0.510	0.611
R-squared		0.2764	
No. observations		169	

(*) Reports results from estimating the following equation:

$$(E\pi^J{}_{t+10} - \frac{1}{T^J}\sum_{t=1}^{T^J} E\pi^J{}_{t+10})^2 / (\frac{1}{T^J}\sum_{t=1}^{T^J} E\pi^J{}_{t+10})^2 = \sum_J \beta^J \cdot Dummy_t^J(J) + \varepsilon^J{}_t$$

where in this case J indicates an economic region and no 'regimes' or announcement strategies considered. p-values are defined conventionally as the probability that the t-statistic is equal to zero, thus indicating a level of significance of 5% (1%) if the p-value is equal to 0.05 (0.01, respectively).

4.2 Co-movement of short-term and long-term inflation expectations

If a central bank is successful at anchoring long-term inflation expectations, it would be expected that current shocks to inflation would have no visible effect on long-term expected inflation, since over a number of years (say 6 to 10 years ahead) the effects of the shock would be expected to unwind gradually and inflation to converge close to the *steady-state* rate. A simple approach to examine if in an economy current shocks have no visible impact on long-term expectations would be to test whether revisions in long-term expectations are correlated with revisions in short-term expectations.
To perform this test, the following regression can be implemented:

$$\Delta E\pi^J{}_{t+10} = \sum_I \beta^I \cdot \Delta E\pi^J{}_{t+1} \cdot Dummy_t^J(I) + \varepsilon^J{}_t \quad (2)$$

where as for equation (1) I and J index announcement strategies and countries respectively. The term in the left-hand-side in (2) is the change in long-term inflation expectations in period t with respect to the previous observation. The term *Dummy(I)* in the right-hand-side is an indicator variable reflecting the type of implemented strategy (*I*) relating the announcement of a quantitative target in a given country (*J*) and year (*t*). The correlation between short term and long term revisions in regime *I* is measured by the coefficient β^I.

Table 6 shows the results of estimating equation (2) in a panel of countries which are classified in terms of their type of quantitative announcement of the inflation objective (or the lack thereof), as outlined in Table 3. All coefficients in Table 6 correspond to variables defined as the product of *dummy* variables indicating each of the categories or "regimes" in Table 3 in each economic region and changes in short term inflation expectations in the same region and year.

Overall, Table 6 suggests that, with very few exceptions, the differences in the degree of correlation between revisions in short-term versus long-term expectations across types of announcements of a quantitative objective (including the absence of announcement) seems very limited.

It is clear that any interpretation of this evidence should be made with a high degree of caution, in particular since the size of the sample is not large and the regression leaves out a large number of important factors (including the fact that in the period 1995-1996 the downward trend movement in inflation and inflation expectations was still taking place to some extent in many of the countries considered).

Table 6: Co-movement of short-term and long-term inflation forecasts: announcement strategies*

	1995-2002	
	Coefficient	t-value
No explicit announcement (excluding Japan and US)	0.103	0.89
Japan	0.323	1.94*
US	0.111	0.45
Quantitative definition of price stability	0.047	0.29
Target range	0.015	0.11
Point target	0.079	0.57
R-squared	0.109	
No. observations	211	

(*) Reports results of estimating equation (2): All reported coefficients correspond to the terms "β^I" in equation (2) (i.e. the coefficients associated to the interaction term with the product of observed changes in short-term inflation expectations in that country and a regime dummy associated to the central bank in that country). Short-term inflation expectations refer to 1-year ahead survey-based measures from Consensus Forecasts, as described in Annex I. Finally the symbol (*) denotes coefficient statistically significant at 5%-level.

Table 7 reports the results of performing the equivalent of regression in equation (2) for a panel of countries instead of *regimes* (i.e. types of announcement of a quantitative objective).[29] From Table 7, countries with the smallest estimated correlation between revisions in short-term and long-term forecasts are Germany, New Zealand, The Netherlands, Australia, France and Italy.

Overall, although no strong implications may be extracted from this evidence, the regression results in Tables 6 and 7 also confirm the claim that the precise form of the announced quantitative inflation objective (i.e. a target, a range or an explicit upper bound) does not appear to have a strong impact on the central bank's performance at anchoring expectations.

Table 7: Co-movement of short-term and long-term inflation forecasts: countries*

	1995-2002		
	Coefficient	t-value	p-value
Euro area (1999-2002)	0.075	0.313	0.754
Memo item: euro area countries (1995-1998)			
France	0.166	0.631	0.529
Germany	-0.038	-0.174	0.862
Italy	0.117	0.787	0.432
Netherlands	0.091	0.578	0.564
Spain	0.432	2.680	0.008
Other European countries			
Sweden	0.180	1.740	0.083
Switzerland	0.307	1.570	0.117
U.K.	0.194	0.693	0.489
Other OECD countries			
U.S.	0.216	0.975	0.331
Canada	0.116	0.637	0.525
Japan	0.427	3.540	0.001
Australia	0.123	1.610	0.110
New Zealand	0.020	0.176	0.861
Constant	-0.038	-2.280	0.024
R-squared		0.135	
No. observations		211	

(*) Reports results from estimating the following equation, where in this case J indicates an economic region and no 'regimes' or announcement strategies considered.

$$\Delta E\pi^{J}{}_{t+10} = \beta^{J} \cdot \Delta E\pi^{J}{}_{t+1} + \varepsilon^{J}{}_{t}$$

Short-term inflation expectations refer to 1-year ahead survey-based measures from Consensus Forecasts, as described in Annex I. p-values are defined conventionally as the probability that the t-statistic is equal to zero, thus indicating a level of significance of 5% (1%) if the p-value is equal to 0.05 (0.01, respectively).

[29] See note to Table 7 for details.

5. Summary and conclusions

This paper reviewed the literature concerned with the trade-offs involved in choosing different formats for framing the specification of central banks' primary objective. In addition, it compared the developments in the level and volatility of inflation expectations in the euro area and a sample of industrial countries.

As regards the rationales for different formats, the available literature suggests that a range format has the relative advantage of signalling more clearly that price developments are surrounded by large uncertainty and are only imperfectly controllable, particularly at short horizons. Moreover, a range may give more flexibility to accommodate the uncertainty in the estimate of, and possible moderate variations in the optimal inflation rate. By contrast, point targets have the relative advantage of providing a clear focal point for firmly anchoring inflation expectations.

As regards the patterns in the level of inflation expectations across countries and economic areas, it is noted that in the majority of cases where either a point or a symmetric range is used as the format of the objective, it is observed that inflation expectations have converged to that point or mid-point in the range. In the case of the euro area, measures of inflation expectations were slightly below 2% since the start of Stage III of EMU.

As regards the patterns found in the volatility of inflation expectations, although no strong conclusions may be extracted from evidence based on relatively short samples, the overall evidence shows that long-term inflation expectations are well anchored in the large majority of countries considered. This is indicated by both a low and generally decreasing volatility of expectations and a low and a generally decreasing degree of correlation between revisions in short-term and long-term inflation expectations. Moreover, the specific features of the inflation objectives do not appear to have a visible effect on the performance at anchoring inflation expectations. In particular, there does not seem to be evidence that the announcement of a quantitative objective in the form of a point or of a range for admissible inflation rates makes any appreciable difference. With regard to the two countries in our review where no numerical value for the inflation objective was announced, the United States and Japan, inflation expectations appear to be well anchored in the former but not in the latter. This may suggest that the track record by the central bank to consistently deliver a given inflation rate is a crucial factor for the anchoring of long-term inflation expectations.

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Annex I: Data and definition of reported statistics

Consensus Forecasts

All the forecasts on inflation used in this paper were drawn from Consensus Forecasts and Asia-Pacific Consensus Forecasts. Consensus Economics, founded in 1989, is the world's leading international economic survey organisation and polls more than 600 economists each month to obtain their forecasts and views. These surveys cover estimates for the principal macroeconomic variables (including growth, inflation, interest rates and exchange rates) in over 70 countries. The forecasts are compiled into a series of publications, among which there are Consensus Forecasts and Asia-Pacific Consensus Forecasts. All the series on short term inflation expectations (i.e. the annual rate of inflation expected to prevail in the following year relative to the survey) and long term inflation expectations (i.e. annual rate of inflation expected to prevail between 6 and 10 years ahead) were drawn from Consensus Forecast, with the exception of those for Australia and New Zealand from December 1994, for which we consulted Asia-Pacific Consensus Forecast. Short-term inflation expectations are available on a monthly basis, while long-term ones are biannual (issues: April and October of each year). Short-term inflation expectations are available from December 1989, while long-term ones from April 1990, at least for some countries. In particular, for the regions included in our analysis, long-term inflation forecasts are available from April 1990 for the following regions: U.S., Japan, Germany, Italy, France, U.K., Italy, and Canada. Australia's series begins in April 1991. Finally, data for Spain, Sweden, New Zealand, and The Netherlands are available from April 1995, while for Switzerland the first estimates date April 1998.

As regards the construction of the series of long-term inflation expectations for the euro area previously to the start of Stage III of EMU, this series, results from averaging inflation expectations of Germany, France, and Italy from April 1990 up to October 1994 (the weights being, respectively, 0.414847, 0.295488, and 0.2896665), and of Germany, France, Italy, Spain, and The Netherlands from April 1995 to October 2002 (weights: 0.334115, 0.237984, 0.233294, 0.127784, 0.066823), based on Consensus Forecasts information for these countries.

In addition, for each of the economic regions considered, the following statistics are reported for a number of overlapping periods (see the tables in Displays 1-14).

Average long-term inflation expectations: Reports the average release from Consensus expectations.

Average absolute deviation of inflation expectations from point target. Reports the average of the absolute value of deviations from observed Consensus long-term expectations to the point inflation target, when applicable. For comparability, it is also computed for countries which do not have strictly a point target but where a point reference might be extracted (e.g. the mid point in an announced range for inflation objective).

Standard deviation of inflation expectations: As a measure of the volatility of inflation expectations, it reports the standard deviation of Consensus long-term inflation expectations.

Coefficient of variation of inflation expectations: To take into account that volatility measured by the standard deviation may be clouded by the level of inflation, it reports the ratio of the standard deviation over the average of inflation expectations (which is always positive in the sample).

Standard deviation of realised inflation: reports the standard deviation of headline inflation. The precise underlying consumer price index is reported in footnotes to the Tables. To facilitate comparability, observations of headline inflation used to calculate this statistic correspond to the exact same month when Consensus inflation expectations are reported (thus each statistic reports the exact same number of observations for the coefficient of variation of realised and expected inflation).

Average absolute period-on-period change in expectations. As an alternative measure of variability of inflation expectations, it reports the average absolute value of the change in Consensus long-term inflation expectations relative to the previous release.

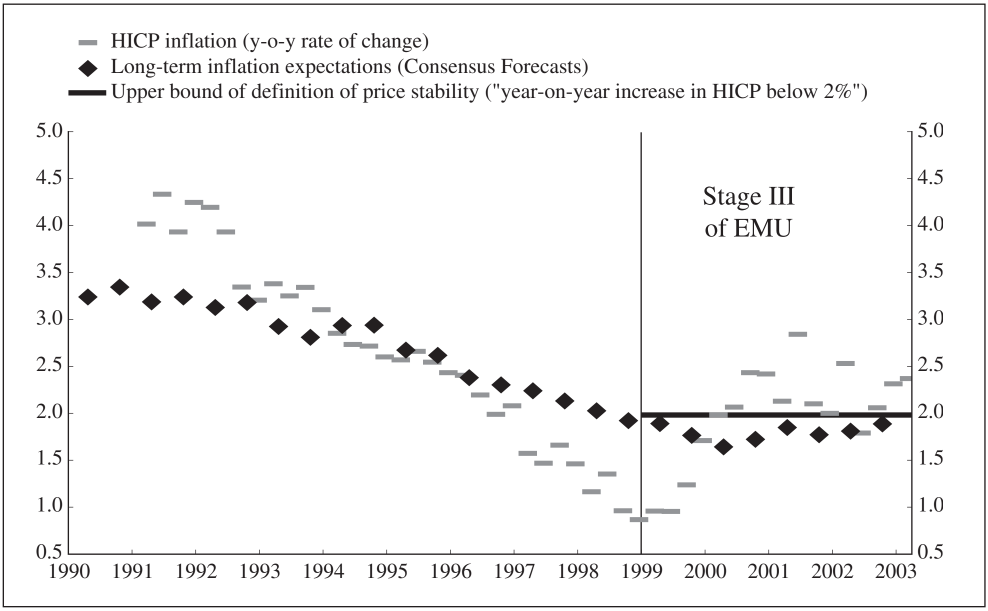
Ratio of the standard deviation of expectations over the standard deviation of realised inflation: This ratio reports the relative volatility of long-term inflation expectations and realised inflation. This is done to take into account that a fraction of the volatility in long-term expectations could reflect the volatility in headline inflation emanating from the characteristics of the price index (e.g. as regards statistical properties – like the treatment given to durable goods or mortgage payments – or related to structural features of the economy -related to the size or degree of openness of the economic region).

Annex II: Developments in long-term inflation expectations in a sample of industrial countries[30]

Display 1: Euro area

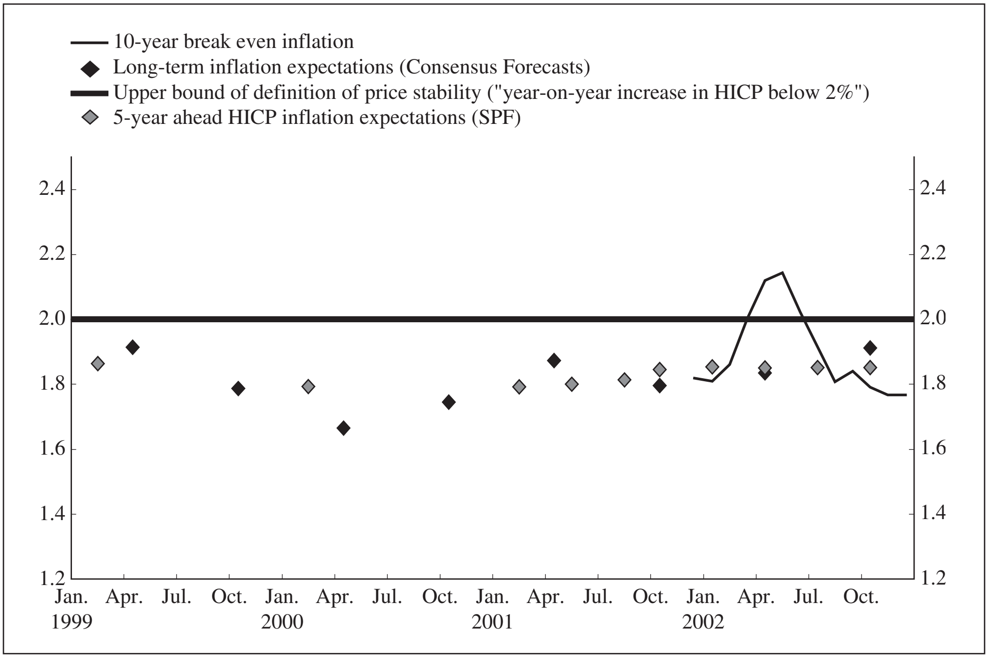
Euro area	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	3.13	2.32	1.82
Standard deviation of inflation expectations	0.18	0.27	0.09
Coefficient of variation of inflation expectations	0.06	0.12	0.05
Standard deviation of realised inflation	-	0.60	0.63
Average absolute period-on-period change in expectations	0.11	0.13	0.09
Stand. dev. of expectation over stand.dev. of realised inflation	-	44.83	13.48

Euro Area: Expected and realised inflation
(as at January of each year)



[30] For all charts and tables in the displays in this Annex, 'Inflation expectations' refers always to long-term inflation expectations from Consensus Forecasts. See Annex I for details on the construction of the long-term inflation expectations series for the case of the euro area and definition of the reported statistics. For the case of the euro area, inflation expectations 5 years ahead are reported from the ECB Survey of Professional Forecasters. 'Realised inflation' refers to Eurostat's HICP inflation for the euro area, to RPI inflation in the case of the U.K. and to CPI inflation in all other cases, as reflected in each of the displays under the chart's legend.

Euro area: Inflation expectations

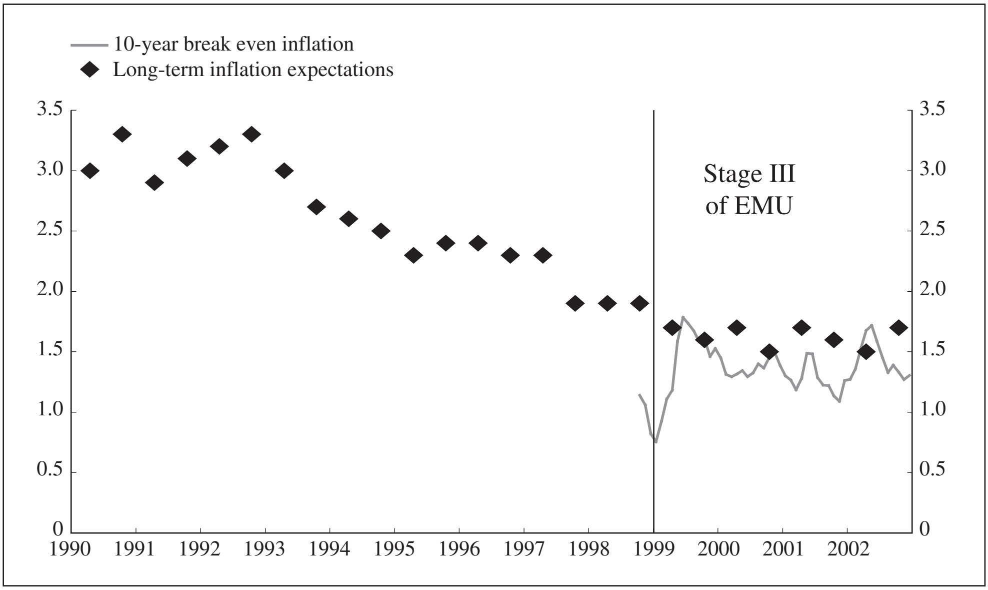


(*) Expected annual inflation 5-years-ahead are from ECB's Survey of Professional Forecasters, (see e.g. ECB Monthly Bulletin May 2003).

Display 2: France

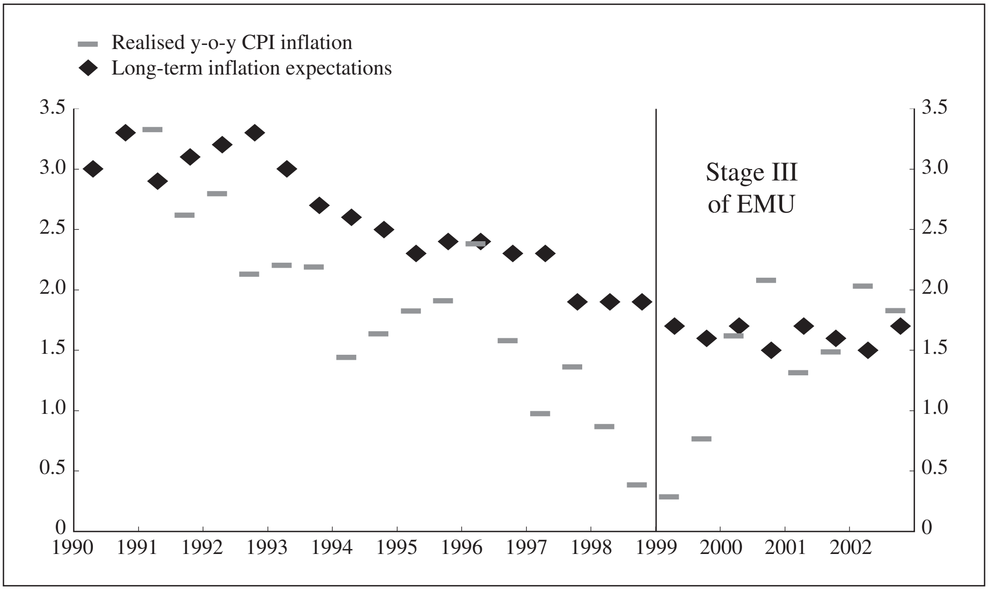
France	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	2.96	2.18	1.63
Average absolute deviation of expectations from point target	-	-	-
Standard deviation of inflation expectations	0.28	0.23	0.09
Coefficient of variation of inflation expectations	0.10	0.11	0.05
Standard deviation of realised inflation	0.61	0.65	0.62
Average absolute period-on-period change in expectations	0.21	0.10	0.15
Stand. dev. of expectation over stand.dev. of realised inflation	46.29	35.82	14.18

France: CPI Inflation expectations
(as at January of each year)



France: CPI Inflation expectations

(as at January of each year)

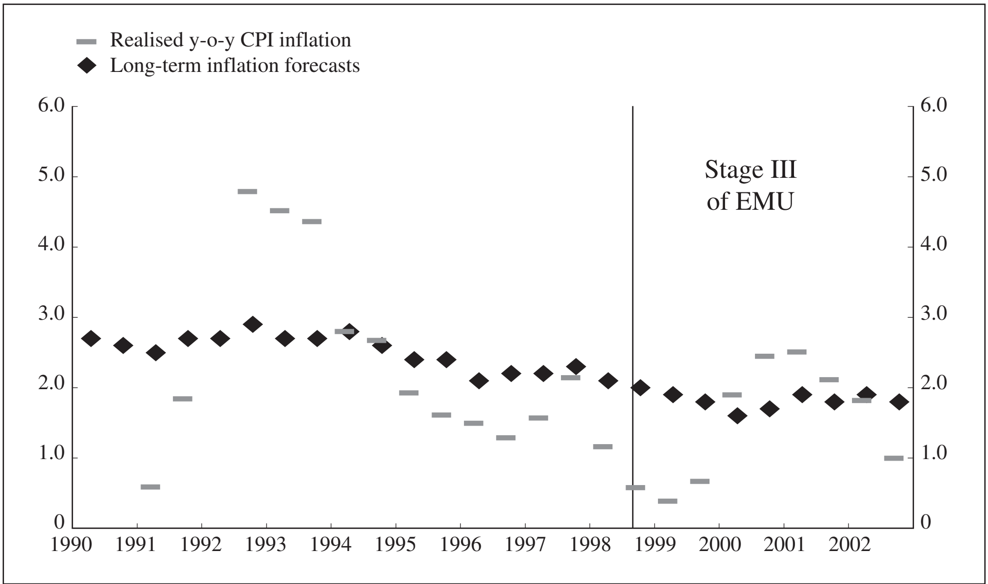


Display 3: Germany

Germany	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	2.69	2.21	1.80
Average absolute deviation of expectations from point target	-	-	-
Standard deviation of inflation expectations	0.11	0.15	0.11
Coefficient of variation of inflation expectations	0.04	0.07	0.06
Standard deviation of realised inflation	1.78	0.48	0.81
Average absolute period-on-period change in expectations	0.13	0.13	0.13
Stand. dev. of expectation over stand.dev. of realised inflation	6.19	30.35	13.12

Germany: Expected and realised inflation

(as at January of each year)

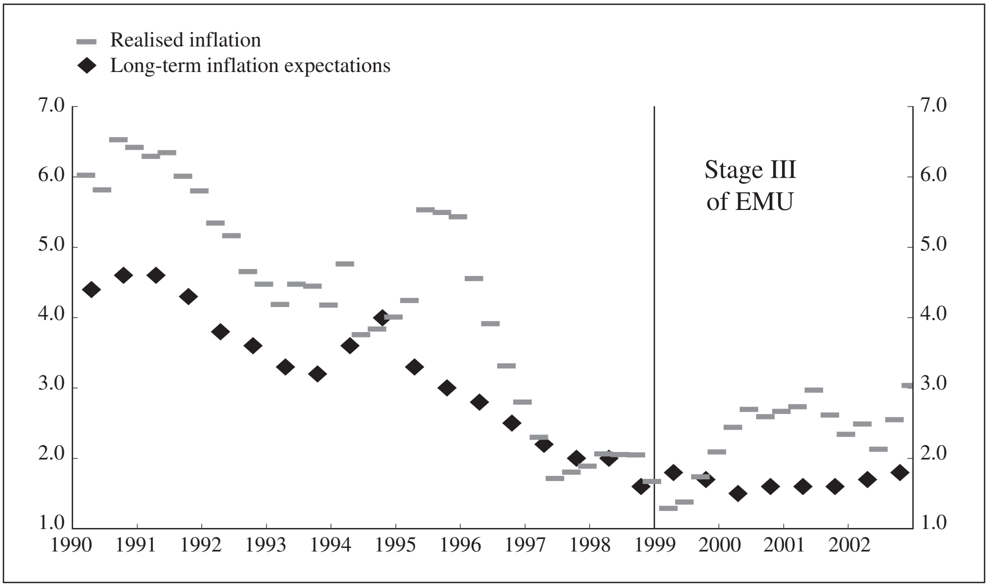


Display 4: Italy

Italy	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	3.94	2.43	1.66
Average absolute deviation of expectations from point target	-	-	-
Standard deviation of inflation expectations	0.52	0.58	0.11
Coefficient of variation of inflation expectations	0.13	0.24	0.06
Standard deviation of realised inflation	0.87	1.39	0.51
Average absolute period-on-period change in expectations	0.27	0.30	0.10
Stand. dev. of expectation over stand.dev. of realised inflation	59.80	41.45	20.77

Italy: Expected and realised inflation

(as at January of each year)

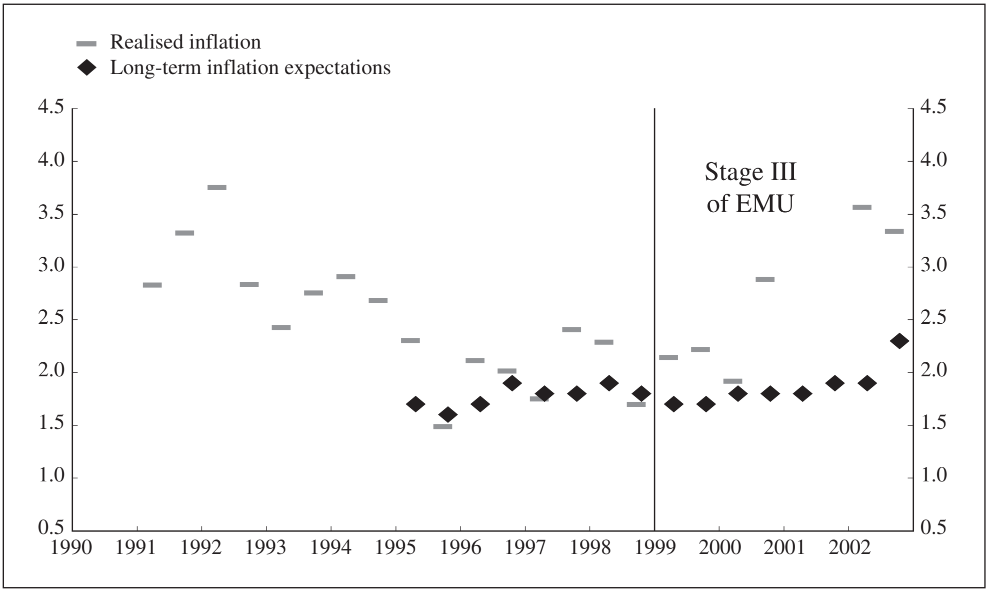


Display 5: Netherlands

The Netherlands	1995-1998	1999-2002
Average long-term inflation expectations	1.78	1.86
Average absolute deviation of expectations from point target	-	-
Standard deviation of inflation expectations	0.10	0.19
Coefficient of variation of inflation expectations	0.06	0.10
Standard deviation of realised inflation	0.33	1.04
Average absolute period-on-period change in expectations	0.30	0.09
Stand. dev. of expectation over stand.dev. of realised inflation	31.26	18.42

Netherlands: Expected and realised inflation

(as at January of each year)

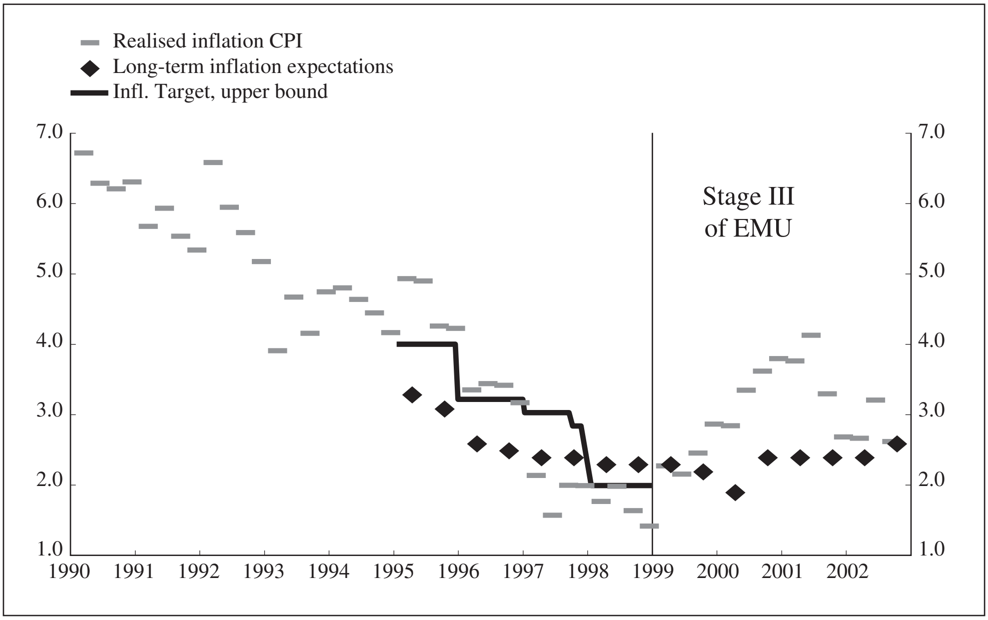


Display 6: Spain

Spain	1995-1998	1999-2002
Average long-term inflation expectations	2.61	2.33
Average absolute deviation of expectations from point target	-	-
Standard deviation of inflation expectations	0.38	0.21
Coefficient of variation of inflation expectations	0.15	0.09
Standard deviation of realised inflation	1.25	0.56
Average absolute period-on-period change in expectations	0.14	0.14
Stand. dev. of expectation over stand.dev. of realised inflation	30.43	36.80

Spain: Expected and realised inflation

(as at January of each year)

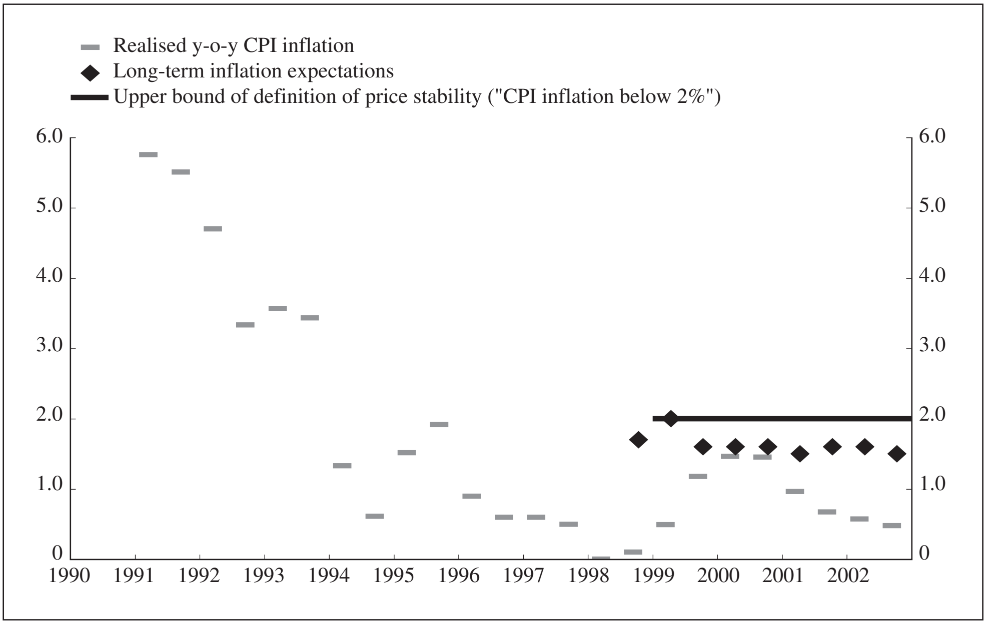


Display 7: Switzerland

Switzerland	1999-2002
Average long-term inflation expectations	1.62
Average absolute deviation of expectations from point target	-
Standard deviation of inflation expectations	0.16
Coefficient of variation of inflation expectations	0.10
Standard deviation of realised inflation	0.41
Average absolute period-on-period change in expectations	0.13
Stand. dev. of expectation over stand.dev. of realised inflation	38.13

Switzerland: Expected and realised inflation

(as at January of each year)

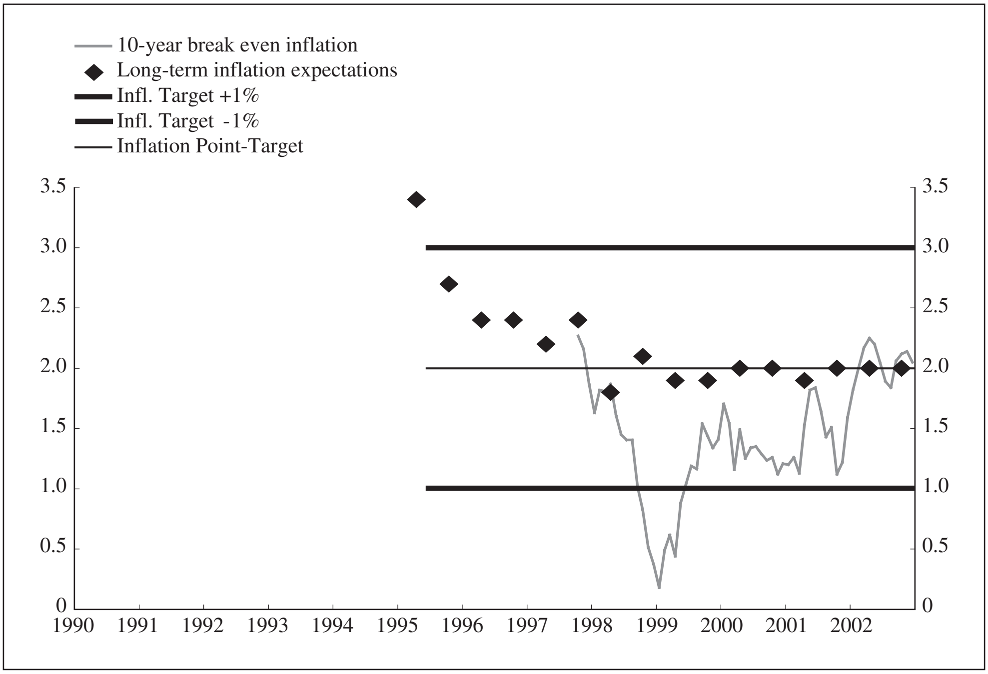


Display 8: Sweden

Sweden	1995-1998	1999-2002
Average long-term inflation expectations	2.43	1.96
Average absolute deviation of expectations from point target	0.18	0.04
Standard deviation of inflation expectations	0.47	0.05
Coefficient of variation of inflation expectations	0.20	0.03
Standard deviation of realised inflation	1.36	0.95
Average absolute period-on-period change in expectations	0.33	0.06
Stand. dev. of expectation over stand.dev. of realised inflation	34.97	5.44

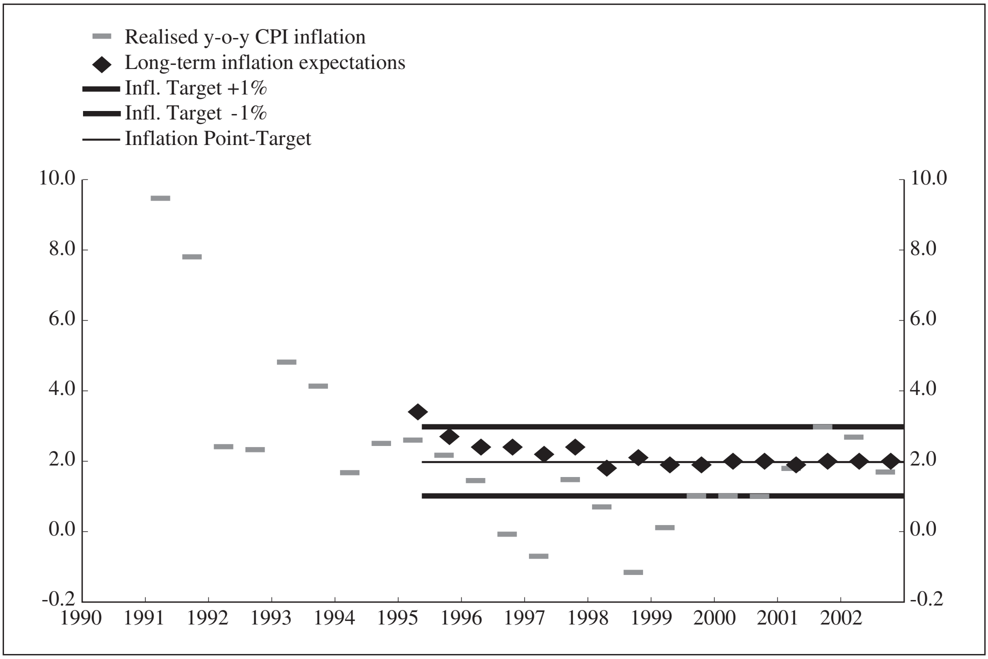
Sweden: CPI inflation expectations

(as at January of each year)



Sweden: Expected and realised inflation

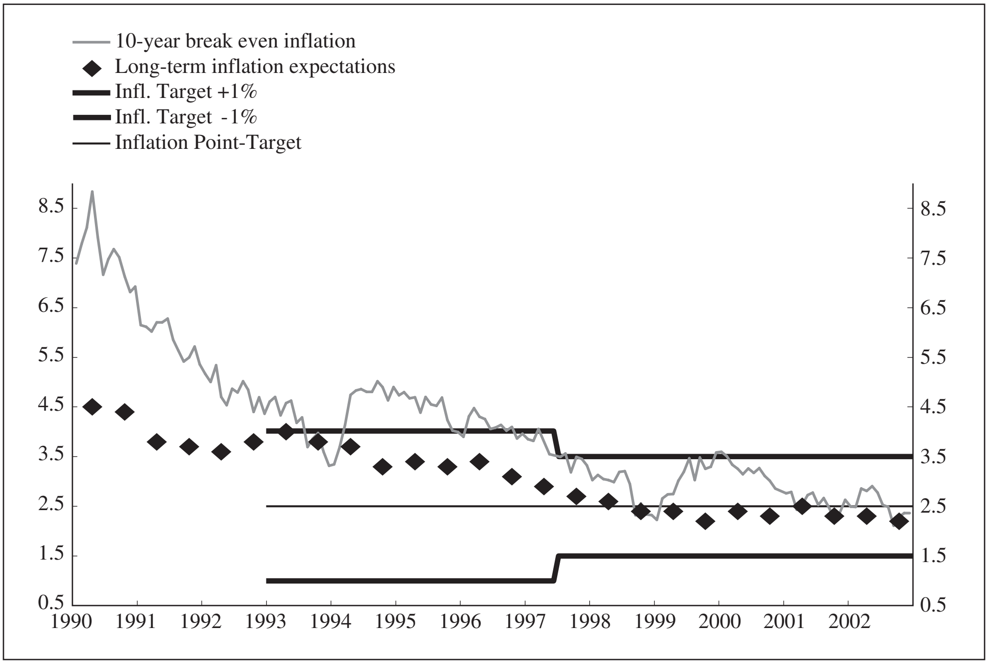
(as at January of each year)



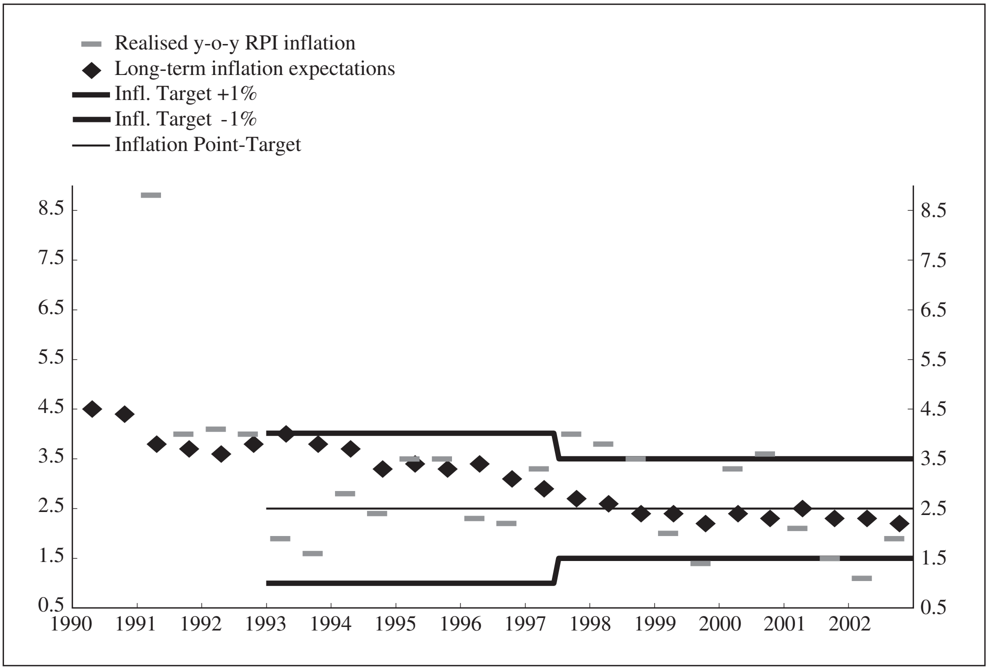
Display 9: United Kingdom

United Kingdom	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	3.86	2.98	2.33
Average absolute deviation of expectations from point target	-	0.50	0.18
Standard deviation of inflation expectations	0.36	0.38	0.10
Coefficient of variation of inflation expectations	0.09	0.13	0.04
Standard deviation of realised inflation	2.28	0.66	0.89
Average absolute period-on-period change in expectations	0.24	0.16	0.13
Stand. dev. of expectation over stand.dev. of realised inflation	15.74	58.17	11.58

United Kingdom: RPI inflation expectations
(as at January of each year)



United Kingdom: Expected and realised RPI inflation
(as at January of each year)

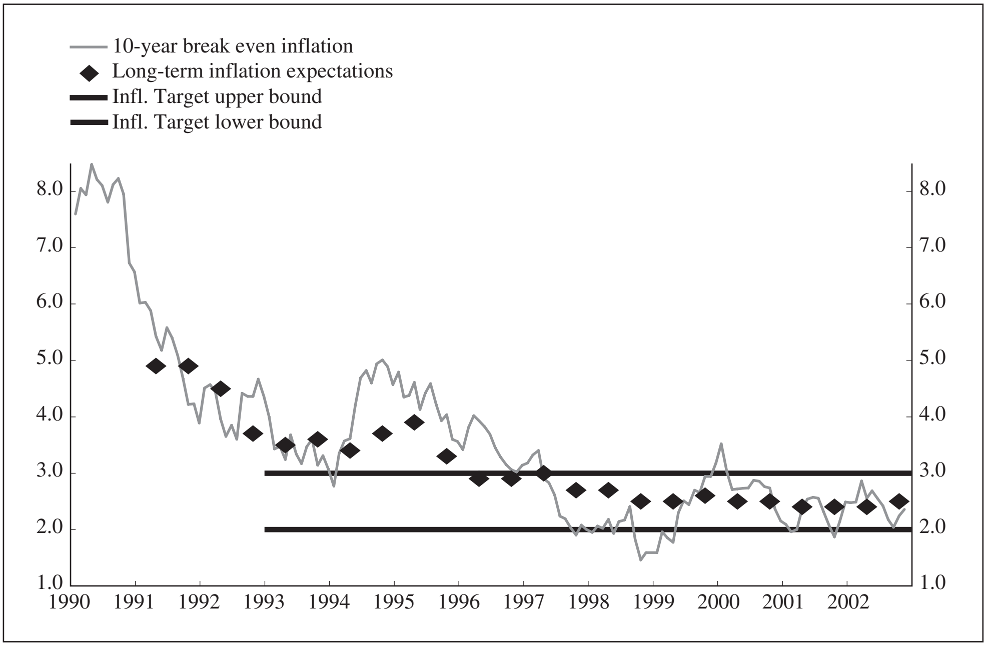


Display 10: Australia

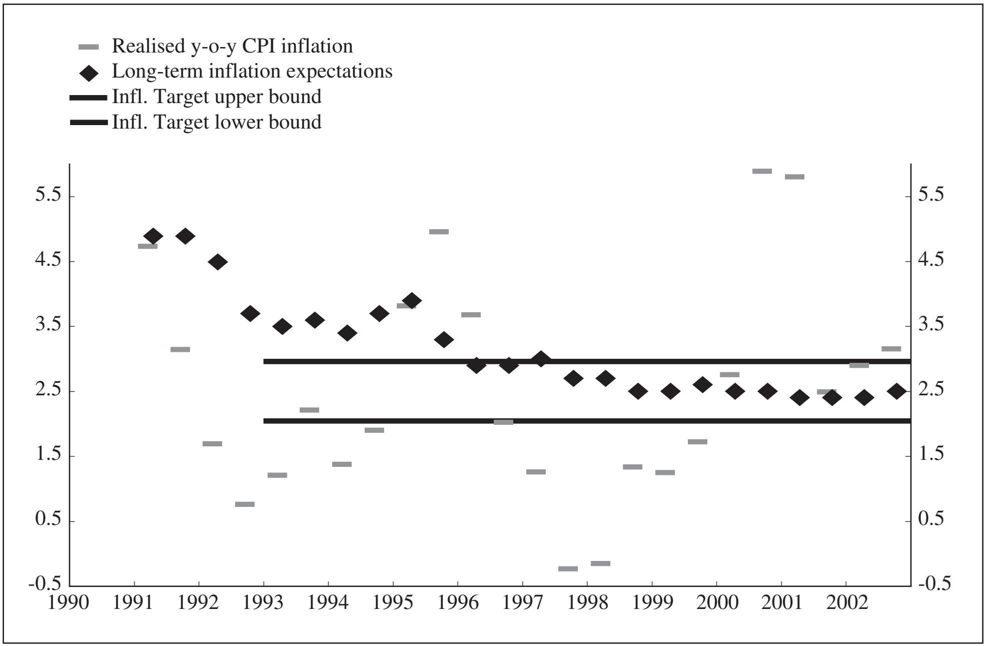
Australia	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	4.03	2.99	2.48
Average absolute deviation of expectations from point target	-	0.27	0.05
Standard deviation of inflation expectations	0.63	0.44	0.07
Coefficient of variation of inflation expectations	0.16	0.15	0.03
Standard deviation of realised inflation	1.28	1.91	1.73
Average absolute period-on-period change in expectations	0.33	0.23	0.05
Stand. dev. of expectation over stand.dev. of realised inflation	49.55	22.92	4.09

Australia: CPI inflation expectations

(as at January of each year)



Australia: Expected and realised inflation
(as at January of each year)

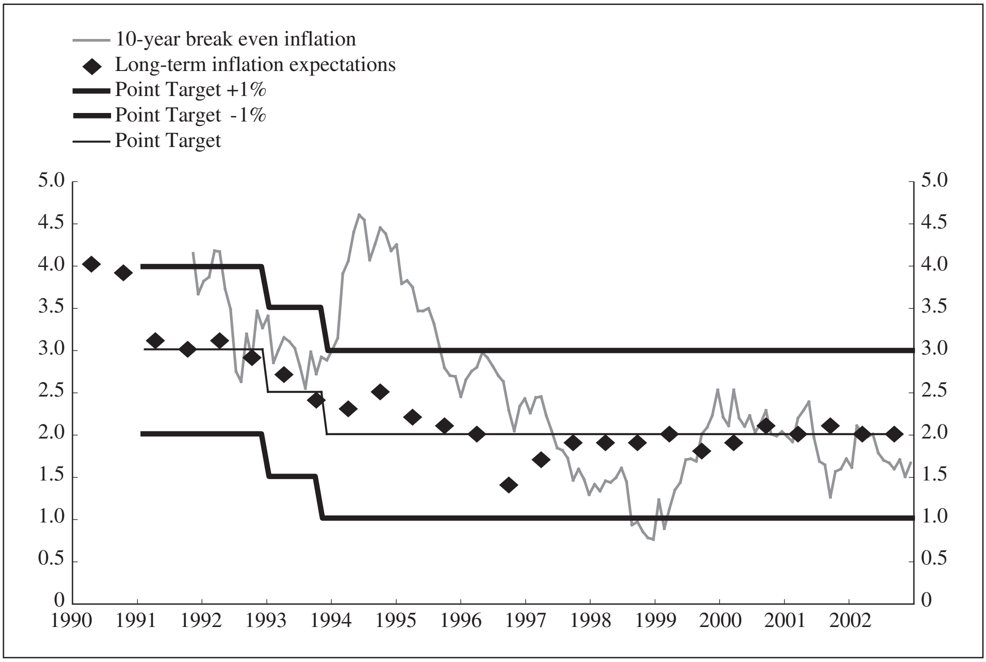


Display 11: Canada

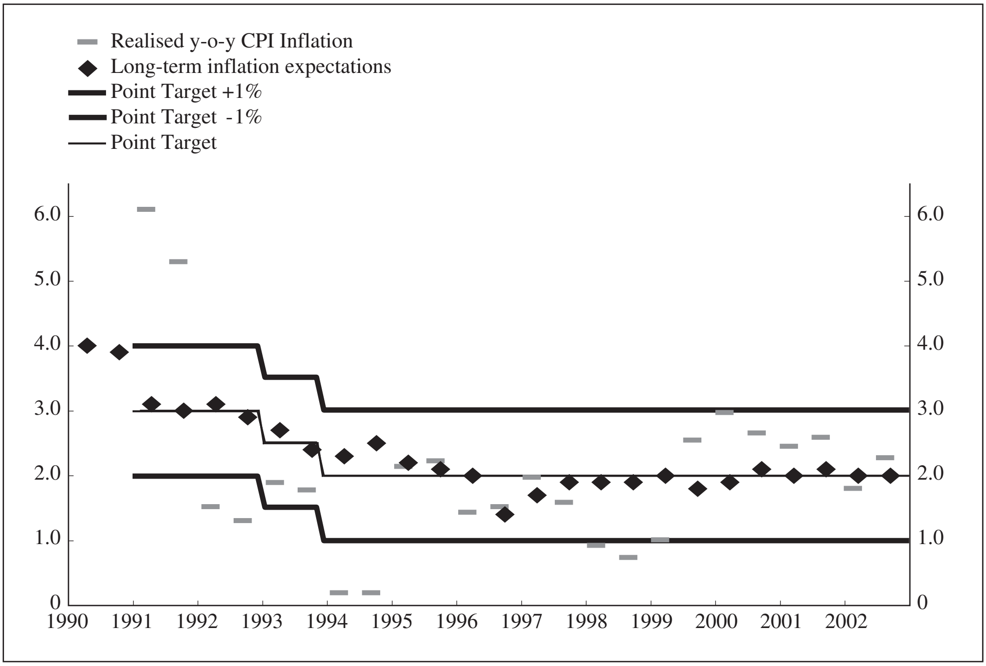
Canada	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	2.99	1.89	1,99
Average absolute deviation of expectations from point target	0.18	0.19	0.06
Standard deviation of inflation expectations	0.58	0.25	0.10
Coefficient of variation of inflation expectations	0.19	0.13	0.05
Standard deviation of realised inflation	2.21	0.54	0.62
Average absolute period-on-period change in expectations	0.25	0.20	0.11
Stand. dev. of expectation over stand.dev. of realised inflation	26.21	45.78	16.09

Canada: CPI inflation expectations

(as at January of each year)



Canada: Expected and realised inflation
(as at January of each year)

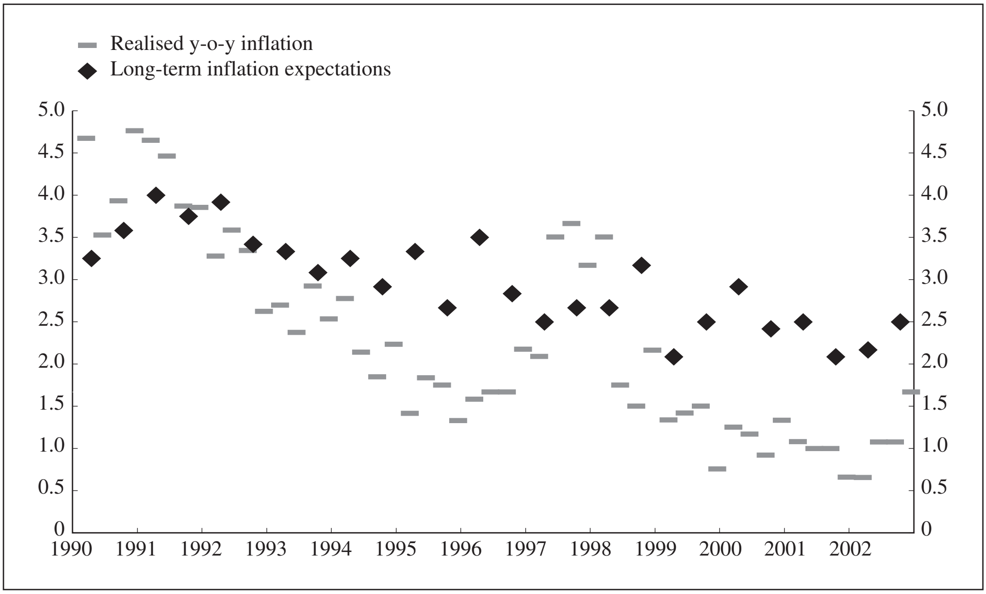


Display 12: Japan

Japan	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	2.14	1.50	0.88
Average absolute deviation of expectations from point target	-	-	-
Standard deviation of inflation expectations	0.43	0.44	0.34
Coefficient of variation of inflation expectations	0.20	0.29	0.39
Standard deviation of realised inflation	1.09	0.97	0.35
Average absolute period-on-period change in expectations	0.33	0.54	0.50
Stand. dev. of expectation over stand.dev. of realised inflation	39.27	45.34	96.03

Japan: Expected and realised inflation

(as at January of each year)

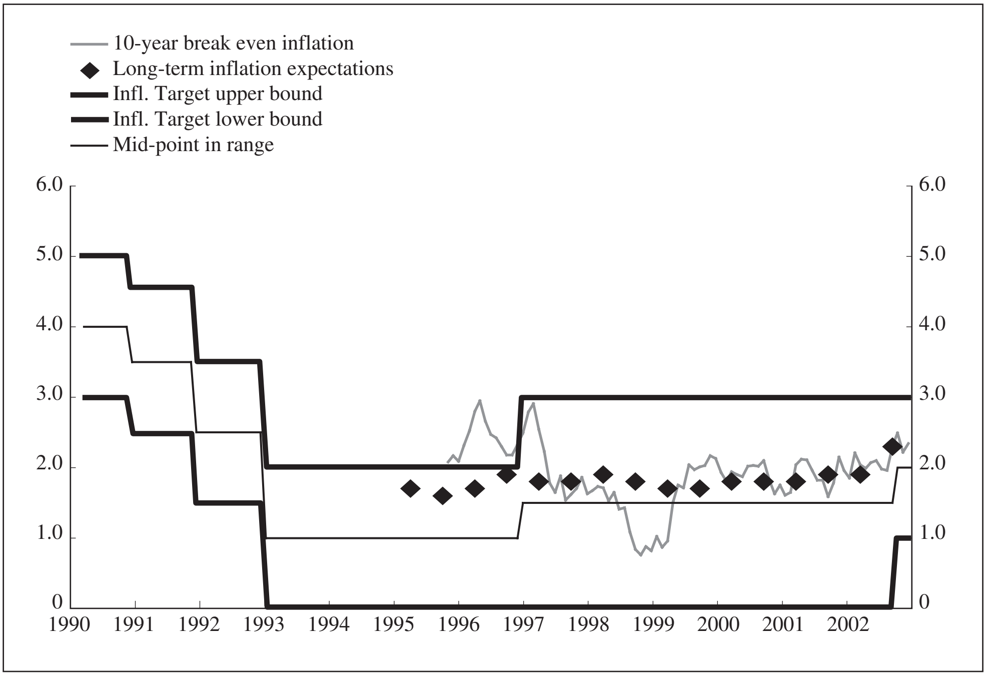


Display 13: New Zealand

New Zealand	1995-1998	1999-2002
Average long-term inflation expectations	1.78	1.86
Average absolute deviation of expectations from mid-point point range	0.50	0.36
Standard deviation of inflation expectations	0.10	0.19
Coefficient of variation of inflation expectations	0.06	0.10
Standard deviation of realised inflation	1.02	1.38
Average absolute period-on-period change in expectations	0.10	0.09
Stand. dev. of expectation over stand.dev. of realised inflation	10.16	13.91

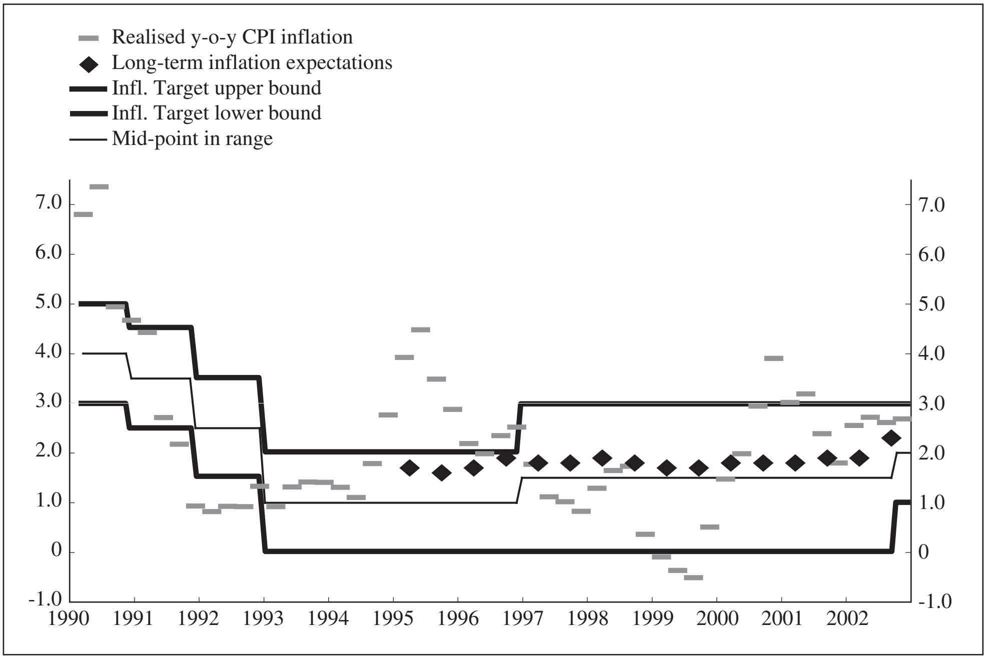
New Zealand: CPI inflation expectations

(as at January of each year)



New Zealand: Expected and realised inflation

(as at January of each year)

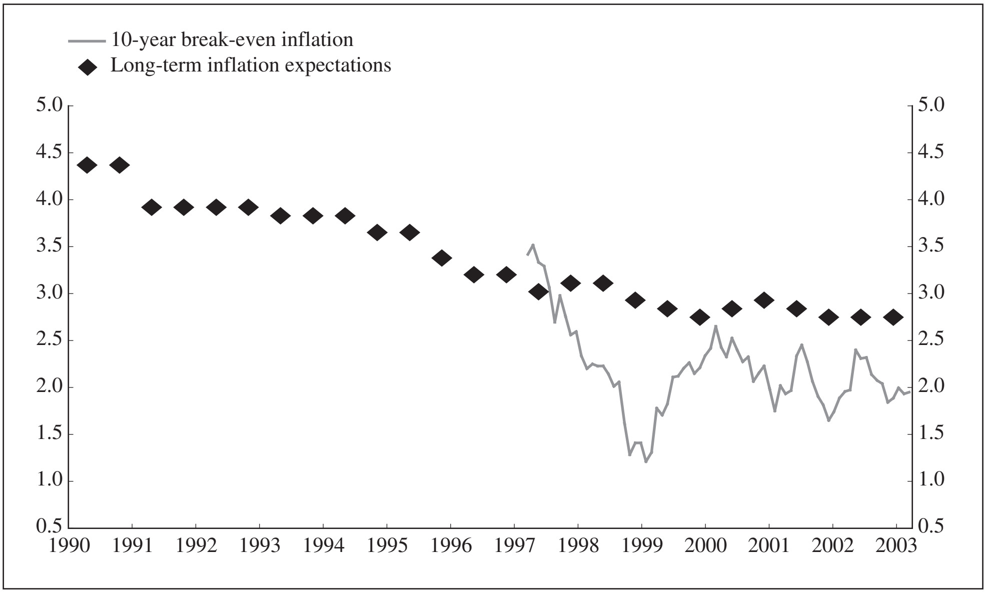


Display 14: U.S.

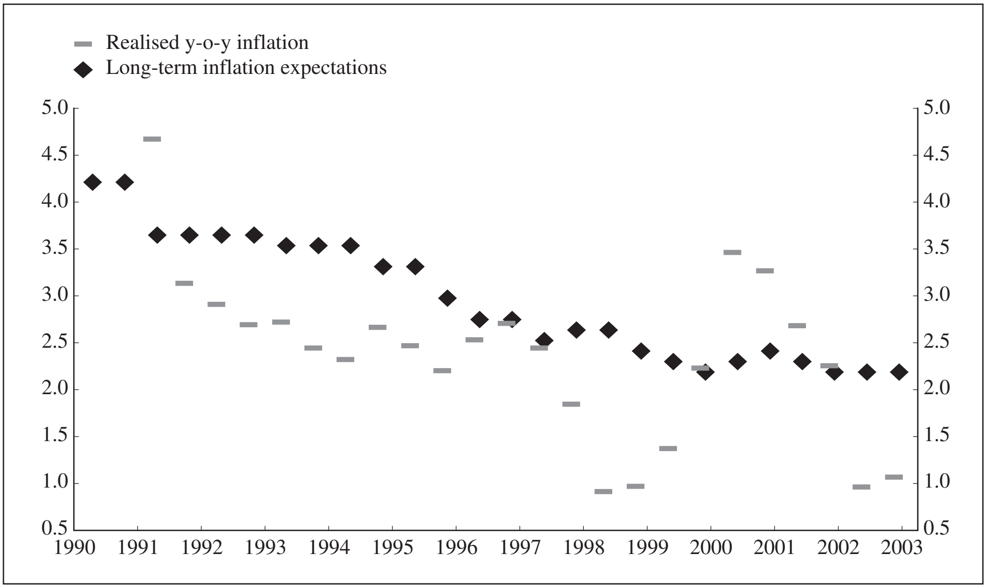
U.S.	1990-1994	1995-1998	1999-2002
Average long-term inflation expectations	3.84	3.00	2.56
Average absolute deviation of expectations from point target	-	-	-
Standard deviation of inflation expectations	0.26	0.25	0.07
Coefficient of variation of inflation expectations	0.07	0.08	0.03
Standard deviation of realised inflation	0.66	0.63	0.85
Average absolute period-on-period change in expectations	0.04	0.13	0.08
Stand. dev. of expectation over stand.dev. of realised inflation	39.26	39.87	8.72

U.S.: CPI inflation expectations

(as at January of each year)



U.S.: Expected and realised inflation
(as at January of each year)



4

Relevant economic issues concerning the optimal rate of inflation*

Gonzalo Camba-Mendez, Juan Ángel García and Diego Rodríguez Palenzuela

* Comments and discussions with V. Gaspar, K. Masuch, S. Nicoletti-Altimari and H.-J. Klöckers are gratefully acknowledged. Comments by G. Kenny, F. Mongelli, R. Motto, P. Moutot, F. Smets, J. Turunen, members of the Eurosystem's Monetary Policy Committee and an anonymous referee are gratefully acknowledged.

1. Introduction

A widespread support for price stability as the overriding objective of monetary policy emerged after the period of high inflation experienced in the 1970s in most industrialised countries. Gradually all central banks have committed to maintain the rate of inflation within a comfort zone, with a view to keep inflation stable at low levels and also to exclude deflation. Indeed, monetary policy frameworks nowadays usually feature an explicit definition of price stability or an inflation target (both in terms of point targets and ranges). These have broadly converged in the last decade to the approximate range of 0% to $3\frac{1}{2}$%.

The implication of this explicit commitment to maintain price stability should not be overlooked. In modern economies, which are characterised by highly decentralised markets, the characteristics of the inflation process (e.g. as regards its mean, volatility and its relationship with other variables in the economy) are relevant for virtually all decisions taken by economic agents. The importance assigned by economists in the last decades to this issue is therefore not surprising, and central banks are certainly not indifferent to developments in this front.

In this context, this paper provides a survey of the literature on some of the relevant economic issues relevant for defining the price stability objective of a central bank. Our analysis focuses on: a) the existing evidence on the costs of inflation and deflation, b) the potential mitigating effects of positive inflation rates in the presence of downward nominal rigidities, as well as in the case where the latter combines with persistent regional inflation differentials within a large currency union. Although our main interest is on the economic welfare costs of inflation and deflation in the euro area, we also review the available empirical evidence for other economies, notably the US, and indeed most of the conclusions drawn would seem to apply more generally to any large and developed currency area.

The main conclusions in the paper may be summarised as follows. As regards the costs of inflation and deflation, the undesirability of inflation is underpinned by the high degree of aversion to departures from price stability systematically expressed by the public in surveys[1] and also by the results of research on the effects of inflation and deflation. Economic research has uncovered a number of channels through which inflation and deflation significantly reduce welfare. Specifically, some of these channels, like distortions stemming from the interaction of inflation and the tax system, have been systematically found to be a source of substantial welfare losses. Other channels, like agents' efforts to economise on real balances and the over-development of the financial system resulting from inflation, have robustly been found to entail significant (albeit more limited) losses in welfare. Experts have also pointed to potential 'benefits' of small positive rates of inflation (namely, preventing that nominal downward rigidities and the zero lower bound on nominal interest rates become binding restrictions and avoiding effective deflation if there is a positive and significant upward bias in the overall consumer price index).[2]

Economists have attempted to gauge the magnitude of each of these costs and

[1] See Shiller (1997) for a review.

[2] The important issues of the lower bound on nominal interest rates and the potential bias in measures of inflation are not treated in this paper.

'benefits' of inflation both in terms of welfare and economic performance. However, the assessment of the overall effect of inflation is hindered by a number of factors. First, the practical importance of these effects from inflation has been estimated until recently only on a *partial* basis: even though they are usually analysed in general equilibrium frameworks, the driving factors have tended to be analysed only one by one, often disregarding the interactions of the different factors. Second, some of the effects that were deemed potentially relevant have proven to be particularly elusive. This is particularly the case for nominal downward rigidities as a rationale for maintaining positive rates of inflation.

The recent contributions to the discussion on the optimal rate of inflation may be characterised by the higher generality and completeness of the analytical frameworks used to set up the question. These studies extend the dynamic general equilibrium frameworks used in earlier studies by considering simultaneously a number of relevant channels from inflation to welfare. A notable property of these 'all-encompassing' structural approaches is that they often allow for a fully explicit derivation of the optimal rate of inflation.[3] Interestingly, the available results in this vein thus far have tended to make an even stronger case for the objective of price stability.

In sum, taking the results as a whole, the evidence on the estimated costs and potential 'benefits' (including measurement bias and zero lower bound for nominal interest rates considerations) of alternative long-term inflation rates provides strong support for the objective of low inflation.

As regards the specific costs of deflation, in contrast with the analysis of the costs of inflation, the discussion has in general not been centred on the calculation of the economic welfare costs associated to each rate of deflation. Rather, the primary concern in this respect has been the more general issue of the overall controllability of price developments in the vicinity of zero inflation, in particular in connection with the risks of emergence of self-fulfilling deflationary expectations and eventually a liquidity-trap. Welfare costs related to these possibilities are difficult to gauge but are generally seen as being of a higher order relative to the costs of moderate inflation.[4]

From a specific euro area perspective, two main considerations may be highlighted. First, at least *a priori,* it may not be ruled out that the combination of sustained inflation differentials across euro area countries and nominal downward rigidities (at least in the lower inflation euro area countries) could hamper the performance of lower inflation countries (which normally operate with inflation rates lower than the Eurosystem's average). However, such rigidities could tend to disappear as the low inflation regime becomes fully ingrained in agents' expectations and wage bargaining practices. Second, there is a notable imbalance in the number of available studies in favour of the US, compared to the euro area. However, the extent to which results based on US data could be extrapolated as relevant knowledge for the euro area is not always clear.

The rest of the paper is organised as follows. Section 2 reviews the existing evidence

[3] Looking forward, these developments suggest that, as economic knowledge progresses further and the 'all-encompassing' approach delivers better estimates of the optimal inflation rate, it is likely that the relative weight of the scientific content will tend to increase at the expense of the judgmental content to buttress the assessment of the optimal rates of inflation.

[4] This, together with other considerations, advises that monetary policy should aim at maintaining inflation above a certain safety margin, rather than a literal interpretation of price stability (i.e. zero inflation).

on the welfare costs of the inflation process, with a view to characterising all aspects in which inflation may impinge on the economy (e.g. including both the effects of anticipated and non-anticipated inflation). The focus here is primarily targeted towards the more recent contributions to the literature. Section 3 considers the contributions that highlight the potential benefits from positive rates of inflation. In particular, Section 3.1 addresses the issue of nominal downward rigidities in prices and wages. Section 3.2 reviews and discusses the potential implications from the simultaneous presence of downward nominal rigidities and heterogeneity in the inflation rates for the optimal rate inflation in a large currency area. Finally, concluding remarks are presented in Section 4.

2. Costs of inflation

This section reviews the literature on the main channels through which inflation negatively affects economic performance, first in terms of long-term growth and second in terms of economic welfare. However, given the vastness of the underlying literature, it is necessary to restrict somewhat the scope of our survey. In this respect we aim at reviewing the literature which sheds light on the welfare costs associated with the process of inflation associated to a given monetary policy regime. That is, our interest relates primarily to the welfare implications of a given inflationary process, rather than the properties of the inflationary process that is likely to emerge under an optimal scheme for monetary policy, however defined.

A second feature of our survey is that we put a relatively small emphasis on distinguishing the welfare effects of the so-called anticipated versus unanticipated components of inflation. This is for a number of reasons. First, it is our view that any monetary policy strategy ultimately impinges on virtually all aspects of the price formation process (i.e. in more technical terms, on both the unconditional and conditional mean and volatility of the inflation process). The existing knowledge on the welfare costs of unanticipated inflation is thus also of interest for central banks. Second, it cannot be ruled out that the structural features of the economy imply a systematic empirical relation between the mean of inflation over long horizons and the standard deviation of the medium and short-term trends around that mean. This would imply that in setting an inflation objective, a direct impact on inflation volatility could need to be weighted, which may require an assessment of the costs associated to the less predictable component of the inflation process.[5]

Finally, in the review following, the recent general equilibrium contributions that gauge the overall effects of inflation when they operate simultaneously through various channels are given particular attention.

[5] More generally, it could be argued that the distinction between the costs of anticipated vs. non-anticipated inflation is all but clear-cut. For instance it is sometimes argued that it is unanticipated inflation which puts a veil on relative price signals, leading to the misallocation of resources. However, even if inflation rates can be accurately anticipated over the long run in a context where the central bank credibly aims at a given rate of inflation, the price level may be difficult to predict over long horizons, making it more difficult to value certain assets.

2.1 Effect of inflation on long-term growth

The relationship between inflation and long-term growth has been extensively studied. There is growing consensus in that high rates of average inflation (in the order of 15% and above[6]) have a considerable negative impact on long-term GDP growth. The link between growth and inflation seems less clear cut for lower average rates of inflation, at least on the basis of reduced-form estimates (see for instance Bruno and Easterly, 1998, and Issing, 2001, for a summary of empirical findings in this regard). However, some recent studies (e.g. Andrés and Hernando, 1999)[7] continue to find a negative impact of inflation on long-term growth.

The empirical ambiguity in the reduced form relation between inflation and long-term growth might reflect the fact that in the reduced form approach a number of complex structural effects tend to counter each other. First, the relationship between growth and inflation is likely to be different at business cycle frequencies (which tend to exhibit a positive relation) and at lower frequencies (which are more likely to yield a negative relation). Second, the effect of high average inflation on growth is likely to depend on the characteristics of the country, in particular on the degree of development of the financial system.

Taken together, these structural effects suggest that evidence from reduced form regressions relating growth and inflation is likely to be of limited use for understanding the working of the effects from sustained inflation on long term economic performance. In contrast to the reduced-form approach, Dotsey and Sarte (2000) tackle this question within a structural model calibrated for the U.S. economy. Building on a neo-classical endogenous growth model with money, their calibrated model is able to reproduce the structural effects mentioned above. Interestingly, Dotsey and Sarte (2000) find that higher average inflation has a negative effect on steady-state growth (due to higher transaction costs from inflation in the money market). By contrast, they argue that higher inflation volatility has a more ambiguous effect on growth. This is because higher inflation volatility has a positive impact on precautionary savings, which fosters growth in their setting. However, higher inflation volatility entails an unambiguous decline in welfare, even if the effect on growth could be positive, since the latter works through a precautionary savings effect (i.e. consumers are "forced" to save – or work – more to procure themselves insurance against more volatile shocks). Overall, they find that the negative effect on growth of higher average inflation clearly overwhelms the positive effect from higher inflation volatility, thereby supporting the view that higher inflation has a predominantly negative impact on growth performance.

[6] See Barro (1995) for a detailed discussion.

[7] They find that reducing the rate of inflation from 20% to 19% could imply a permanent increase in output by 0.5%. Furthermore, their analysis suggests that the positive effect on permanent output of decreasing inflation could be significantly higher at lower rates of inflation.

2.2 Effect of inflation on welfare

The economic literature highlights a number of channels through which inflation becomes costly. They may be grouped under the following categories:[8]

- Noise in the information content of relative prices.
- Nominal rigidities.
- Distortions in taxation.
- Direct transaction costs from inflation.
- Income redistribution.

2.2.1 'Noise' in the information content of relative prices

Both inflation and deflation are costly because of their distortionary impact on relative prices across the economy and thus on the efficiency of market allocations. Lucas (1973) suggested that relative prices might be affected by inflation if suppliers of a given good fail to identify the cause of a given increase in the nominal demand for their good. This increase may be caused either by an aggregate shock to nominal money supply, or a sector specific shock, i.e. a relative shift in real demand towards the agent's good. Suppliers would not like to adjust the quantity supplied of their good in the first case, but would like to respond to the second type of shock. Whenever agents do not correctly interpret the signals provided by the market system and make economic decisions based on these incorrect inferences, misallocation of resources results.

Horwitz (2002) suggested that the costs of inflation listed above, which represent those captured by 'mainstream' macroeconomic analyses, may be much greater if one is to adopt the theoretical framework of 'Austrian' economists. From this more radical point of view, prices act as surrogates for the frequently contradictory information generated by a disequilibrium market process. A key function played by relative prices is that of facilitating market discoveries by entrepreneurs. Distortions in relative prices due to inflation thus undermine those tasks that are central to entrepreneurial activity and discovery in a market process. This means that such effects do not only take the form of temporary economic inefficiencies but they impinge more fundamentally on the functioning of key institutions in the economic process, with persistent effects.

2.2.2 Nominal rigidities

Economists have argued that the interaction of nominal rigidities[9] in prices and/or wages with both inflation and deflation entail welfare costs. In this regard, two issues should be considered. First, what is the empirical evidence of nominal price and wage rigidities? Second, what are the welfare implications of higher inflation in the presence

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[8] In this respect, a distinction is sometimes introduced between costs of anticipated and unanticipated inflation. Although this distinction may be useful for some purposes, an attempt to classify here the costs of inflation in these terms would detract from the clarity of the exposition without adding necessarily many insights. In particular, if there were a link between the level and volatility of inflation, the distinction between costs of anticipated versus unanticipated inflation becomes less useful. Moreover, if contract indexation is difficult or costly, such distinction becomes void.

[9] This should be distinguished from the issue of nominal downward rigidities, which have been pointed to as a potential rationale for targeting positive inflation rates.

of nominal rigidities? Regarding the first question, the more recent evidence suggests that, at least for the US, nominal price rigidities are less relevant than previously thought. Bils and Klenow (2002) find for a large sample of consumer goods in the US that price changes for individual goods occur with an average frequency of 4.3 months.[10]

More indirect evidence on nominal rigidities is obtained from model based estimates. Nominal rigidities have been introduced in models in two main different forms: Menu costs (i.e. a small fixed costs incurred every time that a price or wage is changed) and "nominal lock-in" (i.e. sellers inability to modify listed prices in certain periods).[11] Examples of nominal lock-in are the so-called Taylor contracts (i.e. the inability to modify wages for a fixed, determined period, as modelled in Taylor (1979)), and the so-called Calvo-pricing (i.e. the inability to modify prices for a period of random duration, as modelled in Calvo (1983)).

i) Menu costs

A cost of inflation is brought about by the so called 'menu costs' of changing prices.[12] Levy et al. (1997) and Dutta et al. (1999) extended the definition of 'menu costs' to those which result from: a) the (labour) costs of changing shelve prices, b) the costs of printing the new price labels, c) mistakes made during the process of changing prices, and d) costs of supervising the process. The development of e-commerce has prompted some authors to suggest that the nominal rigidities in prices associated with 'menu costs' are soon to be a feature of the past. But this assertion is at odds with the empirical evidence presented in Chakrabarti and Scholnick (2001), that reported that prices charged by online booksellers exhibit within-store-synchronisation of price changes no less marked than for traditional retailers. This puzzle may be easily solved if a broader definition of 'menu costs', which also includes the management costs associated with the process of changing prices, is to be adopted. The management costs are those associated with the time spent by managers in assessing all their available information and making a decision on changing prices and will result regardless of whether inflation is anticipated or unanticipated. These "management" or "planning" costs could in principle be substantially exacerbated by price instability, as it would make the outcome of certain investment opportunities more uncertain. This would force economic agents to divert resources from productive investments to devote them both to a more detailed analysis of the likely returns of an investment project under different price scenarios and also to insure themselves against the risks of price uncertainty.

ii) Nominal *lock-in*

From a theoretical perspective, nominal lock-in (either in the form of 'Taylor contracts' or 'Calvo-pricing') has proven to be a useful hypothesis to explain price inertia. In addition, recent research (e.g. Gali and Gertler, 1999, and Gali et al., 2001) finds support

[10] Further evidence for a relatively low level of nominal rigidity in micro data is reported in Golosov and Lucas (2003) in the context of the U.S. retailing sector.

[11] The effects of these two forms of nominal rigidity are particularly difficult to distinguish empirically. Estimates of the welfare costs from inflation from such nominal rigidities tend to rely on model calibration and simulation.

[12] This approach follows the seminal contributions by Mankiw (1985) and Akerlof and Jellen (1985).

for the existence of nominal rigidities:[13] estimates that sellers in the euro area may change prices in a frequency of only between 3 and 4 quarters on average.[14] For the US the estimated average frequency of price changes is in the range of 2 to 3 quarters.[15] This has direct implications on aggregate welfare and the optimal rate of inflation: nominal lock-in hinders the adjustment of relative prices, reducing economic efficiency. Importantly, any departure from price stability would exacerbate this loss in efficiency from nominal lock-in. This is because firms subject to nominal lock-in in a given period suffer a distortion in their relative price that increases proportionally with the rate of growth of the overall price index.

This strand of the literature that gives a prominent role to the presence of nominal lock-in has a clear implication on the optimal rate of inflation: monetary policy should aim at price stability (i.e. zero inflation) to minimise the distortion on relative prices. However, the welfare costs of targeting a positive rate of inflation have yet not been estimated in this analytical framework.

2.2.3 Distortions in taxation

The tax system, even in industrial countries, and even in the absence of inflation, causes losses of economic efficiency since it distorts agents' economic decisions, and the presence of inflation may exacerbate these distortions.[16] In particular, tax systems have been found to be particularly distortionary in their tendency to reduce the rate of capital accumulation and to induce over-investment in owner occupied housing. It is a well established fact that consumer price inflation significantly exacerbates the inefficiencies caused by the tax system.[17] This results from the considerable costs of introducing indexation in countries with more complex personal income tax systems. Without indexation, inflation changes the effective tax rate of different activities because taxes are levied in nominal terms rather than on real income. The more prominent effect discussed in the literature (see Feldstein, 1999, and Dolado et al., 1999, for a review) of the inflation-taxation interaction is that inflation reduces the real net-of-tax return to corporate and household savings.[18] In addition, in countries where personal income tax schedules are progressive but not indexed, inflation may have a substantial negative

[13] However, these papers do not clarify entirely what type of nominal rigidity –menu costs or nominal lock-in- is empirically more relevant. Instead, different forms of nominal rigidity tend to be chosen in terms of their analytical convenience.

[14] Obviously, these results are not easy to reconcile with the micro-based estimates of nominal rigidity reported in Section 2.2.2., which point to a significantly lower degree of rigidity. Recent work exploring the interaction between nominal and real rigidities in the context of non-walrasian labour markets helps to alleviate this tension between micro and macro-based estimates of nominal rigidity (in this respect see e.g. Walsh, 2003).

[15] This seems to be a fair account of the consensus view in the literature. However, as cited before, recent work by Bils and Klenow (2002) has somewhat challenged this view.

[16] A tax system that introduces no inefficiencies would be based on lump-sum taxes. This is prevented by fairness and political economy considerations.

[17] This is sometimes labelled the Tanzi effect.

[18] At the corporate level, inflation reduces the value of depreciation allowances, thereby increasing the effective tax rate. This in turn reduces the rate of return on corporate investments. As regards households, taxes levied on nominal capital gains and nominal interest also causes the effective tax rate to increase with the rate of inflation.

impact on labour supply. For the US, Feldstein (1997) estimates that a reduction of long run inflation from 2% to 0% would imply a permanent increase in welfare of about 1% of GDP (in present discounted value terms, and using a discount rate of 5%, this amounts to a net welfare gain of as much as 29% of initial GDP[19, 20]). A very rough estimate of the welfare loss from the interaction of inflation and the tax systems in the euro area is provided in IMF (2002): a reduction of inflation from 2% to 1% could permanently increase welfare by 1%. On a present discount value basis (with a 3% discount rate), this would amount to a welfare gain by 17% of initial GDP. Available evidence for individual countries suggests that the estimated gains of moving from low inflation to price stability, are also substantial. Tödter and Ziebarth (1999) find that the welfare gain from reducing inflation by 2 percentage points was equivalent to a perpetuity of 1.4% of initial GDP.[21] For Spain, Dolado et al. (1999) find an even larger gain of 1.7% of initial GDP. However, for the UK the estimated effects are substantially lower (see Bakhshi et al., 1999).

2.2.4 Direct transaction costs from inflation

i) Reduced consumer surplus from real balances (the so –called *shoe-leather* costs)

A long tradition in economics (starting with Bailey, 1956) has approached the measurement of welfare costs from inflation by treating money as any other consumption good. As such, a positive nominal interest rate represents a tax on non-interest bearing money and causes welfare costs from losses in consumer's surplus from real balances.[22] The welfare costs of a positive interest rate in turn determine the welfare costs of inflation, since in steady state the former relates one-to-one with the latter (through the 'Fisherian' equation). This aspect of the welfare cost from inflation in general equilibrium (which is often labelled as the "shoe-leather costs") has been often studied in isolation from other effects of inflation, and the distortion of other decision margins in the economy beyond the demand for real balances is not simultaneously considered.

There are two important implications from this approach for the welfare costs of inflation. First, it provides a clear-cut method to estimate a component of the welfare costs of inflation or interest rates (i.e. losses in consumers' surplus from real balances). Second, it ultimately leads to an (admittedly, incomplete) theory of the optimal rate of inflation and rate of interest in the economy (namely the so-called Friedman rule).

- Estimates of welfare costs of inflation from this approach. The large number of papers that have tackled this question tend to yield markedly different results. Some

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[19] This results from subtracting the one-off cost from disinflation –estimated at 6% of GDP- from the present discounted value of the gross welfare gain -estimated at 35% of initial GDP and resulting from discounting at the annual rate of 5.1% a permanent increase in welfare of 1% of initial GDP. See Feldstein (1999) for a detailed discussion.

[20] Further evidence of significant costs from the interaction of inflation and the tax system for the U.S. can be found in Bullard and Russell (1997).

[21] This results from the higher marginal taxes in Germany.

[22] That is, the area between the demand for real balances and the opportunity cost of holding non-interest-bearing deposits, i.e. the prevailing interest rate.

authors (e.g. Fischer, 1981) suggest that the "shoe-leather" gain in welfare (defined as the present discounted value of the permanent effect in output[23]) from a 10 percentage point reduction in inflation is as limited as 0.3% of GDP. In the other extreme, Gillman (1985) reports substantially larger figures (as high as 40% of initial GDP on present discounted value terms). More recent papers (e.g. Chadha et al., 1998, Lucas, 2000) have stressed the large uncertainty surrounding measures of the consumers' surplus from real balances. In particular, it would seem almost impossible to know the magnitude of welfare losses of reducing nominal interest rate from a small figure to zero. This is for a number of reasons. First, as stressed in Lucas (2000), estimates seem largely dependent on the assumed functional form of the demand for real balances. Second, empirical evidence is characterised by the scarcity, if not the absence of observations for which nominal interest rates are in the neighbourhood of zero. Third, the demand for real balances is highly non-linear precisely in the neighbourhood of zero interest rate (see Stracca, 2001). This means that the question of whether there is consumer's satiation for real balances when the interest rate is zero is both crucial for the calculation and difficult to answer. Subject to all these caveats, Chadha et al. (1998) suggest that the welfare gain from reducing inflation from 4% to 0% in the UK amounts to a permanent increase of 0.22% in output (a net welfare gain of around 9% of initial GDP in present discounted value terms when using a discount rate of 5%). This is well above previous estimates (e.g. Fischer, 1981, and McCallum,1989).[24]

- Derivation of the welfare maximising rate of inflation. The first application of this approach to the derivation of an optimal rate of inflation and interest rates is Friedman (1969), which puts forward the well known Friedman rule. The Friedman rule boils down to the idea that, to avoid any social waist in economising on real balances, nominal interest rates should be brought down to zero. This implies in particular that the optimal rate of inflation is a constant but moderate rate of price *deflation*. Phelps (1973) introduces one important caveat to the Friedman rule: inflation seignorage is one more tax in the economy and as such the optimal rate of inflation should be subject to public finance principles of optimal taxation. Chari et al (1996) shows that the resolution of the Friedman-Phelps controversy ultimately hinges on the magnitude of the income elasticity of money demand. In particular, barring other considerations (e.g. other distortions of inflation in general equilibrium), if the income elasticity of money demand is above one (which implies that taxing money – seignorage – is relatively distortive), inflation should be as low as possible and the Friedman rule obtains. In contrast, when the income elasticity of money demand is below 1 (which implies that taxing money – seignorage – is relatively innocuous for welfare) then it is efficient to set the interest rate (and,

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[23] The net welfare effect of a reduction in inflation is interpreted as the lump-sum transfer (as a percentage of initial GDP) that the representative agent would need to receive in a steady state with high inflation in order to be indifferent to the situation of a steady state with lower inflation (see Lucas (2000) for a more formal definition).

[24] It should be noted that all these studies treat money as a regular commodity. However, as the search-theory based models of money show (e.g. Trejos and Wright, 1995), there is a fundamental network externality in the demand for fiat money (i.e. each agent's demand for money depends on the willingness to accept money as a medium of exchange by all other agents). Introducing this principle in the analysis of welfare cost of inflation could significantly alter the results.

[25] See also De Fiore (2000) for the case when tax levying costs are present.

possibly, inflation) above zero. Furthermore, Correia and Teles (1999)[25] substantially strengthen the case for the Friedman rule by showing that the conditions under which the Friedman rule is optimal are considerably more general than those established by Chari et al. (1996). [26]

ii) Over-development of the financial system

A very related but distinct welfare loss due to positive inflation relates to the economic resources that are allocated to the financial sector in order to accommodate the increased number of transactions chosen by households as they attempt to reduce the cost of holding currency. For instance, in order to satisfy increased customer activity under higher inflation, banks may need to hire additional tellers, build more and larger branches, etc. Such "over-development" of the financial sector entails a welfare loss because these resources are seen as inefficient investments, oriented to minimising the effects of higher transaction costs inflation, and are distracted from potentially more productive uses. A number of researchers have estimated the magnitude of the welfare loss due to an inefficient over-development of the financial system. English (1999) analyses the fraction of the financial system in GDP in a panel of OECD countries. He concludes that the effect of inflation, *ceteris paribus* (i.e. controlling for a number of relevant factors like per capita GDP) on the size of the financial system is significant, both economically and statistically. Furthermore, he finds that the related welfare cost of an increase in the inflation rate from 0% to 10% could be, in present discounted value terms, about 1% of GDP. Dotsey and Ireland (1996) estimate that a 10% increase in the rate of inflation (relative to a zero inflation benchmark) has welfare costs in the range of 1% to 2% of GDP. At the high end of estimates, Lacker and Schreft (1996) find that the cost of an inflation rate of 10% could amount to as much as 4% of GDP.[27]

iii) Comprehensive account of the costs of inflation

The costs of inflation described in the previous two sub-sections correspond only to what might be labelled the *direct* costs of inflation (i.e. in terms of losses in consumer surplus from real balances and inefficient over-development of the financial sector). However, these estimates could differ substantially once all the effects of inflation on the

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[26] The more recent research has analysed the robustness of the Friedman rule in more general settings. A branch of this more recent literature has focused on its robustness when the social planner is unable to commit to future outcomes. Results in this respect seem mixed: Rankin (2001) suggests that if the social planner is limited to operate under discretion, the Friedman rule does not obtain in equilibrium. Alvarez et al. (2001) finds that the Friedman rule obtains also under discretion in empirically relevant ranges of the parameters. A second line of research has analysed the optimal level and volatility of inflation when both monetary and fiscal policies are set optimally. Results differ markedly depending on whether nominal price rigidities are considered. Within this strand of research Chari et al. (1991) in a DGEM model with perfect competition and flexible prices find a relatively high level of optimal volatility of inflation, a result which is confirmed in Schmitt-Grohe and Uribe (2001a) with imperfect competition and flexible prices. By contrast, Schmitt-Grohe and Uribe (2001b) and Benigno and Woodford (2003) show that a very small degree of nominal rigidities suffices to reverse the previous result and obtain a relatively very low degree for optimal inflation volatility for empirically plausible degrees of nominal rigidity.

[27] English (1999) provides more informal information on welfare costs under very high rates of inflation and hyperinflation and suggests that in such cases the welfare cost of inflation from an over-expansion of the financial system could be proportionally much higher.

economy (e.g. distortion in labour supply, in savings decision, etc.) are simultaneously taken into account in a general equilibrium setting. Only recent research has tackled this question. Dotsey and Ireland (1996) calibrate a dynamic general equilibrium model (DGEM) where money enters in a cash-in-advance constraint, and where agents can produce financial services as an alternative to money to make transactions. In this setting, inflation is costly because (in addition of having direct costs in terms of reduced consumer surplus from real money balances) it distorts a number of decision margins. This induces agents to inefficiently invest in the production of financial services i.e. as in the previous sub-section. In addition, distortions from inflation discourage agents' dedication to market activities relative to leisure. The authors find that the effect of sustained inflation on steady state growth is significant albeit limited. However, and importantly, they find that in their general equilibrium setting sustained inflation has an overall impact on total welfare that is considerably higher than what partial equilibrium estimates would suggest. Specifically, they calculate that a sustained increase in inflation from 0% to 4% would imply a permanent decline in the level of output in the range of 0.4% to 1.1%. A sustained increase in inflation from 0% to 10% would imply a permanent decline in output in the range of 0.9% to 2.2%. This is substantially higher than the partial equilibrium-based estimates (e.g. Fischer, 1981, and Lucas, 1981).

Khan et al. (2000) derive optimal monetary policy and the optimal rate of inflation in a dynamic general equilibrium model where inflation introduces two types of distortions:[28] those related to nominal lock-in (i.e. as in subsection 2.2.2. ii)) and those related to a direct cost of holding money (i.e. as in sub-section 2.2.5.i)). In their model, which is calibrated for the US economy, the optimal rate of inflation is close to zero and the role of optimal monetary policy (leaving out second order effects) is to stabilise the price level around trend.

Taking a more general perspective, Goodfriend and King (2001) argue that, in a New Neo-classical Synthesis setting characterised by imperfect competition and price and wage nominal rigidities, in which inflation introduces a number of distortions, price stability would provide a good approximation to the optimal monetary policy. Intuitively, price stability minimises the need to undertake price changes for the average firm, thereby getting close to minimising the distortion from inflation in the presence of nominal rigidities.

2.2.5 Income redistribution

In the absence of inflation-indexed contracts (which are costly to implement) both inflation and deflation change the wealth distributions by generating transfers between nominal creditors and nominal debtors. This *per se* does not necessarily amount to a welfare loss but to a simple re-distribution of welfare. But, as pointed out by Issing (2001), there are certain aspects to this transfer of wealth that may have important real effects. For example, there may be a transfer of wealth from the less risk averse to the more risk averse, or from the young to the old. On a different level, in an environment of high inflation, the reduction in the real value of the nominal debt may very well act as a deterrent for lenders to supply credit. Furthermore, re-distributive effects of inflation are likely to make the distribution of wealth more uneven. Some authors (e.g. Erosa and

[28] There are other distortions relative to frictionless economy in their model (e.g. imperfect competition), but they are not a consequence of a positive rate of inflation).

Ventura (2001)) have shown analytically and empirically that inflation acts like a regressive consumption tax and find important distributional consequences for the case of the U.S.

3. Potential benefits of positive inflation

3.1 Nominal downward rigidities

A long standing debate starting with Tobin (1972) on the empirical relevance of nominal downward rigidities in prices and/or wages has recently gained momentum in the context of the lower average inflation rates seen in industrial countries in the last years. This is of direct interest for monetary policy, particularly for underpinning the optimal range for the inflation target, since nominal downward rigidities, if prevalent, could in principle hamper the functioning of monetary policy if the central bank aims for zero inflation.[29]

However, this debate is hampered by a number of difficulties, both at the conceptual and empirical levels. It may therefore be useful to look in some detail into each of the more important elements of the arguments put forward to form a balanced assessment of the relevance of downward nominal rigidities for the optimal rate of inflation. Fortunately this literature is making substantial progress in recent years and hopefully some of these issues will be clearer in a near future.

First, it would be important to get clear conceptual foundations for the presence of downward nominal rigidities. This would allow addressing questions like: Should rigidities be expected to be the same upon different types of shocks faced by the firm and the worker (e.g. productivity, vs. demand shocks; individual vs. aggregate shocks)? Do downward nominal rigidities refer to hourly wage rates or total nominal employees' income (e.g. independently of hours worked)? How are such downward rigidities affected by the degree of unionisation of the plant/firm or other institutional factors? Would rigidities vary with characteristics of the employment relationship (e.g. tenured vs. temporary workers; 'white' vs. 'blue collar' workers, etc.)?

Second, observable microeconomic implications would need to be extracted from the conceptual framework. Here the main problem is to distinguish between the presence of what can be labelled *exogenous* downward nominal rigidities (i.e. related to behavioural factors like money illusion or fairness considerations) and purely economic factors that may also tend to limit the variability of compensation related variables in the vicinity of zero inflation. For instance, even if the employment relationship were primarily governed by (implicit) long-term relations aimed at providing insurance and long-term career incentives to the worker, it could still be true that short-term changes in workers' compensation exhibit asymmetries around zero inflation. However, in this case such asymmetries would be reflecting equilibrium behaviour, rather than an intrinsic difficulty in or resistance to reductions in nominal wages.

Third, to assess the importance of such rigidities for firms and the economy, the more relevant concept is likely to be the rigidity of total unit labour costs and not wages *per se*. Even in the presence of downward nominal rigidities in contractual wages, the firm

[29] This is for obvious reasons: under a negative demand or positive productivity shock nominal downward rigidities prevent the needed decline in prices or wages implying the emergence of persistent imbalances.

might be able to attain labour cost flexibility in a low inflation environment, for instance if productivity growth does not falter or if workers' earnings incorporate some flexible components (bonuses, overtime, etc.). Furthermore, it is also of interest to assess the effects of downward rigidity in compensation related variables against the background of the overall flexibility of firm-worker relations. For instance, if a firm is constrained not to reduce the nominal hourly wage from the previous value but it has full flexibility to adjust the total number of hours hired, it may be able to fully circumvent such restriction in many practical respects (e.g. realised profits).

Fourth, some further progress on the implications for structural, economic and monetary policies, consistently with the stance taken on the previous issues is still needed, particularly regarding the effects of policy measures on the continuation or dissipation of downward nominal rigidities. Finally, it is also important to study the likely implications of EMU for the future evolution of downward nominal rigidities.

The rest of this section takes stock on the state of the debate on downward rigidities on the basis of the five elements listed above. Table 1 provides a summary of the leading recent papers in this area. The contributions with respect to the first three elements mentioned above are particularly highlighted.

Table 1: Summary of selected papers on downward nominal rigidities

Paper and country	Conceptual framework	Microeconomic evidence	Macroeconomic effects
Altonji and Deveraux (1999) U.S.	Full-rationality micro model (based on MacLeod and Malcolmson, 1993)	Substantial degree of rigidity: reductions in nominal compensation are rare for salaried workers	Inconclusive. Workers supposedly enjoying higher income due to downward nominal rigidities are not less likely to quit the firm.
Lebow, Sacks and Wilson (1999) U.S.	Ad hoc: analysis of distribution of y-o-y changes in: 1) hourly wages and 2) benefits	Substantial degree of rigidity: only about 50% of workers “expected” (from the model) to see a wage cut actually suffer it	Limited *(micro-macro puzzle):* reducing average inflation from 4% to 2% reduces the rate of unemployment by about 0.4 p.p.
Akerloff, Dickens and Perry (2000) U.S.	Bounded-rationality framework. Elements: workers are motivated by relative wages (work harder if they are paid more than in other companies). For low rates of inflation, some workers tend to underestimate the effect of inflation on other companies' wages	Not provided	Long-run inflation unemployment trade-off. Optimal inflation rate is about 2.2%

Table 1 (cont.): Summary of selected papers on downward nominal rigidities

Paper and country	Conceptual framework	Microeconomic evidence	Macroeconomic effects
Fehr and Goette (2000) Switzerland	Ad hoc: analysis of distribution of y-o-y changes in: 1) fixed wage component in full compensation; 2) full compensation (hours treated as exogenous error term)	Substantial degree of rigidity: about 50% of all workers found to be affected by downward nominal rigidities. Evidence of rigidities markedly different for workers with different contracts	Effect of downward nominal rigidities on unemployment significant and systematic across regions and sectors but limited in magnitude (always lower than one percentage point)
Knopikk and Beissinger (2003) Germany	Ad hoc: analysis of distribution of y-o-y changes in total compensation (hours treated as exogenous error term), for workers in age range 25-65	An overwhelming majority of workers found to have binding downward nominal rigidities	Limited macro implications. For inflation rates in the range of 1% to 2% the effect of such rigidities on the rate of unemployment found to be about 0.4 p.p.
Farès and Lemieux (2001) Canadian provinces	Sample 1: Ad hoc: effects of low inflation on 'real wages Phillips curve'. Sample 2: Ad hoc: effects of low inflation on individuals' real wages	Sample 2: Irrespective of the inflation rate, new entrants seem to bear a disproportionate share of the adjustments in real wages	Sample 1: Downward rigidities bind for a subset of workers (older and more senior workers) and seem to have only a modest impact on aggregate wages and employment. 'Provincial real wage Phillips curves' did not become flatter in years of low inflation
Decressin and Decressin (2002) Germany	Ad hoc: analysis of distribution of y-o-y changes in wages	Substantial degree of rigidity, but similar to estimates seen for the U.S., rather than higher	Not discernible macroeconomic effects
Dessy (2002) EU countries	Ad hoc: analysis of distribution of y-o-y changes in total labour earnings	Significant evidence of downward rigidities but frequent instances of nominal wage reductions. Extent of downward rigidities not greater than for the U.S.	Not derived
Annex II in this note OECD countries	Ad hoc: effects of low inflation on 'real unit labour costs Phillips curve'		Real unit labour cost Phillips curves not affected by lower inflation

1. As regards the conceptual foundations of downward nominal rigidities, there seems to be little consensus among authors and some of the elements that underlie proposed views remain still in an early stage of scientific development. Some authors point out that standard principles of economic rationality would not be compatible with the possibility of persistent nominal downward rigidities, which would result primarily from alternative (and less well understood) psychological or behavioural mechanisms, like "money illusion" or the so-called loss-aversion paradigm[30] (on this issues Yates, 1998, provides a comprehensive discussion). Some authors (e.g. Bewley, 1997) see the roots of downward rigidities in workers' fairness concerns (e.g. nominal wage cuts are seen as demeaning by workers). Finally, some papers provide a fully rational basis for downward rigidities. In particular, McLeod and Malcolmson (1993) argue that if wages are determined by periodic bargaining and the outside options for agents (i.e. their pay-off when rejecting to bargain) cannot be indexed to inflation then downward nominal rigidities would emerge in equilibrium as a fully rational phenomenon.
2. As regards available evidence on the presence in the past and possible persistence in the future of downward nominal rigidities, this has recently been addressed by a considerable number of articles, most of which find that a substantial proportion of wages are restricted by downward nominal rigidities. Our assessment of these studies may be summarised as follows:
   - Unfortunately limitations in data availability seem to be an important obstacle to the analysis of nominal downward rigidities. For example the scarcity of data from protracted periods with price stability or very low inflation forces researchers to infer the implications of a regime of permanently low inflation from observed behaviour within a regime of temporarily low inflation. An additional challenge has been to empirically disentangle the relative importance of asymmetric rigidities stemming from resistance to nominal wage cuts (i.e. downward nominal rigidities) from symmetric rigidities stemming from *menu costs* of revising nominal variables.
   - The approach taken in the majority of these papers has been to start by postulating a number of plausible features of the distribution of the changes (usually year-on-year) in observable elements of workers' labour compensation. Such features are then seen as evidence of downward nominal rigidities in a broad sense (i.e. without asserting the nature or cause of such rigidities). In intuitive terms, this approach entails analysing whether there are "too few" data points corresponding to negative nominal changes in the distribution of changes in compensation, relative to a symmetric distribution. In addition, authors analyse whether declines in the inflation rate tend to increase the extent of such asymmetry in the distribution of compensation changes.
   - Most authors find substantial evidence for downward rigidities (although for the case of Germany there are some discrepancies across authors e.g. while Knopikk and Beisinger, 2003, find overwhelming evidence of downward rigidity in German labour markets, Decressin and Decressin, 2002, find more limited evidence). In a recent study Dessy (2002), finds evidence of nominal (but not real) wage rigidities in 12 European countries by analysing yearly wage changes in a sample of individual wage earners between 1994-96. Specifically,

[30] Akerlof et al. (2000) also considers near-rational behaviour to justify the presence of grease effects.

this paper presents descriptive evidence of nominal wage change distributions and finds that a significant share of full-time workers report zero wage change between consecutive years, indicating the presence of nominal wage rigidities for this type of workers. However, Dessy (2002) also finds that wage cuts are relatively common. Differences across countries appear to be considerable. A larger share of workers is affected by wage rigidity in Germany, Belgium and Italy, while a smaller share is affected in Spain and Ireland. However, given the preliminary nature of the results, the possible 'selection' bias due to the focus on specific worker categories (mainly full-time workers) and the lack of statistical control for macroeconomics conditions (such as the contemporaneous annual rate of inflation) or measurement error in the data, this evidence is inconclusive about the extent and consequences of nominal downward wage rigidity in Europe.

- A common thread across studies is that the stringency of such restrictions varies considerably with the characteristics of the worker (e.g. permanent and full time workers exhibit more rigidity that fixed-term and part-time workers; workers in manufacturing exhibit more rigidity than in services). This suggests that institutional features of the employment relationship may have a bearing on the emergence of such rigidities.
- Interestingly, when considering the extent of downward wage rigidities it is generally found that downward nominal rigidity in variable components of compensation (additional non-wage incentives) is considerably smaller than in the wage component. This supports the view that variable components in labour compensation would soften downward nominal restrictions. Furthermore, some studies document that workers accept nominal cuts in the wage component when they shift from a fixed wage compensation to a compensation system that embodies both fixed but also variable components (i.e. incentives' oriented). This would suggest that the overall stringency of downward nominal rigidities may tend to decline over time as proportionally more workers see their labour income determined on the basis of performance-based systems, as according to some experts is the case (see Lebow, 1999, for the US and Aghion et al., 1999, for European countries).
- Finally, none of these studies has been able to formally test whether measured downward nominal rigidities result from "rational" considerations or "money illusion" (which of course is not easy, given remark 1 above).

3. As regards the assessment of the extent to which downward nominal rigidities have discernible macroeconomic effects, authors have taken two main approaches. First, to extract a counterfactual distribution of wages that could have resulted without rigidities and infer the respective (counterfactual) unemployment rate, which is compared to the actual unemployment rate. Second, to estimate the effects of very low inflation rates on a standard or modified Phillips curve.
   - As regards the first approach, most studies seem to coincide in finding that such effects are limited (particularly in the case of the U.S.), in spite of the fact that the latter seem pervasive. This has led to some authors to talk of a *micro-macro puzzle,* that is, the surprising result that such a widespread phenomenon like downward rigidities has apparently a limited aggregate impact. In this respect, some authors (e.g. Altonji and Deveraux, 1999, and Lebow et al., 1999) argue that firms possibly foresee the effects of nominal downward rigidities and thus

set up ex ante the wage policy of the firm so as to "sterilise" ex post such effects (e.g. by setting 'low' – below productivity – wages at the point of entry in the firm, so that workers 'pay' up front in their career the potential future rents derived from downward rigidity

- As regards the second approach (i.e. analysing the effect of low inflation rates on the slope of the Phillips curve), the degree of consensus in the results seems to be relatively small. Akerlof, Dickens and Perry (2000) argue that average inflation rate in the range of 2% to 3% would reduce the long term unemployment rate by 2 percentage points (p.p.) relative to the case with zero average inflation. By contrast, for the case of Canada Farès and Lemieux (2001) find that lower inflation had no impact on real wage adjustment, which rejects the view that downward nominal rigidity is binding (since otherwise very low inflation would increase the sluggishness of real wage adjustment). For European countries some very tentative evidence is available in Wyplosz (2000) and Dickens (2001). The results of these studies refer only to a limited number of countries and are overall very tentative. As stated in Dickens (2001), available results at this stage "do not make an iron clad case against the ECB's target range for inflation of 0 to 2% but they should give the ECB reason for concern". Using an approach similar to Farès and Lemieux (2001), Annex I shows that for a sample of OECD countries, inflation rates below 2% have no impact on the adjustment of real unit labour costs (i.e. downward nominal rigidities are not found to affect the adjustment of real unit labour costs relative to unemployment). By contrast, Annex I shows that some institutional characteristics of the labour impact have a significant impact on the sluggishness of the adjustment process.

4. As regards the derivation of policy implications, consensus among authors seems particularly limited. While some authors refrain from drawing policy implications, possibly as a consequence of the preliminary state of the discussion (e.g. Altonji and Deveraux, 1999, Lebow et al., 1999) others argue that, based only on considerations from downward nominal rigidities, average inflation should be in the range of 2% to 3% in the U.S. (see Akerlof et al., 2000) or higher than 3% in Germany (Knopikk and Beissinger, 2003) to minimise the long-term NAIRU.
   However tentative the results may be and in the light of the still very preliminary state of the debate it seems crucial to bear in mind a few potentially important considerations for the discussion on desirable policies:
   - Whatever the ultimate source of downward rigidities, it would seem that they are not everywhere and every time a deep rooted phenomenon. Rather, specific labour market institutions seem to favour the emergence or strengthen the effects of such rigidities. This suggests that the existence of downward nominal rigidities themselves should not necessarily be taken as given and could be seen as one objective for structural economic policies.
   - The evidence discussed above and also historical evidence[31] suggests that

[31] Some authors (e.g. Cole et al., 2002) have recently argued that downward nominal rigidities strengthened deflationary forces in the Great Depression in the U.S. and European countries. Conversely, downward nominal flexibility has possibly contributed to limit the destabilising impact from deflation and close-to-zero nominal interest rates in the last years.

downward nominal rigidity is an undesirable feature of labour relations. Thus, arguments weighting any possible shorter term gains from monetary policy accommodating such rigidities (e.g. by deliberately increasing average inflation rates) must take into account the effects of accommodating and perhaps entrenching them in the longer term.

- From a more general perspective, if certain psychological or behavioural factors like money illusion were going to be explicitly taken as an important consideration, it could be difficult to establish a clear-cut welfare criterion to assess policy outcomes. Should the welfare criterion represent the money illusion in agents' preferences, or should money illusion be ignored for such calculations (i.e. social welfare not aggregating consumers' preferences but modified versions of it) and welfare be conventionally defined in terms of real variables (e.g. consumption and leisure)? Furthermore, even if it were deemed appropriate that economic policies should be calibrated to take into account the existence of money illusion on the part of the public, it is not clear which implications this would have in terms of desirable rates of inflation.[32]

5. Finally, Monetary unification in Europe is a fundamental regime shift likely to trigger over the longer term transformations in patterns of price and wage setting. From a macroeconomic point of view, there seem to be some consensus in the literature on the fact that EMU will probably tend to increase the demand for nominal wage flexibility in labour contracts, related to the need for alternative adjustment mechanisms (given the absence of country specific monetary policy under EMU) following idiosyncratic shocks (see Bertola, 2001, Calmfors, 2002, and references therein).[33] A potentially important impact effect of EMU, that would work through increased market competition in the euro area, could be the potential decline in the degree of centralisation of collective bargaining at the country level. The fact that excessive wage increases in the tradable sector would become more strongly 'punished' by the market under a monetary union may reduce the incentives to co-ordinate and centralise wage negotiations, thus possibly leading to a somewhat more informal co-ordination of wage settings (see Boeri *et al.,* 2001). However, evidence in this respect is still scant, as most of the available empirical evidence refers to the ERM years. Specifically, Eichengreen (1998) reports the absence of significant increase in nominal wage flexibility in the European countries after joining the ERM.[34]

A final caveat that should be mentioned in this context relates to the strict focus of these on the potential distortions arising from nominal downward rigidities in prices and

[32] In this connection, the survey in Howitt (2002) suggests that the presence of money illusion could be a compelling argument favouring the case for price stability.

[33] Another factor contributing to higher nominal wage flexibility is deunionisation in most European countries as reported in Ebbinghaus and Visser (2000) and Calmfors et al. (2001), who show that average union density in Western Europe has declined from 44 percent in 1979 to 32 percent in 1998.

[34] Related to this, Calmfors (1998), and Calmfors *et al.* (2001, Ch. 4) examine the actual experiences in the 1980s and 1990s of Austria, Belgium, France and the Netherlands, the countries with the more consistently performing hard-currency policies in the ERM, and do not find instances of aggregate nominal wage reductions even in years with very high unemployment. The Netherlands however provides an example of nominal wage cuts in the public sector after the Wassenaar agreement in 1982.

labour compensation. Obviously, any advice from these papers on the optimal rate of inflation should be taken with due caution, as the required analysis regarding the optimal inflation rate should necessarily encompass and carefully weight the implications from all relevant considerations, not least the direct costs from departing from price stability reviewed in Section 2 of this paper.

3.2 *Downward nominal rigidities and inflation differences within the euro area*

Ever since the project of the economic and monetary union in Europe moved into its decisive phase in the second half of the 1990s, there has been an intensive debate on the effects of a common monetary policy in an area with potentially diverging economic developments and different economic structures across regions and countries. In this respect, some researches and policy makers had questioned whether "one size fits all" in terms of conducting monetary policy will be ultimately feasible. Related to this debate is the notion that large and persistent cross-country inflation differentials might complicate the conduct of a common monetary policy in Europe. Inflation differentials may affect competitiveness of countries participating in a currency union, and exchange rate adjustments can no longer be used to compensate for potential losses in competitiveness.

To assess the relevance of inflation differentials for the optimal rate of inflation in the euro area, it seems crucial to carefully consider the sources of potential inflation differentials across countries.[35] In addition, it would be necessary to clarify which aspects of inflation differentials reflect equilibrium phenomena (for which economic policy action may not be required), which aspects reflect imbalances that would in principle call for national remedies and, finally, which aspects could pose challenges for conducing monetary policy.

Relating such analysis of the sources of inflation differentials, the available evidence (see IMF, 2002) indicates that a number of structural factors can account for a significant fraction of the observed inflation differentials across euro area countries: *inter alia*, the tendency towards convergence in price levels, the so-called Balassa-Samuelson effect and other structural factors related to real convergence across euro area countries (e.g. changes in sectoral composition, shifts in labour participation rates). Given available evidence, it would be difficult to gauge the relative contribution of these factors in explaining current and future euro area inflation dispersion at this stage.

As regards the contribution of differences in countries' price levels to inflation differentials, a recent paper (see Rogers, 2002) estimates that the contribution of price level dispersion in 1999 to observed annual HICP inflation dispersion at the end of 2002 was in the range of 12% to 31%. Moreover, this study argues that since euro area countries seem to have achieved already by 1999 a level of price level convergence similar to that of US regions, the effect of price level convergence on countries' inflation dispersion should be considerably weaker in the coming years, relative to the estimates for 2002.[36]

As regards the role of the Balassa-Samuelson effect (BS-effect henceforth) in explaining inflation differentials, a number of recent studies[37] have attempted to gauge

[35] For a very enlightening discussion see Blanchard (2000).
[36] See also ECB (2002).
[37] Alberola and Tyrväinen (1998), Canzoneri et al. (1998), De Grauwe et al. (2000) and Sinn and Reuter (2001). See also IMF (2002) for a broader discussion.

its magnitude. Overall, these studies suggest that the BS-effect would imply sustained and non-negligible inflation differentials in euro area countries. Taken together, these studies would suggest that, as a result of the BS-effect, the spread in average inflation between the lowest average inflation country (which in all studies corresponds to Germany) and the highest average inflation country could be in the range of 1.1 to 2.4 percentage points.

Table 2: Inflation differentials in the euro area arising from B-S effect

	Canzoneri et al. (2000)	Alberola and Tyrvainen (1998)	Sinn and Reutter (2001)	De Grauwe - Skudelny (2000)	IMF (2002)
Sample Years	(1973-1997)	(1975-1995)	(1987-1995)	(1987-1995)	(1995-2001)
Belgium	2.1	2.6	1.4	1.6	1.5
Germany	0.5	0.8	0.6	1.2	1.4
Greece	-	-	4.7	-	2.2
Spain	1.9	2.6	2.1	1.5	1.8
France	1.9	1.2	1.9	1.1	1.4
Ireland	-	-	2.9	-	2.9
Italy	2.3	1.9	2.1	1.9	1.4
Netherlands	-	1.8	2.0	1.5	1.8
Austria	1.3	1.3	2.0	2.0	2.0
Portugal	-	-	1.4	1.6	2.2
Finland	1.9	1.9	3.3	0.9	1.8
Max-Min	1.8	1.8	4.1	1.1	1.5
Dispersion	0.6	0.6	1.1	0.4	0.5

Note: Euro area inflation has been normalised to 1.5% to facilitate comparability across studies.

Table 2 summarises existing estimates of the Balassa-Samuelson effect in euro area countries.[38] (Comparability across studies is hindered by differences in considered sample periods and methodologies). To facilitate comparability, average euro area inflation is normalised to 1.5%.

[38] For background information on actual average inflation differentials in euro area countries see Annex II.

All estimates in Table 2 are broadly in line as regards overall dispersion (last two rows), except perhaps the ones in Sinn and Reuter (2000).[39] However, looking at individual countries, wider discrepancy between estimates emerges, reflecting a high degree of uncertainty surrounding the size of BS effects. Taken at face value, these estimates[40] suggest that the BS effect could by itself explain a considerable fraction of observed differentials. However, given the high degree of uncertainty surrounding estimates (stemming also from methodological shortcomings – e.g. the fact that few of these studies consider a comprehensive analysis of inflation differentials), a high degree of caution in the assessment of these results is needed.

A more general approach to explaining inflation differentials through the Balassa-Samuelson hypothesis attempts to assess the extent to which different factors (including changes in mark-ups, labour costs and labour productivity) contribute to explain the observed changes in inflation in tradable and non-tradable goods prices. This approach has been implemented by Canzoneri *et al.* (1999) for the OECD countries and by Ortega (2003) for the four larger euro area countries. These authors examine in particular whether the effect of changes in relative productivity is, as the Balassa-Samuelson hypothesis would suggest, predominant. If this were not the case, sustained inflation differentials would likely be, in this view, the result primarily of changes in the relative competitiveness of euro area economies. The result of the work for the euro area in Ortega (2003) shows that relative prices have moved in line with relative productivity over the long run as prescribed by the Balassa-Samuelson hypothesis. However, these results also show that the Balassa-Samuelson hypothesis fails to account for the whole amount of the inflation differentials in the main European economies in the years prior to 1999. Persistent changes in relative wages and the ratio of nominal unit labour costs to marginal labour productivity have also played a significant role.

Overall, the current assessment of overall factors impinging on sustained inflation differentials suggests in particular that the magnitude of the BS-effect is plausibly limited and should be declining over time (see Rogoff, 1996). Beyond that, a reliable breakdown of the persistent component in inflation differentials according to the possible underlying causes is at the time not available.

To summarise, there is little question that some inflation differentials across euro area countries will persist as long as real convergence continues to progress. However, there is a strong case to argue that such inflation differentials should be seen primarily as an equilibrium phenomenon, with little bearing on the conduct of monetary policy. Some recent research contributions support this claim. Duarte and Wolman (2003), in a two country dynamic general equilibrium model with tradable and non-tradable goods show that a calibrated distribution of structural productivity shocks can easily account for equilibrium inflation differentials of the magnitude seen in the euro area. Benigno (2003) and Benigno and López-Salido (2002), in dynamic general equilibrium

[39] The results in Sinn and Reuter (2001) would seem to overestimate the Balassa-Samuelson effect and indeed they suggest a very high degree of dispersion compared to the other studies (but sample differences make this comparison difficult). Moreover, it suggests a very high HICP inflation rate in Greece as a result of the BS effect, (i.e. slightly above of what is seen even under the recent period of strong price increases).

[40] To the extent that real convergence among current member countries implies a gradual diminishing impact of the BS effect, the estimates in Table 2 might be subject to an upward bias. Therefore these estimates should be regarded as representing a rather pessimistic view of the potential size of BS effects in those countries.

macromodels (DGEM) of a two-country currency union, show that (as long as inflation persistence is similar across currency union countries) optimal monetary policy (in their setting) can be expressed in terms of the inflation rate in the currency union alone, without regard for differences in countries' rate of inflation.[41]

Some experts have argued that the combination of sustained inflation differentials across euro area countries and the existence of nominal downward rigidities in prices and, particularly, wages (or more generally labour costs), could pose problems for the functioning of the single monetary policy. The logic of the argument would be:

- Sustained inflation differentials combined with the objective of euro area HICP inflation below 2% implies that the lower inflation countries (i.e. those with a higher income per capita) exhibit "very low" inflation rates. That is, if average euro area HICP inflation is, say, 1.5% and due to structural reasons a number of countries have significantly higher average inflation than others, then the average inflation of lower inflation countries would need to be below 1.5%.
- If nominal downward rigidities prevail, in particular in the lower inflation euro area countries, then these countries may have no margin to adjust downwards real labour costs upon a negative aggregate shock. This potential problem of lack of margin for adjustment would be particularly stringent in periods when productivity growth is low.
- An additional risk associated with some countries exhibiting close to zero inflation with some recurrence is the detrimental effect this could have on financial stability (e.g. if markets associate to this the possibility of deflationary spirals setting in) and the sustainability of fiscal positions (e.g. since the government debt level would be increased in real terms).

All in all, assessing whether lower inflation countries in the euro area may face these sort of risk of is difficult given the short history of EMU and since only very few studies have addressed specifically this question. The possibility of one region facing sustained deflation in a single region of a monetary union while the union as a whole enjoys price stability seems to be very unlikely. The main concerns with a situation of deflation are the risks of emergence of self-fulfilling deflationary expectations and eventually a liquidity trap. However, an episode of sustained deflation or even a deflation spiral in a region of the euro area seems to be unlikely. In a region within a monetary union which as a whole experiences price stability, the emergence of medium to long-term deflation expectations would tend to be offset by expectations of stronger aggregate demand, as deflation would have an immediate impact on the competitiveness of the region relative to the rest of the monetary union. As regards the risk of deflation for the euro area as a whole, the risk that the monetary authority would have to lower interest rates to zero and then be effectively constrained by the zero lower bound does not seem to be substantial for inflation objectives below but close to 2% per annum.

[41] The results of course reverses if countries exhibit different degrees of inflation persistence. The point is that in their framework inflation differentials arising from the BS-effect do not inform optimal monetary policy.

4. Conclusions

This paper has discussed some of the issues that should be taken into consideration in assessing the optimal rate of inflation, with a view to contributing to the debate on the desirable properties of the inflation process in the euro area. Two main lines of argument have been reviewed: the contributions assessing the costs of inflation (both in terms of long-term real GDP growth and economic welfare) and two elements related to the potential 'benefits' of small positive rates of inflation, namely the role of nominal downward rigidities in price and wage setting and the role of sustained inflation differentials across euro area countries.

Against this background, the main conclusions of the paper may be summarised as follows.

First, recent evidence confirms the presence of a negative and significant effect of inflation on long term growth, even at moderate rates of inflation. As regards the relative effects on long-term growth of high average inflation versus high inflation volatility, recent structural analysis suggests that higher average inflation has a negative impact on growth and welfare, whereas higher inflation volatility has a negative impact on welfare and a likely negative, albeit quantitatively minor effect on growth.

Regarding the detrimental effects of average inflation on welfare, four main channels are reviewed.

1. On the interaction of inflation and the tax system, the latest evidence confirms that inflation considerably exacerbates the inefficiencies stemming from non-indexed tax systems, in particular in some European countries.
2. Regarding the effects of nominal rigidities, two types are distinguished: i) menu costs (i.e., it is costly to change prices) and ii) nominal lock-in (i.e. it is not possible to change prices in a time interval). Recent work suggests that in the presence of symmetric nominal rigidities the optimal inflation rate is zero (to minimise the distortions of nominal rigidities on relative prices). However, precise estimates of the welfare costs of inflation stemming from nominal rigidities are not available and the risks associated with the zero lower bound on nominal interest rates are not taken into account.
3. As for the effects of inflation on income redistribution it is likely to be significant, but quantitative evidence is not available.
4. Regarding the direct costs from inflation, two types are distinguished:
   - 4.1 Reduced consumer surplus from real balances (so-called shoe-leather costs). Recent estimates suggest that these costs might be significant and possibly greater than what had been estimated in the past. Some of the recent theoretical and empirical research focusing strictly on these considerations tends to give fairly strong support to the so-called Friedman rule (i.e. zero nominal interest rates, implying steady but moderate deflation).
   - 4.2 Excessive allocation of resources to the financial system: Recent empirical work based on international evidence would indicate that inflation induces the financial sector to grow beyond what would seem optimal. This work suggests that the welfare loss arising from such inefficient allocation of resources could be significant.

Second, we have also briefly addressed those risks associated with deflation. The main concerns with a situation of sustained deflation are the risks of emergence of self-fulfilling deflationary expectations and eventually a liquidity trap, as well as the limitations a zero lower bound on interest rates entail for monetary policy. The possibility of episodes of sustained deflation or even a deflation spiral in a region of the euro area seem to be unlikely. In a region within a monetary union which as a whole experiences price stability the emergence of medium to long-term deflation expectations would tend to be offset by expectations of stronger aggregate demand. Deflation in one region would have an immediate positive impact on the competitiveness of the region relative to the rest of the monetary union. In a similar vein, the risks that monetary policy would have to lower interest rates to zero and then effectively be constrained by the zero lower bound in the euro area seems rather small for inflation objectives below but close to 2% per annum.

Third, as regards, the simultaneous presence of nominal downward rigidities and inflation differentials in a monetary union, a conclusive answer is difficult to find. It is difficult either to confirm or dismiss their macroeconomic relevance, albeit the more recent evidence suggests, with few exceptions, that the macroeconomic effect of downward nominal rigidities is limited. Overall, the evidence indicates that such rigidities relate prominently to prevailing institutional features of the labour market. In this respect, it seems that the more relevant issue is how structural policies could aim at preventing or eliminating them or even whether downward rigidities can be expected to gradually disappear in a low inflation regime, rather than whether or not the quantitative definition of price stability can ensure that downward nominal rigidities do not become binding (which could perhaps ultimately entrench such rigidities in labour markets).

Finally, all in all, taking also into account the evidence surveyed and provided in Yates (2003), Coenen (2003) and Klaeffling and Lopez (2003) on the factors impinging on the likelihood of nominal interest rates hitting the zero lower bound –an issue not addressed in detail in this paper- it would seem that the benefits of an inflation policy that tolerates a positive small average rate of inflation more than offset the direct costs of such rate of inflation. Those benefits would relate primarily to a reduced probability of nominal interest rate approaching the zero bound and the emergence of deflationary expectations. This suggests introducing a small safety margin in the price stability objective, which makes explicit that monetary policy would act to prevent that inflation trends do not come close to zero. Such small safety margin introduces an element of insurance against outcomes of a low probability but with potentially damaging effects. At the same time, taking into account the previous review of the evidence, the possibility of nominal downward rigidities being a relevant factor to determine such a safety margin seems considerably less clear, given that results in this respect across countries are markedly uneven and seem to depend strongly on institutional factors. In particular, one clear conclusion from the available evidence is that whenever flexible forms of contracting in labour markets are present, the macroeconomic relevance of nominal downward rigidities tends to vanish.

A more general consideration in this connection is how to determine the appropriate small safety margin for the price stability objective. In this respect, a misguided approach would be to estimate different sizes of such safety margin taking into account each time only one or a few of the relevant considerations (i.e. the zero lower bound for nominal interest rates, measurement bias in the HICP, nominal downward rigidities, etc.), and then add them up to find an overall safety margin. Such approach would 'double-count' the benefits of an extra margin in the price stability objective. Instead, gauging the size of the appropriate safety margin requires a sound judgement of all the relevant factors simultaneously, taking into account that a small safety margin above zero inflation permits to alleviate all those risks simultaneously. Finally, it should be kept in mind the strong evidence of the significant direct costs of inflation even for low rates of inflation.

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[42] From the Blanchard-Wolfers (2000) data-base.

Annex I: Low inflation and the adjustment of real unit labour costs in OECD countries

This Annex analyses whether low inflation rates (below 2%) have any effects on the labour cost adjustment process, i.e. if low inflation hampers the adjustment process (e.g. due to downward nominal wage rigidities. This approach to gauge the relevance of downward nominal wage rigidities is similar to some approaches taken in the optimal inflation literature. Fares and Lemieux (2001) estimates a real wage Phillips curve where it is tested whether the presence of low inflation rates hampers the adjustment process in the context of data for Canada. This annex broadly replicates this approach for a sample of OECD countries by considering the effect of low inflation rates on the slope of a real unit labour cost Phillips curve. The logic of the exercise is based on realising that downward nominal rigidities entail an increase in real wage rigidity as inflation becomes low.

Tables AI 1 and AI 2 show the panel-data results of an instrumental variable estimation where the year-on-year change in real unit labour costs is regressed on the rate of unemployment (decomposed by age and gender groups), institutional characteristics[42] (for Table AI 1) and regional dummies (for Table AI 2). In both cases instruments used are demographic variables and institutional characteristics.

The more salient implication of Tables AI 1 and AI 2 is that the interaction variable with the product of dummy for below 2% inflation and the aggregate unemployment rate is not significant. Thus, while a higher unemployment rate exerts downward pressure on real unit labour costs, the fact that inflation is below 2% does not seem to impinge on the adjustment process. However, the important caveats mentioned in section 3, that should be applied to available studies assessing the extent of downward nominal rigidities, should be applied also here. In particular, since the number of observations with low inflation in the sample is limited.

Results in Table AI 1 and Table AI 2 indicate that there is very little evidence that low inflation rates affect the real unit labour costs adjustment process. By contrast, Table AI 1 (which includes the institutional variables from Blanchard-Wolfers (2000)) suggests that structural reforms affecting the institutional design of labour markets could have a very considerable impact on the adjustment process.

Table AI 1: Real unit labour cost Phillips curve (1)

		Coefficient	Std.Error	t-value	t-prob
Constant	Exogenous	0.0461	0.0300	1.5400	0.1260
Unemp. Rate, males, 15-24 years	Endogenous	-3.9549	2.0550	-1.9200	0.0550
Unemp. Rate, males, 25-54 years	Endogenous	-0.2577	2.1580	-0.1190	0.9050
Unemp. Rate, males, 55-64 years	Endogenous	-3.4792	3.6770	-0.9460	0.3450
Unemp. Rate, females, 15-24 years	Endogenous	1.6378	1.4980	1.0900	0.2750
Unemp. Rate, females, 25-54 years	Endogenous	0.5210	0.9288	0.5610	0.5750
Unemp. Rate, females, 55-64 years	Endogenous	1.2365	2.9140	0.4240	0.6720
Dummy (a)	Endogenous	-4.5589	4.6410	-0.9820	0.3270
Interaction dummy (b)	Endogenous	3.6825	4.1260	0.8930	0.3730
Dummy for period 1960-82	Exogenous	-0.0091	0.0214	-0.4270	0.6700
Dummy for period 1983-92	Exogenous	-0.0009	0.0120	-0.0785	0.9370
Replacement rate	Exogenous	0.0003	0.0003	0.8790	0.3800
Unemployment benefits	Exogenous	0.0024	0.0031	0.7570	0.4490
Active labour market policies	Exogenous	0.0002	0.0003	0.6110	0.5420
Union centralisation	Exogenous	-0.0001	0.0075	-0.0131	0.9900
Union density	Exogenous	0.0007	0.0003	2.6700	0.0080
Tax wedge	Exogenous	0.0001	0.0003	0.4040	0.6860
Coordination	Exogenous	0.0188	0.0100	1.8900	0.0600
Employment protection	Exogenous	0.0009	0.0013	0.6650	0.5060

Notes: Number of observations: 402; (a) refers to an inflation rate below 2%; (b) refers to the product of 'inflation rate below 2%' and 'aggregate unemployment rate'.

Table AI 2: Real unit labour cost Phillips curve (2)

		Coefficient	Std.Error	t-value	t-prob
Constant	Exogenous	0.0058	0.0050	1.0200	0.3070
Unemp. Rate, males, 15-24 years	Endogenous	-2.3038	0.8250	-2.7900	0.0060
Unemp. Rate, males, 25-54 years	Endogenous	0.7857	0.6530	1.2000	0.2300
Unemp. Rate, males, 55-64 years	Endogenous	0.1026	1.3640	0.0700	0.9400
Unemp. Rate, females, 15-24 years	Endogenous	1.0432	0.7020	1.4800	0.1380
Unemp. Rate, females, 25-54 years	Endogenous	0.3218	0.4680	0.6800	0.4930
Unemp. Rate, females, 55-64 years	Endogenous	-1.6632	1.4240	-1.1700	0.2440
Interaction dummy [(a)]	Endogenous	0.3174	0.8453	0.3750	0.7080
Dummy for period 1960-82	Exogenous	0.0103	0.0080	1.2700	0.2050
Dummy for period 1983-92	Exogenous	-0.0117	0.0040	3.1300	0.0020
Northern continental Europe	Exogenous	-0.0126	0.0050	-2.4300	0.0150
Southern continental Europe	Exogenous	-0.0015	0.0050	-0.2800	0.7820
Japan	Exogenous	-0.0115	0.0060	-1.8100	0.0710
Scandinavian countries	Exogenous	-0.0069	0.0050	-1.4100	0.1590

Notes: Number of observations: 403; (a) refers to the product of ‘inflation rate below 2%’ and ‘aggregate unemployment rate’.

Annex II: Observed average inflation differentials in the euro area

Observed inflation differentials are summarised in Table AII, which presents normalised average annual HICP inflation rates in euro area countries, with average euro area inflation set equal to 1.5% (this normalisation is for comparability purposes). Table AII indicates a slight decline in dispersion when only EMU Stage Three years are included. (Sample availability is restricted by starting date of official headline HICP inflation at the country level). Observed inflation differentials may result from a number of factors could explain *inter alia*, differences in countries fiscal stance, differences in national government policies, other than fiscal (e.g. indirect tax and administrative price changes, product and labour markets regulatory frameworks, etc.), sectoral productivity differentials (e.g. in the tradable and non-tradable goods sectors, as formulated in the Balassa-Samuelson framework.[43]) and differences in cyclical positions between countries, which usually imply differences in inflation rates.

Table AII: Observed inflation differentials in the euro area (HICP)

Sample years	(1996-2002)	(1999-2002)
Belgium	-0.1	0.0
Germany	-0.4	-0.4
Greece	2.8	1.0
Spain	0.8	0.8
France	-0.4	-0.5
Ireland	1.1	1.6
Italy	0.6	0.3
Netherlands	0.7	1.0
Austria	-0.4	-0.4
Portugal	0.9	1.0
Finland	0.0	0.2
Average annual HICP inflation in euro area	1.9	2.2
Dispersion	0.8	0.7

5

Downward nominal wage rigidity and the long-run Phillips curve: Simulation-based evidence for the euro area

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1. Introduction and summary

In the case of the euro area, the IMF (2002) and the OECD (2002) have identified the existence of downward nominal wage rigidity as an important argument for maintaining a small positive inflation rate. This argument reflects the widely-held view that a small positive inflation rate may facilitate wage adjustments in an economy in which workers show resistance to nominal wage cuts and, thereby, improve the economy's overall macroeconomic performance.[1]

Central to this argument is the assumption that, in an environment of very low inflation, downward rigidity in nominal wages is likely to be an important feature of wage-setting behaviour. The binding effect of downward nominal wage rigidity will raise the average level of real wages and, thus, impact adversely on aggregate supply. Moreover, firms facing a rise in wage costs will, at least in part, pass on these increased costs to higher prices, which, at the aggregate level, will induce an upward bias in inflation. To the extent that the monetary policy-makers try to keep inflation close to target and counteract the resulting upward bias in the inflation rate, this will lead to a rise in nominal as well as real interest rates and, thereby, to a reduction in aggregate demand. Hence, under the assumption that workers do not learn and change their behaviour over time, the sustainable level of aggregate demand itself depends on the targeted level of inflation.

This paper revisits the importance of the above argument employing stochastic simulations of a small estimated model of the euro area with staggered wage contracts which accounts for downward nominal wage rigidity by restricting the change in nominal contract wages to be non-negative. The following results have emerged from the stochastic simulation exercise:

- With an annual trend rate of productivity growth equal to 1.5 percent, the impact of downward nominal wage rigidity on the determination of inflation and output is noticeable but economically not significant for inflation targets set at 1 percent or higher.
- The magnitude of the induced distortions is increasing in the degree of inflation persistence, but the adverse consequences of downward nominal wage rigidity remain limited with an inflation target of 1 percent even if the degree of inflation persistence is high.
- The asymmetry of wage adjustments arising from downward nominal wage rigidity generates a non-vertical long-run Phillips curve, with output falling increasingly short of potential with lower inflation targets. However, even with an inflation target equal to zero, the output loss is in the order of one-eighths to one-fourths of a percentage point, depending on the degree of inflation persistence.

Although the study provides a number of useful insights into the functioning of the euro area economy in the presence of downward nominal wage rigidity, there are several caveats which seem worth mentioning. First, the study utilises a relatively stylised model of aggregate demand and aggregate supply. As a result, the model does not

[1] For an influential study of the consequences of downward nominal wage rigidity see Akerlof, Dickens and Perry (1996), who present empirical and simulation-based evidence for the U.S. economy. More recently, using data from Switzerland, Fehr and Götte (2000) have shown that downward rigidity of nominal wages may hamper real wage adjustments even in a low-growth environment where workers' resistance to wage cuts is typically considered to be lower.

incorporate an explicit labour market, the existence of which would allow analysing more deeply the effects of nominal wage rigidity on the supply side via its impact on the formation of real wages and the level of employment. Second, the study does not distinguish between alternative features of wage compensation schemes such as bonuses and overtime which may provide additional flexibility regarding wage settlements between workers and firms. Similarly, it disregards the possibility of wage reductions which in principle can be achieved as individual workers change their jobs or re-enter the labour market after earlier displacement. Third, increases in productivity, which generally help to maintain the level of nominal wages of workers, while at the same time providing flexibility to adjust real labour costs, are assumed to be exogenous. Fourth, the study assumes throughout that monetary policy-makers follow a standard Taylor rule which very likely is not optimal, especially when the degree of downward nominal wage rigidity is high. Finally, the study does not address the particular challenges which may arise from the existence of downward nominal wage rigidity in a possibly heterogeneous monetary union.[2]

Taken together, these caveats underline the need to conduct further studies, employing alternative models and methods, to obtain a deeper understanding of the relevance of downward nominal wage rigidity for monetary policy-making in the euro area.

The remainder of the paper is organised as follows. Section 2 briefly describes how downward nominal wage rigidity is incorporated in an otherwise linear macroeconomic model of the euro area satisfying monetary super-neutrality. Utilising this augmented model, Section 3 investigates the impact of downward nominal wage rigidity on the determination of inflation and output by employing stochastic dynamic simulations. In this context, the existence of a non-vertical long-run Phillips curve is shown.

2. Downward nominal rigidity in wage-setting behaviour: A macroeconomic perspective

In the paper, the possible consequences of downward nominal wage rigidity are assessed from a purely macroeconomic perspective. Specifically, the study utilises two variants of the estimated small structural model of the euro area developed by Coenen and Wieland (2000) which feature different types of staggered wage contracts:[3] the nominal wage contracting specification due to Taylor (1980) and the relative real wage contracting specification by Fuhrer and Moore (1995).

As explained in more detail in the companion paper of Coenen (2003), the two contracting specifications differ with respect to the degree of inflation persistence that

[2] Regarding the euro area, for instance, both the IMF (2002) and the OECD (2002) have stressed that downward nominal wage rigidity may seriously hamper relative wage adjustments among Member States in response to cross-country differences in economic activity. In the same vein, it has been argued that downward nominal wage rigidity may render it more difficult for Member States to bring about improvements in their relative competitiveness.

[3] A short description of the two alternative contracting specifications, allowing for productivity growth, is given in the appendix For more details on the model used and the employed estimation methodology see Coenen and Wieland (2000) who refer to the two contracting specifications as the NW and the RWS specification respectively. Within the model, monetary policy-makers are assumed to follow an interest rate rule that relates the short-term nominal interest rate to developments in inflation and deviations of actual output from potential. Changes in the short-term nominal interest rate affect aggregate demand through their impact on the ex-ante long-term real interest rate.

they induce, with Fuhrer-Moore-type contracts giving more weight to past inflation developments compared to Taylor-type contracts. To the extent that there are different set-ups of labour market institutions in EMU Member States which translate into different degrees of inflation persistence, the use of the two alternative contracting specifications may possibly shed some light on the particular dimension of the existence of downward nominal wage rigidities in the context of a monetary union.

The non-negativity constraint on nominal wage adjustments is enforced ex post by restricting the change in the nominal contract wage, Δx, to be equal to zero whenever the relevant wage contracting specification prescribes a cut in the wage level, x. In this context, the wage contract prescribed by the contracting specification may be seen as the *notional* contract wage, while the actually *signed* contract reflects workers' resistance to wage cuts.[4] It is important to note that due to the staggering of wage contracts, only a subset of nominal wages is adjustable at a given point in time. This may help reconcile the macroeconomic perspective of this study with the empirical observation that only a fraction of workers is eventually exposed to the threat of wage cuts at a given point in time.

In the steady state of the model, the rate of change in the nominal contract wage, Δx, is determined by the monetary policy-makers' inflation target, π^*, and the trend rate of productivity growth, $\Delta\lambda$. Of course, the higher the inflation target and/or the trend rate of productivity growth, the smaller should be the likelihood that the non-negativity constraint on nominal wage adjustments is binding. As a baseline assumption, the annual trend rate of productivity growth is set equal to 1.5 percent throughout the study, while the consequences of downward nominal wage rigidity is explored for alternative levels of the inflation target.[5]

3. The impact of downward wage rigidity on the stationary distributions of inflation and output

This section evaluates the quantitative impact of the imposed non-negativity constraint on nominal wage growth on the stationary distributions of inflation and output by employing stochastic dynamic simulations for alternative inflation targets that fall in a range between 0 and 4 percent.[6] To this end, the structural model is subjected repeatedly to a sequence of shocks which are drawn from a normal distribution with the covariance matrix of the shocks estimated using historical data. Throughout these counter-factual simulations, monetary policy is assumed to follow the rule proposed by Taylor (1993)

[4] The two contracting specifications were estimated by Coenen and Wieland (2000) without incorporating downward nominal wage rigidity explicitly. To account for the possible consequences of downward rigidity on the wage-setting behaviour at the empirical level, a model with more explicit microfoundations that distinguishes between alternative features of wage compensation schemes will be helpful. For example, flexibility regarding bonuses and overtime may become increasingly important if the likelihood of the non-negativity constraint becoming binding is high.

[5] Since productivity is assumed to follow a deterministic log-linear trend, productivity growth is constant. It would be interesting to allow for endogenous determination of productivity. This, however, is beyond the scope of this study.

[6] For further details on the preparations for the simulations the reader is referred to the companion paper of Coenen (2003). Again, the simulations have been conducted using an efficient solution algorithm implemented in the PcTroll software package which can cope with the non-linearity arising from the non-negativity constraint on nominal wage adjustments.

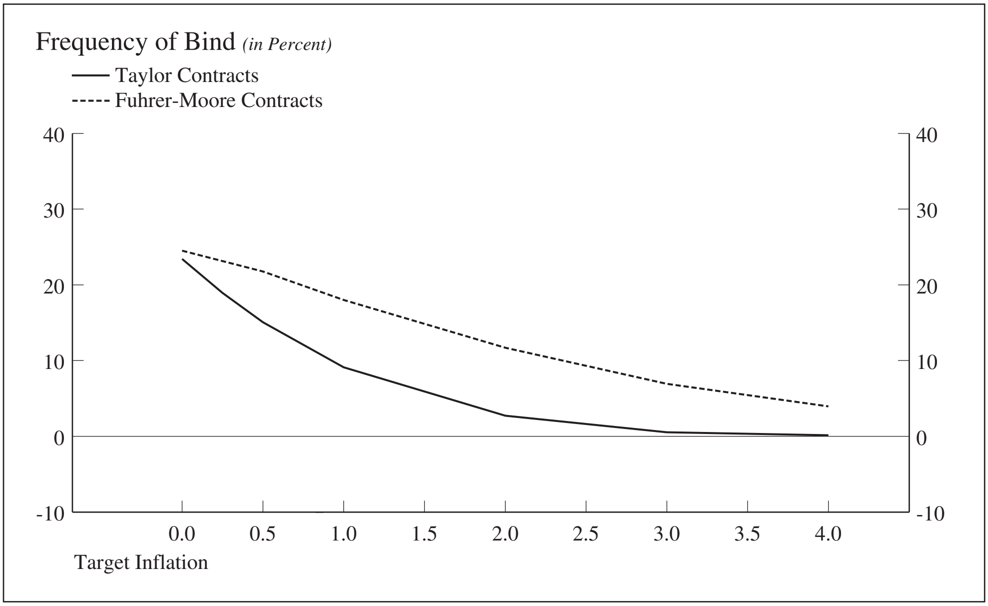
which relates the nominal interest rate to deviations of annual inflation from the inflation target and deviations of output from its potential, with the response coefficients set equal to 1.5 and 0.5, respectively.

3.1 The frequency of bind of the non-negativity constraint on nominal wage adjustments

To evaluate whether the non-negativity constraint on nominal wage adjustments has quantitatively significant effects, the study starts by assessing the likelihood that downward wage adjustments would be constrained by workers' resistance to wage cuts if the economy were subjected to shocks similar in magnitude to those observed historically. Summarising the results of a large number of counterfactual stochastic simulations with alternative inflation targets, **Figure 1** shows the frequency with which the non-negativity constraint would hamper downward wage adjustments. The solid line refers to the model with Taylor-type wage contracts while the dashed line refers to the model with Fuhrer-Moore-type contracts.

As is evident in the figure, under Taylor-type wage contracts the non-negativity constraint on wage adjustments does not represent a quantitatively very important factor for inflation targets set at 1 percent or higher. With an inflation target of 1 percent the constraint becomes binding with about 9 percent frequency, while the frequency of bind falls to less than 3 percent with a target of 2 percent. Although the increase in the frequency of bind is accelerating as the inflation target approaches zero, the frequency of bind remains well below 25 percent. Under Fuhrer-Moore-type contracts the frequency

Figure 1: The frequency of bind of the constraint on wage adjustments



of bind is uniformly higher than under Taylor-type contracts. With an inflation target of 2 percent, for example, the constraint on downward wage adjustments becomes binding with about 12 percent frequency, while the frequency of bind amounts to 18 percent with an inflation target equal to 1 percent.

3.2 The distortion of the stationary distributions of inflation and output

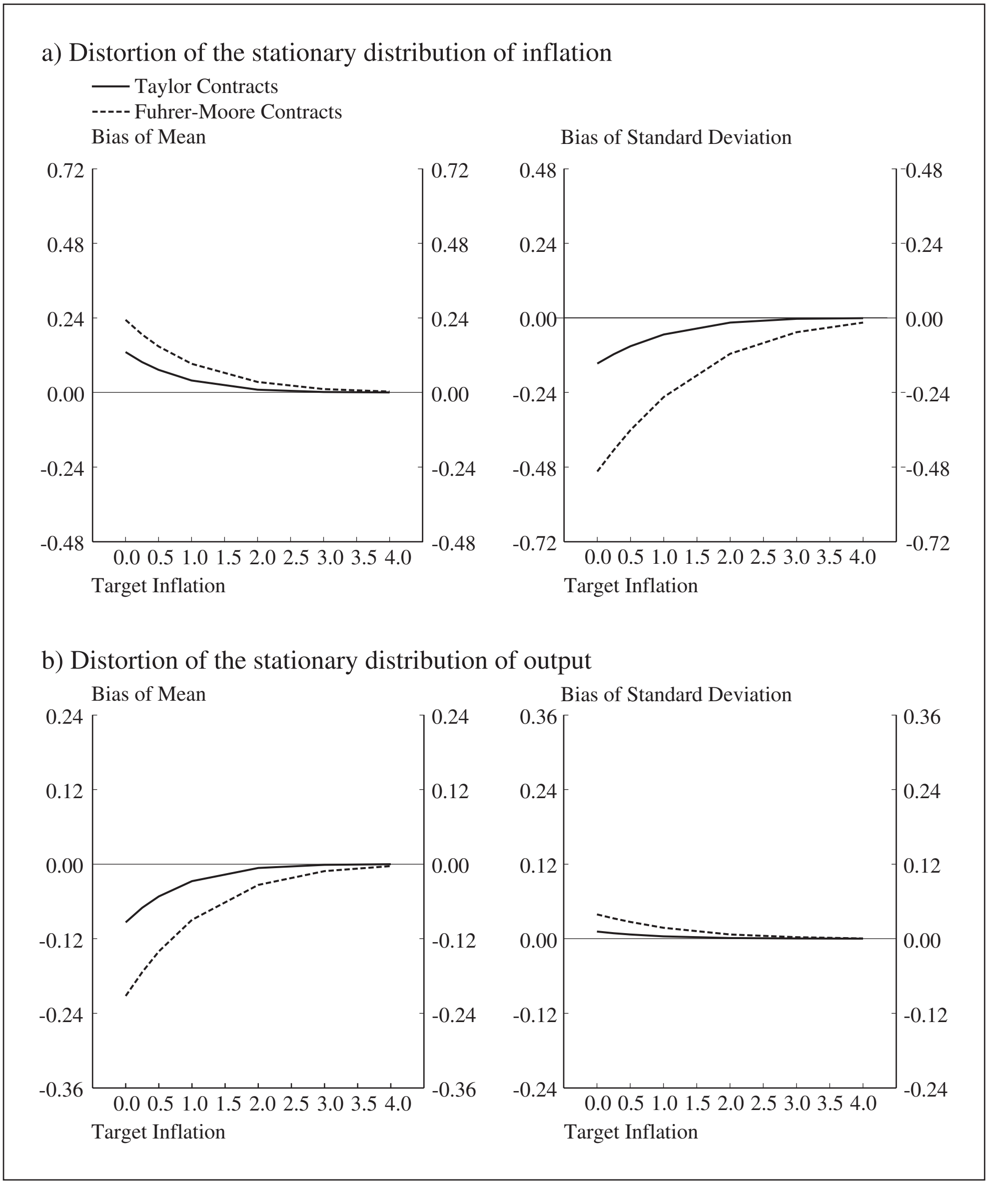
Having provided a quantitative assessment of the likelihood that the non-negativity constraint on wage adjustments becomes binding, the following analysis focuses on the extent to which the behaviour of the annual inflation rate and output are distorted with increased frequency of bind. Quantitative information on the size of the distortion is obtained from the stationary distributions of the variables of interest. These distributions are constructed from the outcomes of the stochastic dynamic simulations with the non-negativity constraint on nominal wage adjustments being imposed.

Figure 2 provides summary information regarding the distortion of the mean and the variability of the variables of interest when the non-negativity constraint on wage growth is imposed. The two panels in the left column of the figure show the induced bias in the means of these variables and the two panels on the right the induced bias in their standard deviations. The benchmarks for comparison are the statistics of the stationary distributions in the absence of the non-negativity constraint on wage adjustments.

Starting with the results for the model incorporating Taylor-type contracts (solid lines), it can be seen in the upper left panel of **Figure 2** that the non-negativity constraint introduces a noticeable upward bias in the mean of the inflation rate for inflation targets near zero. This upward bias comes about as the result of the assumed mark-up policies of firms which pass on to higher prices the increased wage costs due to the occasionally binding non-negativity constraint on wage changes. At the same time, as indicated in the lower left panel, the mean of output is biased downwards, the reason being that the monetary policy-makers try to keep inflation close to target and counteract the resulting upward bias in the inflation rate by raising the nominal interest rate. This will lead to a rise in the real interest rate and, thereby, to a fall in aggregate demand below potential. The quantitative effects, however, are fairly small for inflation targets set at 1 percent or higher. For example, with an inflation target equal to 1 percent, average inflation exceeds the target by 0.04 percentage points, while average output falls short of potential by 0.03 percentage points. With the inflation target approaching zero, the upward bias in average inflation rises to 0.13 percentage points, while the shortfall in average output amounts to 0.10 percentage points. The non-negativity constraint on nominal wage adjustments also introduces a noticeable downward bias in the standard deviation of inflation, while the emerging upward bias in the standard deviation of output appears negligibly small.

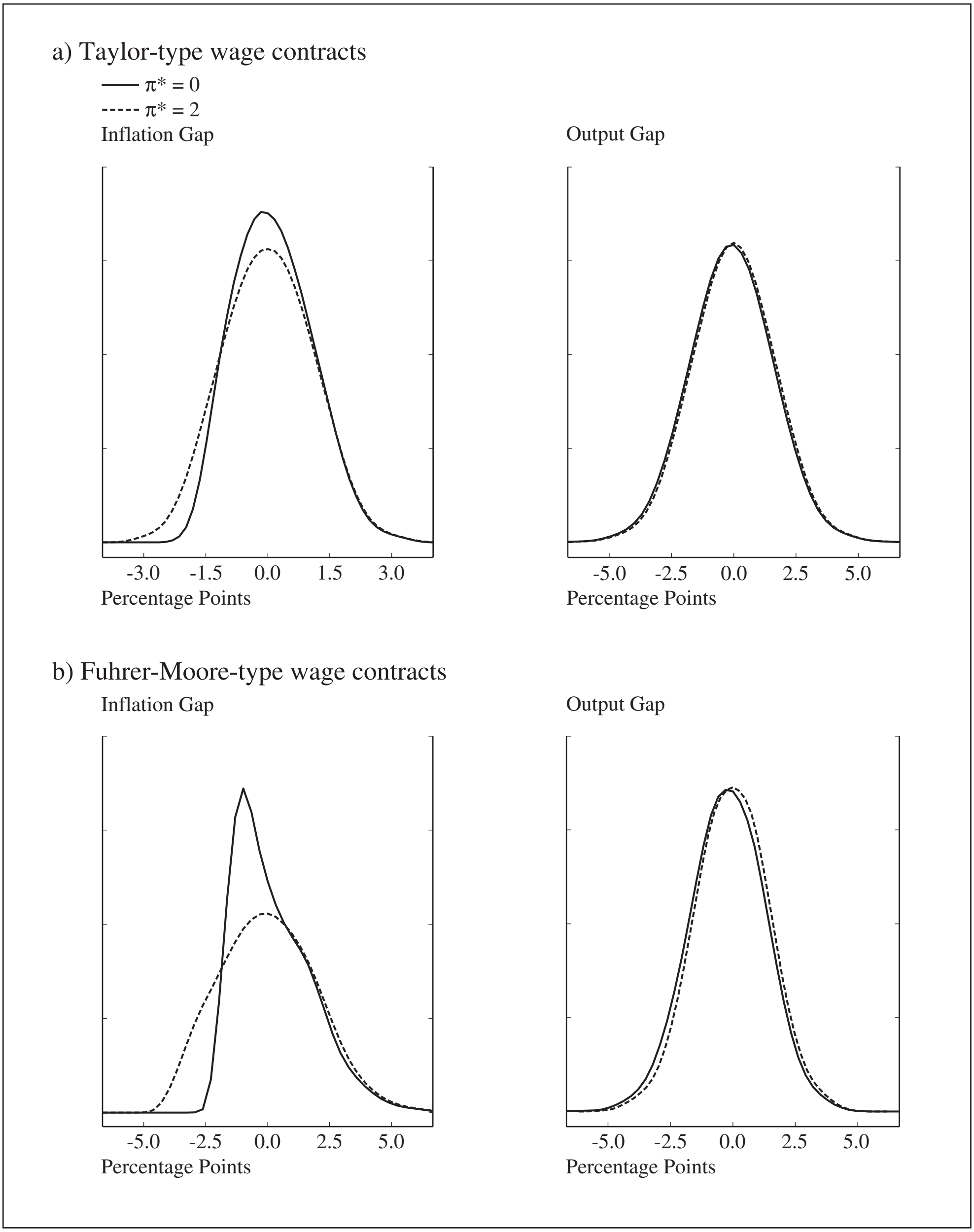
Turning to the results obtained under Fuhrer-Moore-type contracts (dashed lines), the two panels in the left column of **Figure 2** reveal that a more significant bias materialises with respect to the means of both inflation and output if the degree of inflation persistence is high. Under Fuhrer-Moore-type contracts and with an inflation target equal to 1 percent, for example, average inflation exceeds the inflation target by about 0.10 percentage points, while average output falls short of potential by 0.09 percentage points. Similarly, the magnitude of the bias in the standard deviations of inflation and output turns out to be larger by a factor of 2 to 3 if the degree of inflation persistence is high.

Figure 2: The distortion of the stationary distributions of inflation and output



Finally, the solid and dashed lines in **Figure 3** depict the probability density functions of the inflation gap and the output gap with inflation targets of 0 and 2 percent, respectively. As shown by the two panels in the left column of the figure, with an inflation target equal to zero, the probability mass from the left tail of the inflation distribution is noticeably shifted towards its centre, with the distortion under Fuhrer-Moore-type contracts being significantly larger than under Taylor-type contracts. In fact, under the contracting specification by Fuhrer and Moore the probability mass is markedly piled up in the negative region of the inflation distribution. This is consistent with the finding of a more substantial upward bias in the mean rate of inflation, together with a strong downward bias in its standard deviation, as documented in **Figure 2**.

Figure 3: The stationary distributions of the inflation gap and the output gap

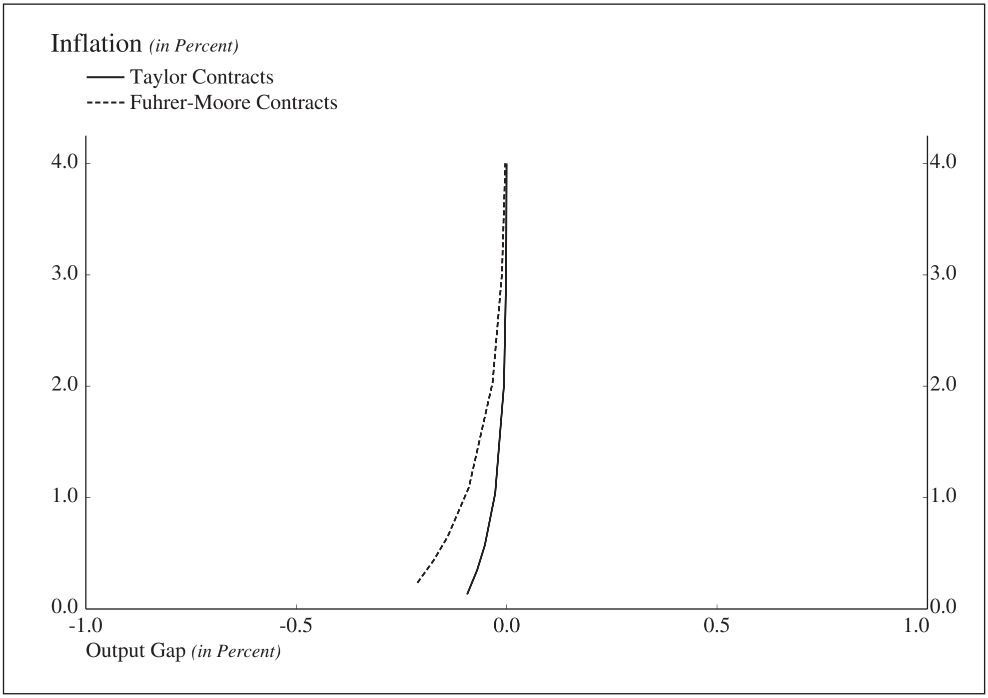


Apparently, the occurrence of larger distortions under Fuhrer-Moore-type contracts reflects that the higher degree of inflation persistence induced by this type of contracts also translates into a larger unconditional variance of inflation. By contrast, as indicated by the two panels in the right column of **Figure 3**, the distortion of the output distribution is rather small under either of the two contracting specifications, although the distortion under Fuhrer-Moore-type contracts is yet again perceptibly larger than under Taylor-type contracts.

3.3 The existence of a non-vertical long-run Phillips curve

The presence of downward nominal wage rigidity invalidates the long-run super-neutrality of monetary policy that obtains in the linear version of the wage contracting models. The relationship between the average level of inflation and the average level of output that is due to the non-negativity constraint on nominal wage adjustments implies the existence of a non-vertical long-run Phillips curve in these models. This is shown in **Figure 4** which plots the upward sloping relationship between average inflation and the average output gap, with output falling increasingly short of potential with lower inflation targets. However, the slope of the long-run Phillips curve induced by downward nominal wage rigidity is only noticeable at average inflation rates below 1 percent. In the extreme case with an inflation target equal to zero, the maximum output loss is in the order of one-eighths to one-fourths percentage point, depending on the degree of inflation persistence.

Figure 4: The non-vertical long-run Phillips curve



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Appendix: The staggered wage contracting specifications

The staggered contracts models of Taylor (1980) and Fuhrer and Moore (1995) assume that workers negotiate long-term nominal wage contracts by comparing the current wage contract to past contracts that are still in effect and future contracts that will be negotiated over the life of this contract. As a result, only a subset of nominal wage contracts is adjustable at a given point in time. The distinction between Taylor and Fuhrer-Moore-type wage contracts concerns the definition of the wage indices that form the basis of this comparison.

Taylor-type wage contracts:

Under Taylor's specification, the nominal wage contract, x_t, is negotiated with reference to the price level that is expected to prevail over the life of the contract, p_{t+i}, adjusted for the expected deviations of output from its potential over this period, y_{t+i}, and the level of productivity, λ_t,

$$x_t = \mathrm{E}_t\left[\sum_{i=0}^{3} f_i p_{t+i} + \gamma \sum_{i=0}^{3} f_i y_{t+i}\right] + \lambda_t$$

where the aggregate price level, p_t, is expressed as the weighted average of productivity deflated current and previously negotiated contract wages, p_{t-i}, which are still in effect,

$$p_t = \sum_{i=0}^{3} f_i (x_{t-i} - \lambda_{t-i}) + \tilde{\varepsilon}_t$$

with $f_i > 0$, $f_i > f_{i+1}$ and $\sum_i f_i = 1$.

The expectation operator $\mathrm{E}_t[\cdot]$ indicates the optimal forecast of a particular variable conditional on all information available in period t and the white-noise shock $\tilde{\varepsilon}_t$ summarises other short-term influences.

Since the price indices p_{t+i} reflect contemporaneous and preceding contract wages, Taylor’s contracting specification implies that wage setters look at an average of overlapping nominal contract wages negotiated in the recent past and expected to be negotiated in the near future when setting the current contract wage. If wage setters expect output to exceed potential, $y_{t+i} > 0$, they adjust the current contract wage upwards relative to overlapping contracts. The parameter γ measures the sensitivity of contract wages to excess demand.

Fuhrer-Moore-type wage contracts:

Under the specification by Fuhrer-Moore, workers negotiating their nominal wage contract compare the implied productivity deflated real wage with the productivity deflated real wages on overlapping contracts in the recent past and near future. This specification implies that the real wage under contracts signed in the current period is set with reference to an average of real contract wage indices expected to prevail over the current and the next three quarters, v_{t+i},

$$x_t - p_t - \lambda_t = \mathrm{E}_t\left[\sum_{i=0}^{3} f_i v_{t+i} + \gamma \sum_{i=0}^{3} f_i y_{t+i}\right]$$

where

$$v_t = \sum_{i=0}^{3} f_i (x_{t-i} - p_{t-i} - \lambda_{t-i}) \, .$$

6

Zero lower bound: Is it a problem in the euro area?

Günter Coenen*

* Helpful discussions with Ignazio Angeloni, Frank Smets and Volker Wieland are gratefully acknowledged.

1. Introduction and summary

Having achieved consistently low rates of inflation, monetary policy-makers in industrialised countries are confronted with a new challenge, namely how to evade the consequences arising from the zero lower bound on nominal interest rates. In an environment of low inflation the zero lower bound presents a particular challenge for monetary policy-makers because it may limit the usefulness of the principal instrument of monetary policy, that is the short-term nominal interest rate, to lower real interest rates. Even worse, with nominal interest rates constrained at zero, a sequence of deflationary shocks may raise real interest rates and thereby induce or deepen a recession.

This paper revisits the relevance of the zero lower bound for monetary policy-making in the euro area.[1] In consideration of the high degree of uncertainty regarding the determination of euro area-wide inflation, the implications of the zero lower bound are evaluated under different assumptions regarding the characteristics of the euro area inflation process, notably the degree of its persistence. While the degree of inflation persistence is evidently a key determinant of the ability of monetary policy-makers to stabilise inflation relative to output, the importance of the existing degree of inflation persistence seems even heightened when facing the zero lower bound.

For this reason, the evaluation is based on two variants of the estimated small structural model of the euro area developed by Coenen and Wieland (2000) which feature different types of staggered contracts:[2] the nominal wage contracting specification due to Taylor (1980) and the relative real wage contracting specification by Fuhrer and Moore (1995). These two contracting specifications differ with respect to the degree of inflation persistence that they induce, because Fuhrer-Moore-type contracts give more weight to past inflation developments. Both types of contracting specifications were found to describe historical euro area data reasonably well and, thus, neither Taylor nor Fuhrer-Moore-type contracts can be rejected on statistical grounds as an empirical description of inflation dynamics in the euro area.[3]

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[1] Orphanides and Wieland (1998) and Reifschneider and Williams (1999) provided earlier quantitative studies of the relevance of the zero lower bound for monetary policy-making, but these studies were focused on the U.S. economy.

[2] A short exposition of the two alternative contracting specifications is given in the appendix. For more details on the model and the employed estimation methodology see Coenen and Wieland (2000) who refer to the two contracting specifications as the NW and the RWS specification respectively. Within the model, monetary policy-makers are assumed to follow an interest rate rule that relates the short-term nominal interest rate to developments in inflation and deviations of actual output from potential. Changes in the short-term nominal interest rate affect aggregate demand through their impact on the ex-ante long-term real interest rate.

[3] There are other mechanisms which have been proposed in the literature as means to induce lag-dependent inflation dynamics. For example, Galí and Gertler (1999) allow for a fraction of backward-looking firms in the staggered nominal contracts model à la Calvo, which follow a “rule of thumb” when changing contracts, while Christiano, Eichenbaum and Evans (2001) assume that nominal contracts are indexed to past prices. Empirical studies for the euro area by Galí, Gertler and Lopez-Salido (2001) and Smets and Wouters (2002) along these directions also conclude that there is a non-negligible degree of persistence in the euro area inflation process, though it is difficult to quantify this degree precisely.

The following results have emerged from the model-based evaluation of the consequences of the zero lower bound for monetary policy-making in the euro area:

- Under Taylor's interest rate rule, the distortions induced by the zero-interest-rate bound are noticeable but economically insignificant once the inflation target is set at 1 percent or higher, if the degree of inflation persistence is low (as represented by Taylor's contracting specification). By contrast, if the degree of inflation persistence is high (as represented by Fuhrer-Moore-type contracts), the zero lower bound may become a matter of concern for monetary policy-makers who follow Taylor's rule with inflation targets below 2 percent.
- Additional sensitivity analysis provides some tentative evidence that the adverse consequences of the zero-bound constraint can be alleviated by following an interest rate rule that allows for a substantial degree of inertia – as estimated Taylor-type rules typically do – and responds in a forward-looking manner to one-year ahead forecasts of inflation. The benefits of such a rule appear particularly large if the observed degree of inflation persistence is high.

Overall, these model-based results suggest that the performance of the euro area economy would likely deteriorate somewhat for inflation targets set below 1 percent. The importance of the deterioration is found to depend on the existing degree of inflation persistence, the specification of the interest rate rule and, not least, the level of the equilibrium real interest rate which, as a baseline assumption, has been set equal to 2 percent throughout the study.

However, while being suggestive, the model-based results call for some further considerations before finally judging the risks and costs arising from the zero-interest-rate bound. First, while clearly pointing to the need of having a "safety margin" to insure the economy against the adverse consequences of the zero bound, the study disregards the costs of tolerating even limited rates of inflation. Apparently, in the absence of distortions like the one due to the zero bound there are good reasons to believe that inflation should be close to zero to reap the full benefits of maintaining price stability. These costs have to be weighed against the costs arising from the zero lower bound.

Second, while Fuhrer-Moore-type wage contracts point to heightened risks and costs, it is not obvious that this type of contracting specification is the most plausible one to describe the determination of euro area-wide inflation in the future. For instance, Coenen and Wieland (2000) show that only Taylor-type contracts fit inflation dynamics for Germany which already enjoyed a credible and predictable monetary policy before joining EMU, while some member countries which experienced a long-lasting disinflation with possibly imperfectly credible monetary policy were better described by Fuhrer-Moore-type contracts. Thus, to the extent that the ECB will likely face a similar environment in the future as did the Bundesbank in Germany, the use of Fuhrer-Moore-type contracts would be considered misleading. In this case, Taylor's contracting specification may be viewed as a more appropriate representation of inflation dynamics in the euro area implying lower risks regarding the zero lower bound.[4]

[4] As already indicated in footnote 3, for the time being there is not sufficient information available to reliably discriminate between alternative models of euro area-wide inflation determination and, thus, the need of further empirical work on inflation dynamics in the euro area ranks high.

Third, relevant to both types of staggered contracts specifications, the reported results may possibly underestimate the true risks arising from the zero lower bound, because fiscal policy is assumed to occasionally boost aggregate demand during sustained periods of deflation to prevent the economy from falling into a deflationary spiral. In the context of this study, such fiscal impetus is necessary because the model economies are not globally stable in the presence of shocks that are large enough to sustain deflationary expectations and to keep the real interest rate above its equilibrium level. However, while resorting to occasional fiscal interventions is analytically convenient to cope with the growing aggregate demand imbalances associated with entrenched deflation, nothing guarantees a priori that such a mechanism would be available in practice.

Fourth, from a conceptual point of view, it may be possible to abate the risks and costs arising from the zero lower bound by further improving the design of monetary policy. For example, monetary policy-makers may lower interest rates pre-emptively when inflation and interest rates have fallen close to zero and the risk of deflation is high. In other words, they may respond more aggressively if they anticipate that the zero-bound constraint will become binding in the near future. Such a non-linear policy response can in principle help offset the distortions arising from the zero lower bound.

Fifth, the variances of the historical shocks used in the model-based evaluation were estimated for the 1980s and 1990s, when the shocks to aggregate demand and aggregate supply were less disruptive than in the 1970s and the zero lower bound never became binding. If the shocks were to be significantly larger, like in a period of substantial economic and/or financial turmoil, the likelihood of hitting the zero lower bound might be far higher and possibly result in substantially larger distortions. By contrast, the baseline assumption of 2 percent for the equilibrium real interest rate is at the lower end of historical estimates. If the assumption for the equilibrium real rate were higher, say, closer to 3 percent, the likelihood that the nominal interest rate is constrained at zero would be correspondingly lower.

Finally, the model that has been used in the analysis is relatively stylised and lacks various mechanisms which may become important to characterise the functioning of the economy in a severe deflationary situation. For example, the model used does not account for the effects operating through the balance sheets of banks, households and non-financial firms which may aggravate the implications of the zero lower bound and re-enforce deflationary trends, as has become most apparent in Japan in the second half of the 1990s. Another limitation to the analysis is that the model relies on the real interest rate as the sole channel to stimulate aggregate demand. In principle, monetary policy-makers can also resort to alternative measures in order to avoid or if necessary to escape deflation. For example, as shown in Coenen and Wieland (2003), they may exploit the exchange rate channel of monetary policy to stimulate aggregate demand and re-inflate the economy via a drastic depreciation of the domestic currency.

The remainder of the paper is organised as follows. Section 2 gives a brief outline of the simulation methodology which is used to investigate the consequences of the zero lower bound for monetary policy-making. Section 3 assesses the frequency of bind of the zero lower bound and investigates the induced effects on the stationary distributions of the short-term nominal interest rate, annual inflation and output. Finally, Section 4 provides some additional sensitivity analysis regarding the robustness of the simulation results to the specification of the monetary policy rule.

2. The methodology

In terms of methodology, the study builds on previous work by Orphanides and Wieland (1998) evaluating the consequences of the zero lower bound using a model of the U.S. economy with a similar, albeit more detailed structure. This methodology employs stochastic dynamic simulations of a particular structural model to assess the frequency with which the nominal interest rate is bounded at zero and to obtain the stationary distributions of key macroeconomic variables under monetary policy rules with alternative inflation targets. To this end, the structural model is subjected repeatedly to a sequence of structural shocks which are drawn from a normal distribution with the covariance matrix of the shocks estimated using historical data.

In preparation for the simulations of the two variants of the small-scale euro area model used in this study the implied sequences of temporary demand and supply shocks have been computed based on euro area data from 1980:Q1 to 1998:Q4. Using the covariance matrix of these historical shocks, 100 sets of artificial normally distributed shocks have been generated with 100 quarters of shocks in each set. For each set, the first 20 quarters of shocks have been discarded in order to guarantee that the effect of the initial values die out. The sets of retained shocks are then used to conduct stochastic simulations under alternative values of the policy-makers inflation target, while imposing the zero-bound constraint on nominal interest rates.[5]

While the non-stochastic version of an estimated interest rate rule has been used for computing the historical demand and supply shocks,[6] it is replaced in the dynamic simulations with the rule proposed by Taylor (1993),[7]

$$i_t = r^* + \pi^* + 1.5 \cdot (\pi_t^{(4)} - \pi^*) + 0.5 \cdot y_t$$

where i is the short-term nominal interest rate, $\pi^{(4)}$ is the annual, year-on-year inflation rate, y is the output gap, π^* denotes the monetary policy-makers' inflation target which determines the steady-state rate of inflation in the model and r^* is the equilibrium real interest rate which is exogenous to the model like the supply side determining potential output. This rule incorporates policy responses to inflation deviations from target and output deviations from its potential. The zero lower bound on the short-term nominal interest rate is then enforced by restricting the interest rate to be equal to zero whenever the Taylor rule prescribes to set it below zero.

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[5] The simulations have been conducted using an efficient solution algorithm implemented in the PcTroll software package which can cope with the non-linearity arising from the zero-bound constraint on nominal interest rates.

[6] Since weighted averages of European interest rates preceding the formation of European Monetary Union in 1999 seem unlikely to be appropriate as a measure of the euro area-wide historical monetary policy stance, a reaction function for the German short-term nominal interest rate has been estimated. After all, movements in German interest rates eventually had to be mirrored by the other European countries to the extent that they intended to maintain exchange rate parities within the European Monetary System. Following work by Clarida, Galí and Gertler (1998), the estimated rule assumes that the short-term nominal interest rate is changed in response to variations of the one-year-ahead forecast of annual average inflation and the current output gap, and also allows for interest-rate smoothing. The estimation period is chosen to start in 1979:Q2, with the formation of the European Monetary System, and ends in 1998:Q4, prior to the launch of the euro in January 1999.

[7] For a critical discussion of the uses of Taylor-style interest rate rules for practical monetary policy-making see ECB (2001).

Of course, the higher the inflation target π^* and/or the equilibrium real interest rate r^*, the higher will be the nominal interest rate in the deterministic steady state and the smaller should be the likelihood that the nominal interest rate is bounded at zero. As a baseline assumption and without loss of generality, the equilibrium interest rate r^* is set equal to 2 percent throughout the study while the consequences of the zero-bound constraint is explored for alternative levels of the inflation target π^*. For a reader who suspects that the level of the equilibrium real interest rate r^* has been higher historically, it should be noted that changes in one parameter can be offset by changes in the other. For example, the results for π^* equal to 1 percent with a baseline assumption of r^* equal to 2 percent also describe the outcome in an economy with r^* equal to 3 percent when π^* is equal to zero.

To ensure the stability of the model with the zero-bound constraint imposed in the presence of large deflationary shocks, a non-linear fiscal expenditure rule is introduced which boosts aggregate demand if the deflationary impetus becomes so severe that the model economy runs the risk of falling into a deflationary spiral.[8] At the same time, if the economy experiences favourable economic conditions over a prolonged period of time, the fiscal rule acts as a drag on aggregate demand in order to support a fiscal position that is close to balance over sufficiently long horizons.[9]

3. The consequences of the zero lower bound on nominal interest rates

This section evaluates the quantitative impact of the zero lower bound on the stationary distributions of key macroeconomic variables such as the short-term nominal interest rate, the annual inflation rate and output by summarising the results of the stochastic dynamic simulations of the two variants of the euro area model for alternative inflation targets that fall in a range between 0 and 4 percent.

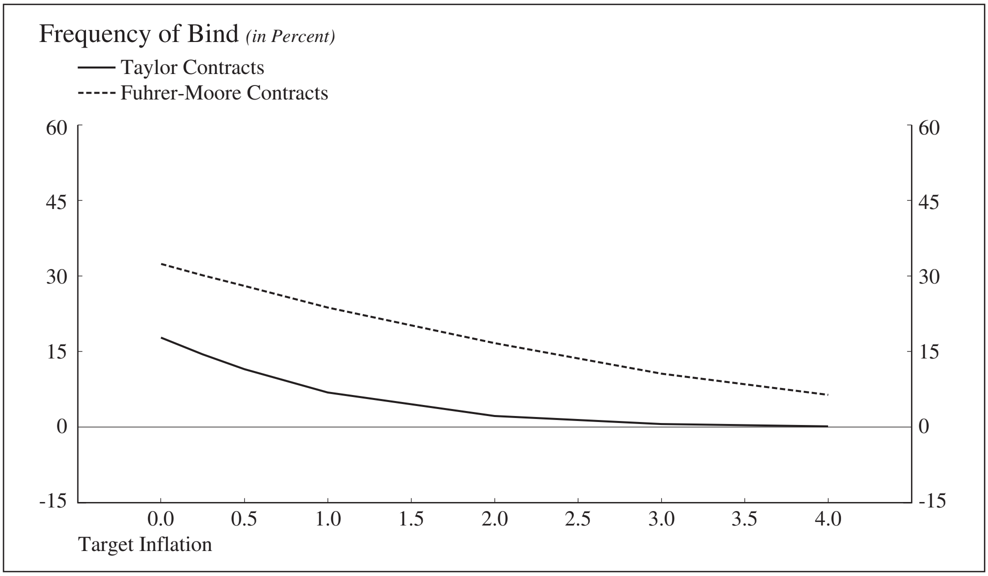
3.1 The frequency of bind of the zero lower bound

To evaluate whether the zero lower bound may limit the effectiveness of monetary policy in a quantitatively significant manner, it is useful to start by assessing the likelihood that nominal rates would be bounded at zero if the economy were subjected to shocks similar in magnitude to those observed historically. Summarising the results of a large number

[8] See Orphanides and Wieland (1998), pp. 27-28, and Reifschneider and Williams (1999), pp. 21-22, for a more detailed discussion of the need to resort to mechanisms such as occasional fiscal interventions to resolve the global instability problem that arises from shocks that are large enough to sustain deflationary expectations and to keep the real interest rate above its equilibrium level, thereby depressing aggregate demand further and sending the economy in a deflationary spiral.

[9] The extent of the fiscal stimulus is related to the deviation of the actual short-term nominal interest rate i_t (which cannot fall below zero) from the *notional* rate i_t^n that would be prescribed by Taylor's rule in the absence of the zero bound. The fiscal stimulus comes into play with a half-year delay and responds to a moving average of negative deviations of the prescribed interest rate from zero. Government expenditure is restrained in a similar fashion whenever the economy experiences very favourable economic conditions, i.e., in a situation when actual output is so far above potential that the interest rate rule prescribes a rate of more than twice the deterministic steady-state value.

Figure 1: Frequency of bind of the zero lower bound on nominal interest rates under Taylor's rule



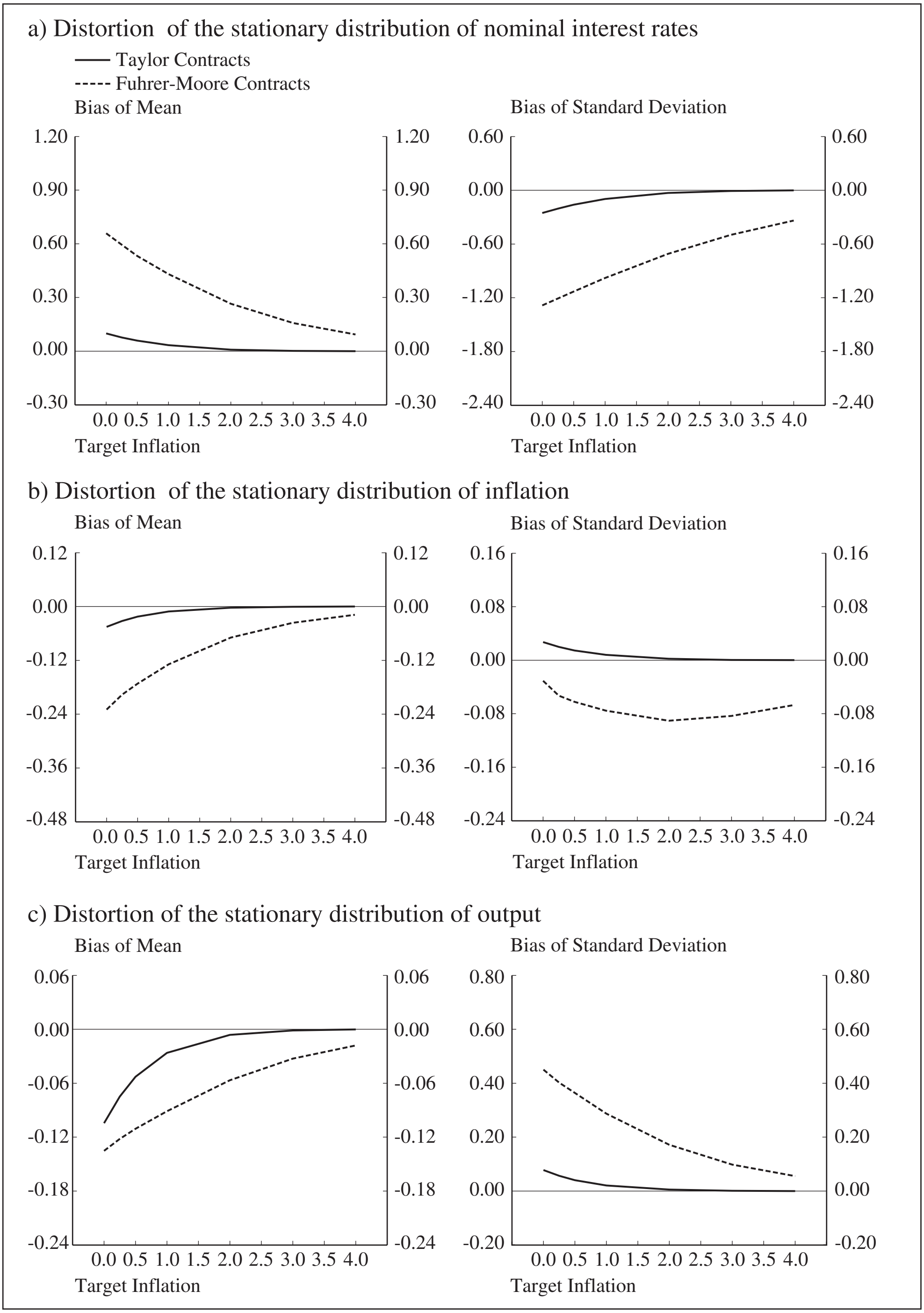
of counterfactual stochastic simulations with alternative inflation targets, **Figure 1** shows the frequency with which the zero lower bound would constrain the monetary policy-makers to set the nominal interest rate below zero if they were to follow Taylor's rule. The solid line refers to the model with Taylor-type contracts while the dashed line refers to the model with Fuhrer-Moore-type contracts.

As is evident in the figure, under Taylor-type wage contracts the zero lower bound on nominal interest rates does not represent a quantitatively very important factor for inflation targets set at 1 percent, or higher. For monetary policy-makers following Taylor's rule the zero-bound constraint becomes binding with less than 7 percent frequency with an inflation target of 1 percent. With a target of 2 percent the frequency of bind falls to 2 percent while it is quickly approaching zero for inflation targets exceeding 2 percent. Although the frequency of bind increases considerably as the inflation target approaches zero, the frequency of bind remains well below 20 percent. By contrast, under Fuhrer-Moore-type wage contracts the constraint induced by the zero lower bound is quantitatively much more important. With an inflation target of 1 percent, the constraint becomes binding with about 24 percent frequency, and the frequency approaches 33 percent with an inflation target equal to zero. Even with an inflation target of 2 percent the frequency of bind amounts to 17 percent.

3.2 The distortion of the stationary distributions of the nominal interest rate, inflation and output

Having provided a quantitative assessment of the likelihood that the nominal interest rate is bounded at zero under Taylor's rule, the following analysis focuses on the extent to which the behaviour of the short-term nominal interest rate, annual inflation and

Figure 2: Distortion of the stationary distributions under Taylor's rule



output are distorted with increased frequency of zero interest rates. Quantitative information on the size of the distortion is obtained from the stationary distributions of the variables of interest. These distributions are constructed from the outcomes of the stochastic dynamic simulations with the zero bound being enforced.

Figure 2 first provides summary information regarding the distortion of the means and the variability of the variables of interest under the zero-bound constraint. Specifically, the three panels in the left column of the figure show the induced bias in the means of these variables and the three panels on the right the induced bias in their standard deviations. The benchmarks for comparison are the statistics of the stationary distributions in the absence of the zero-bound constraint, or – equivalently – when the inflation target is sufficiently high such that the frequency of bind is essentially zero.

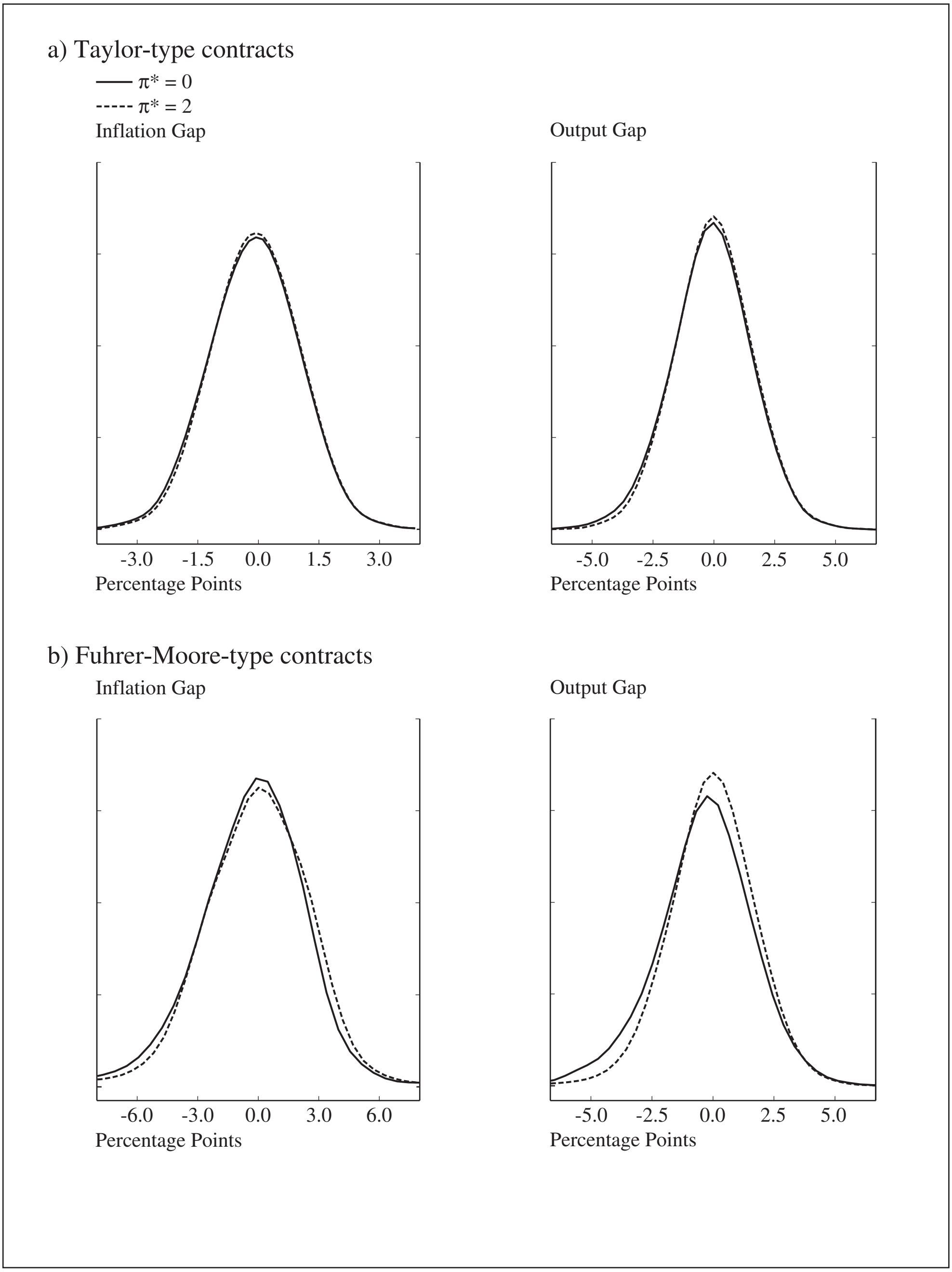
Starting with the results for the model incorporating Taylor-type wage contracts (solid lines), it can be seen in the upper left panel of **Figure 2** that the zero-bound constraint introduces a small upward bias in the mean of the nominal interest rate for inflation targets near zero. As a consequence, the monetary policy stance is tighter on average than in the absence of the constraint. This, in turn, results in a downward bias in the means of output and inflation, as indicated in the bottom and middle panels on the left, respectively. The quantitative effects, however, are fairly small even with an inflation target equal to zero, with output falling short of potential by 0.10 percentage points on average and with inflation falling below target by 0.05 percentage points on average. The zero-bound constraint also introduces a small upward bias in the standard deviations of inflation and output, because it impairs the policy-makers' ability to stabilise the economy.

Turning to the results for the model with Fuhrer-Moore-type wage contracts (dashed lines), the upper panel in the left column of **Figure 2** shows that a substantially larger upward bias in the mean of the short-term nominal interest rate emerges if the degree of inflation persistence is high. Similarly, the middle panel in the left reveals that a more sizeable downward bias materialises regarding the mean of inflation. With an inflation target of zero, average inflation falls below target by about 0.23 percentage points; and even with an inflation target of 2 percent the downward bias in the mean of inflation amounts to –0.07 percentage points. Interestingly, the downward bias in the mean of output is only a little larger than under Taylor-type wage contracts. Apparently, this reflects the more recurrent need to resort to fiscal interventions in order to prevent the economy from falling into a deflationary spiral. The more recurrent need to resort to additional fiscal stimulus may also explain the observed downward bias in the standard deviation of inflation.

Finally, the solid and dashed lines in **Figure 3** depict the probability density functions of the inflation gap and the output gap with inflation targets of 0 and 2 percent, respectively. As shown in the upper two panels of the figure, the distortion of the stationary distributions of inflation and output are fairly small under Taylor-type wage contracts even with an inflation target equal to zero, with the left tail of the distributions slightly pronounced. By contrast, as indicated in the lower two panels, the distortions under Fuhrer-Moore-type contracts turn out to be substantially larger, with the probability mass of the output distribution markedly shifted towards the negative region and the probability mass of the inflation distribution somewhat more concentrated near zero.

In summary, the model-based evaluation shows that, under Taylor's rule, the consequences of the zero-bound constraint are noticeable but fairly small once the

Figure 3: Stationary distributions of the inflation gap and the output gap under Taylor's rule



inflation target is set at 1 percent or higher, if the degree of inflation persistence is low (as represented by Taylor's wage contracting specification). By contrast, if the degree of inflation persistence is high (as represented by Fuhrer-Moore-type wage contracts), the zero lower bound may become a matter of concern for monetary policy-makers who follow Taylor's rule if the inflation target falls below 2 percent.

4. Further sensitivity analysis

So far, the consequences of the zero lower bound have been investigated under the assumption that the monetary policy-makers follow Taylor's rule. To assess the sensitivity of the stochastic simulation results to alternative specifications of the monetary policy rule, this section summarises the results obtained under a forecast-based first-difference rule which relates the change in the interest rate to the one-year ahead forecast of annual inflation and the current output gap,

$$\Delta i_t = 0.50 \cdot \mathrm{E_t}\, [\pi_{t+4}^{(4)} - \pi^*] + 0.25 \cdot y_t$$

with the response to the forecast of the inflation gap calibrated to be somewhat stronger than to the current output gap. Here, Δ denotes the first-difference operator and $\mathrm{E}_t[\cdot]$ indicates the model-consistent forecast, using information available in period t.

The choice of the above forecast-based first-difference rule reflects three considerations. First, the specification in first differences implies a relatively small impact response of the nominal interest rate compared to the impact response under the static Taylor rule. Thus, one may conjecture a priori that the likelihood of hitting the zero lower bound under the first-difference rule is reduced in response to economic shocks.[10] Second, it has been argued that the adverse consequences of the zero-bound constraint can be relieved by a more forward-looking response to anticipated deflation. Finally, it is shown in Coenen (2003) that a calibrated forecast-based first-difference rule similar to that above performs remarkably well across the two alternative models of inflation determination used. Thus, it appears to represent a robust benchmark rule for model-based evaluations of monetary policy in the presence of uncertainty about the prevailing degree of inflation persistence.

Regarding the likelihood that the nominal interest rate is bounded at zero, **Figure 4** reveals that the frequency of bind drops by one fourth to one third under either of the two contracting specifications if monetary policy follows the calibrated forecast-based first-difference rule instead of Taylor's rule. For example, with an inflation target set equal to 1 percent, the frequency of bind under Taylor's wage contracting specification is reduced from 7 to 5 percent, while the frequency of bind under Fuhrer-Moore-type wage contracts falls form 24 to 16 percent.

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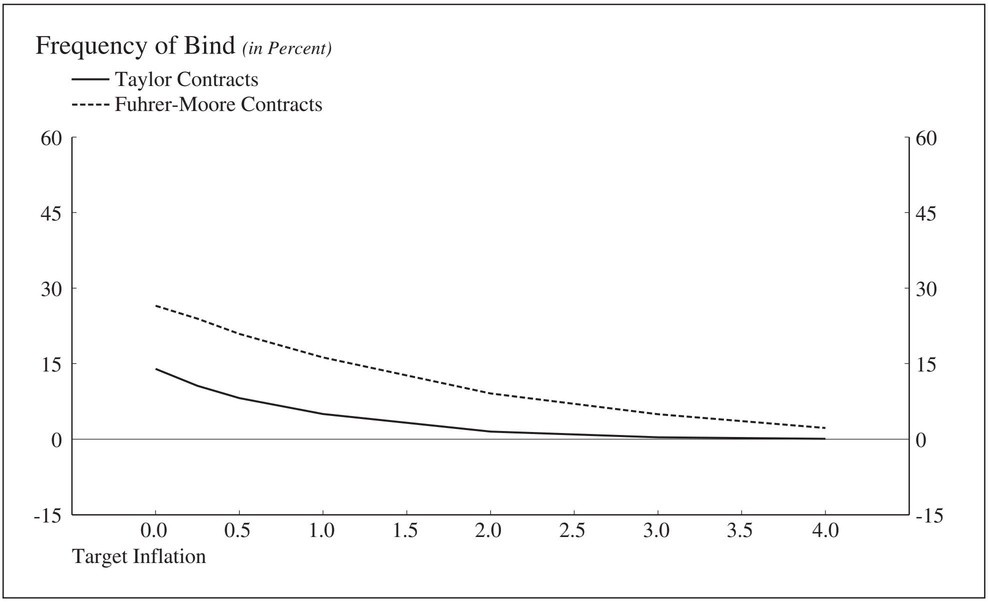
[10] At the same time, the first-difference rule exhibits a substantial degree of inertia ("smoothing"), as estimated interest rate rules typically do. Because aggregate demand is modelled to depend on the ex-ante long-term real interest rate, interest inertia increases the effectiveness of monetary policy via the private sector's anticipation of future interest rate moves as prescribed by the expectation hypothesis of the term structure.

Figure 4: Frequency of bind of the zero lower bound on nominal interest rates under a forecast-based first-difference rule



As to the stationary distributions of the variables of interest, **Figure 5** indicates that the zero-bound constraint under the calibrated forecast-based first-difference rule induces the same kind of distortions as under Taylor's rule. However, while there is little change regarding the bias in the means and standard deviations under Taylor-type contracts, a number of visible changes occur under the contracting specification due to Fuhrer and Moore. For example, when comparing the lower right panels in **Figure 5** and **Figure 2** it can be seen that the upward bias in the standard deviation of output is significantly reduced. At the same time, the bias in the standard deviation of inflation has reversed its sign, while the downward bias in the mean rate of inflation is noticeably raised. Apparently, these changes reflect the less frequent need to resort to fiscal interventions in order to prevent the economy from falling into a deflationary spiral.

Finally, **Figure 6** shows the probability density functions of the inflation gap and the output gap for inflation targets set equal to 0 and 2 percent, respectively. Evidently, the shape of the stationary distributions is distorted less under the forecast-based first-difference rule when compared with the stationary distributions under Taylor's rule in **Figure 3**. This is most obvious for the distribution of the output gap under Fuhrer-Moore-type wage contracts when contrasting the lower right panels of the two figures. While the distribution of the output gap is still skewed towards the left, the probability mass is shifted less markedly to the negative region of the distribution.

In summary, the sensitivity analysis provides some tentative evidence that the adverse consequences arising from the zero-bound constraint can be alleviated by following an interest rate rule that allows for a substantial degree of inertia and eventually responds in a forward-looking manner to one-year ahead forecasts of inflation. The benefits appear particularly large if the observed degree of inflation persistence is high.

Figure 5: Distortion of the stationary distributions under a forecast-based first-difference rule

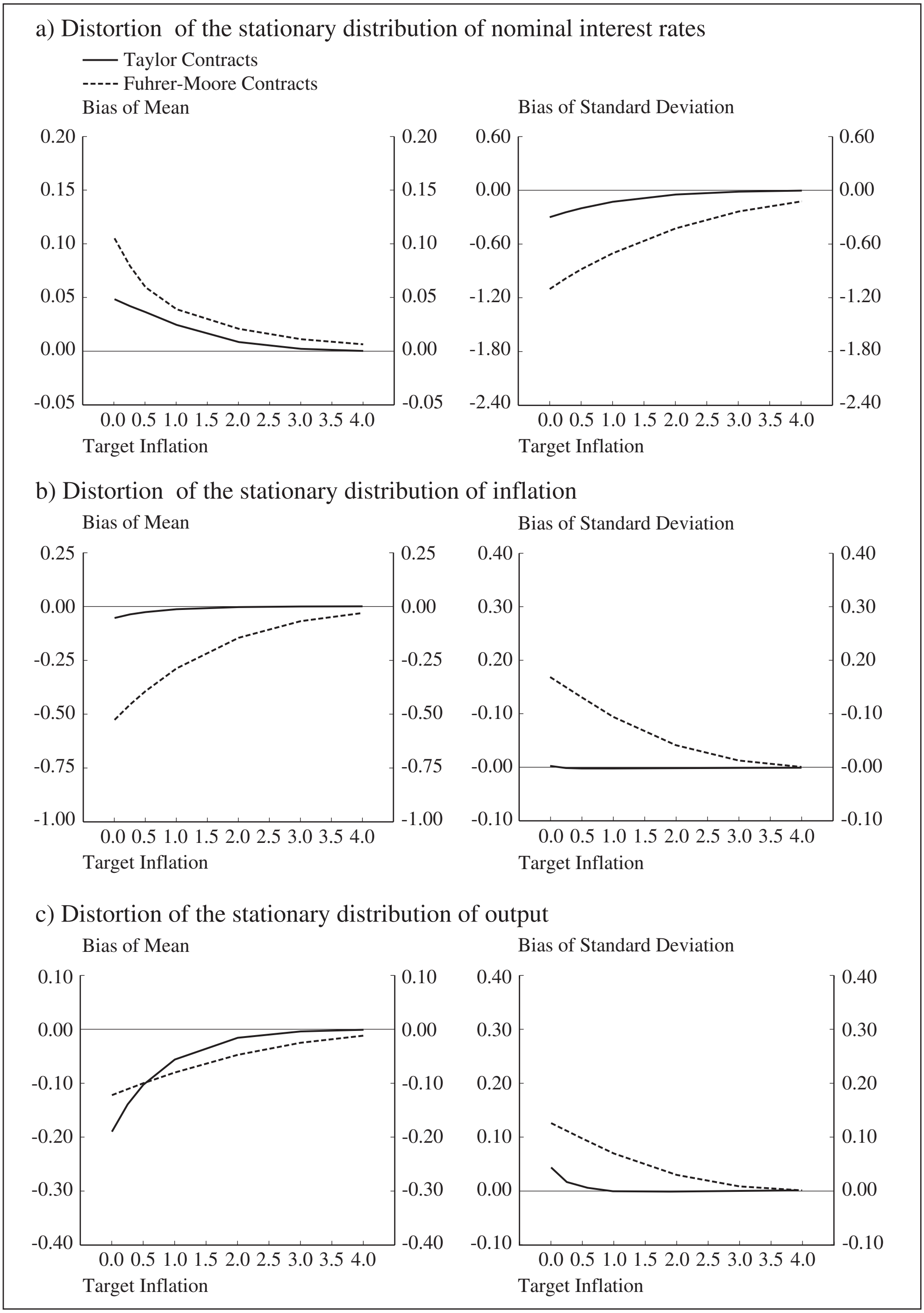
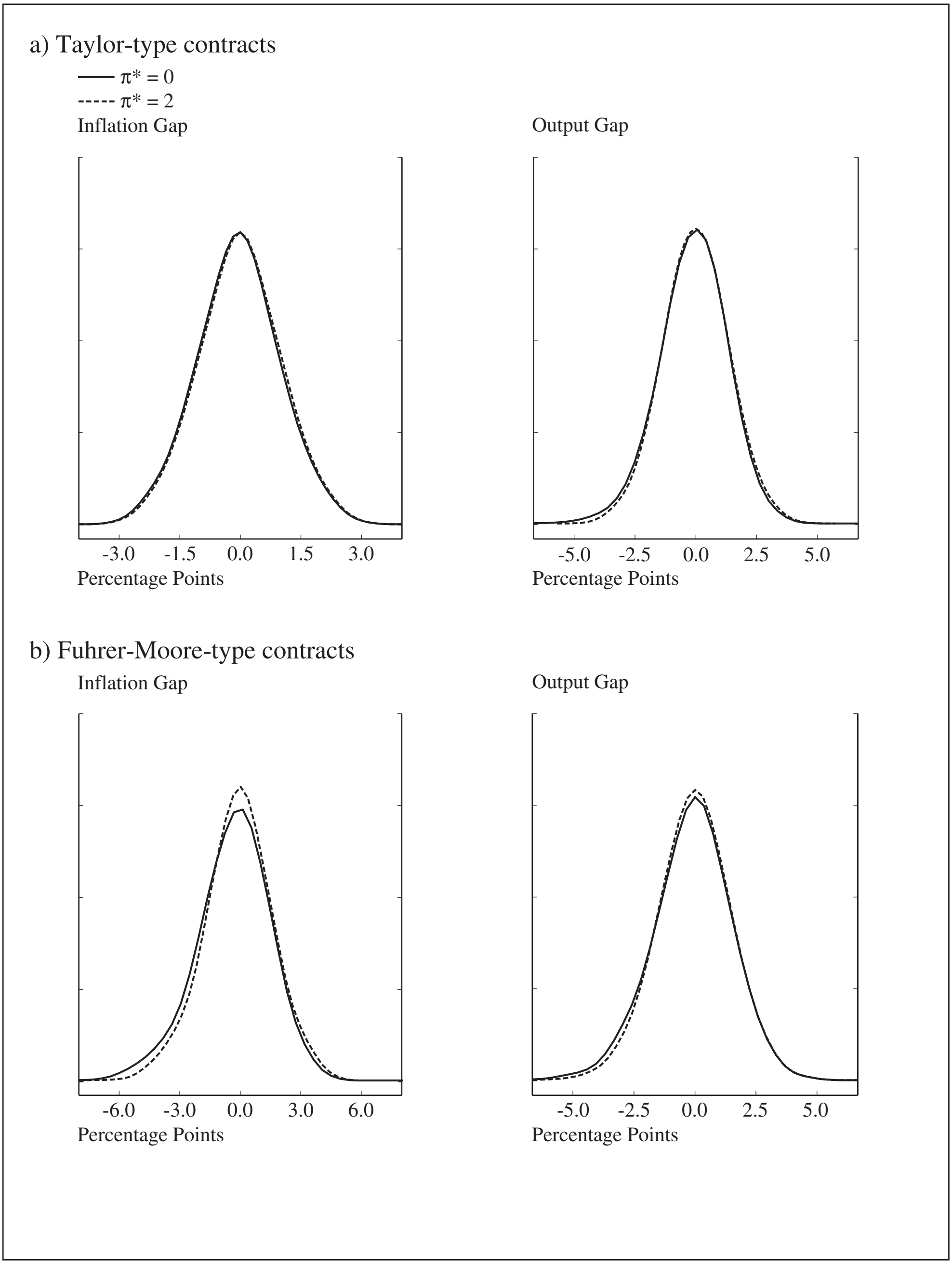


Figure 6: Frequency of bind of the zero lower bound on nominal interest rates under a forecast-based first-difference rule



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Appendix: The staggered wage contracting specifications

The staggered contracts models of Taylor (1980) and Fuhrer and Moore (1995) assume that workers negotiate long-term nominal wage contracts by comparing the current wage contract to past contracts that are still in effect and future contracts that will be negotiated over the life of this contract. As a result, only a subset of nominal wage contracts is adjustable at a given point in time. The distinction between Taylor and Fuhrer-Moore-type wage contracts concerns the definition of the wage indices that form the basis of this comparison.

Taylor-type wage contracts:

Under Taylor's specification, the nominal wage contract x_t is negotiated with reference to the price level that is expected to prevail over the life of the contract, p_{t+i}, as well as the expected deviation of output from its potential over this period, y_{t+i},

$$x_t = \mathrm{E}_t\left[\sum_{i=0}^{3} f_i p_{t+i} + \gamma \sum_{i=0}^{3} f_i y_{t+i}\right] + \varepsilon_t$$

where the aggregate price level p_t is expressed as the weighted average of current and previously negotiated contract wages, x_{t-i}, which are still in effect,

$$p_t = \sum_{i=0}^{3} f_i x_{t-i}$$

with $f_i > 0$, $f_i > f_{i+1}$ and $\sum_i f_i = 1$.

The expectation operator $\mathrm{E}_t[\cdot]$ indicates the optimal forecast of a particular variable conditional on all information available in period t and the white-noise shock ε_t summarises other short-term influences.

Since the price indices p_{t+i} reflect contemporaneous and preceding contract wages, Taylor's contracting specification implies that wage setters look at an average of nominal contract wages negotiated in the recent past and expected to be negotiated in the near future when setting the current contract wage. If wage setters expect output to exceed potential, $y_{t+i} > 0$, they adjust the current contract wage upwards relative to overlapping contracts. The sensitivity of contract wages to excess demand is measured by γ.

Fuhrer-Moore-type wage contracts:

Under the specification by Fuhrer and Moore, workers negotiating their nominal wage compare the implied real contract wage with the real wages on overlapping contracts in the recent past and near future. This specification implies that the expected real wage under contracts signed in the current period is set with reference to an average of real contract wage indices expected to prevail over the current and the next three quarters, v_{t+i},

$$x_t - p_t = \mathrm{E}_t\left[\sum_{i=0}^{3} f_i v_{t+i} + \gamma \sum_{i=0}^{3} f_i y_{t+i}\right] + \varepsilon_t$$

where

$$v_t = \sum_{i=0}^{3} f_i (x_{t-i} - p_{t-i})\,.$$

7

Inflation targets and the liquidity trap

Matt Klaeffling and Victor Lopez Perez*

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1. Introduction

The zero bound on the nominal interest rate is an issue that has received increasing attention from economists in recent times. What seemed to be a topic of purely theoretic interest during the high-inflation period of the 1970s and early 1980s has turned into a hot policy debate due to the steady decline of inflation rates and, above all, the Japanese fall into the liquidity trap since the nineties. As a result, there has developed a rapidly growing literature analysing issues related to the zero bound[1] and trying to learn from the Japanese experience.[2]

Central bankers are concerned about the zero bound on nominal interest rates because it may render nominal interest rate policies unable to create the stimulus needed by an economy when output is below trend and inflation expectations are below target. This simply means that policy becomes less effective under certain circumstances. More importantly, theoretical difficulties arise. As was shown in a series of papers by Benhabib, Schmitt-Grohe, and Uribe (1999, 2000a, 2000b and 2001), the presence of a lower bound on nominal interest rates implies the existence of an alternative steady state, in which the inflation rate is negative (and equal in absolute value to the equilibrium real interest rate) and nominal interest rates are zero. Importantly, the standard steady state is unstable: there are an infinite number of trajectories that take the economy from the standard equilibrium to the alternative one. Moreover, this alternative steady state is indeterminate, i.e. random shocks to expectations (*sunspots*) are compatible with rational expectations. These theoretical considerations have important policy implications because the possibility of sunspots implies that the economy possesses an uncontrollable risk (cost) for the policy authority. A theoretically satisfactory analysis of the relevance of the issue of the lower bound in theoretical models therefore has to deal with the potential multiplicity of steady states. Relative to these issues this paper is modest in scope in that it ignores the sunspot issue and assumes unicity of the equilibrium.

This paper discusses the question of the level of inflation that maximises the welfare of a representative agent within the framework of a Neo-Keynesian rational expectations model. In the context of this model, optimal policy will depend on the trade-off implicit in choosing a target level of inflation. The level of inflation here is postulated to be positively correlated with the variance of demand shocks. Thus, higher levels of the inflation target induce higher macroeconomic variance, which is considered undesirable.[3] On the other hand, a higher level of inflation serves as a protective barrier from the zero bound on nominal interest rates, the trap out of which escape is costly. Costly escape out of the trap is modelled by assuming that otherwise neutral fiscal policy

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[1] See Benhabib, Schmitt-Grohe and Uribe (1999, 2000a, 2000b, 2001), Bernanke (2000), Buiter and Panigirtzoglou (1999), Clouse, Henderson, Orphanides, Small and Tinsley (2000), Goodfriend (2000), Krugman (1998), McCallum (2000), Reifschenider and Williams (2000), Saunders (2000) or Wolman (1999).

[2] See, for example, Bernanke (1999), Cecchetti (1998), Posen (1998) or Okina (1999).

[3] This view is consistent with the distortions related to interactions of inflation with the tax system (Feldstein (1997)) and the empirical finding that the inflation level and the inflation variance are positively correlated both over time and across countries (Okun (1971), Okun (1975), Taylor (1981) and Ball and Cecchetti (1990)).

turns expansionary,[4] thus increasing inflationary pressures, reducing the real interest rate, and ultimately pushing production back towards its equilibrium level. The cost of this intervention is incurred because we assume that government expenditure is essentially wasteful in this model.[5] Finally, monetary policy is designed to maximise the welfare of the representative consumer. Welfare essentially consists of two parts, an expected value term, which is decreasing in government expenditure (consumption equalling production minus government expenditure) and the adjustment for the concavity of the utility function, which is decreasing in the variance of consumption.

The value added by the paper is twofold. On the one hand, it allows for the reaction of the economy to a shock to be state-dependent. This is specially true in the context of the zero bound on nominal interest rates since the degree of effectiveness of the monetary decisions is very limited when interest rates are close to zero.[6] On the other hand, this paper embeds the relationship between the inflation rate and the volatility of the shocks, widely documented in the literature, in an otherwise standard model with nominal rates bounded at zero.

It should be noted that the results of the paper naturally depend on the parameters we use to calibrate the model. In particular, they are sensitive to the assumption on the equilibrium real interest rate. Under the assumption on the equilibrium real interest rate being equal to 2%, we find two main results: first, the probability of hitting the zero lower bound upsurges non-linearly when the inflation target decreases, increasing rapidly as the inflation targets drops below 1 percent and being around 5 percent for an inflation target of zero. And second, the simple economy we propose implies that 2 percent is the inflation target that maximises the expected utility of a representative consumer.

However, if the equilibrium real interest rate is set equal to 3%, the probability for the non-negativity constraint on nominal interest rates to be binding plummets to negligible figures for all non-negative inflation targets and then the welfare maximising inflation target turns out to be zero. Therefore, given the large degree of uncertainty surrounding the estimates of the equilibrium real interest rate, a welfare-maximising central bank, in the context of this model, should weigh these two different scenarios when choosing the quantitative definition of its policy objective. Indeed, a risk-averse policy-maker would presumably buy insurance by means of attaching a higher weight to the “2% real rate” scenario.

Section 2 briefly surveys the literature on optimal inflation and the nominal interest rate zero bound. Section 3 explains the model in greater detail. Section 4 produces the main results, notably, the probability estimates of falling into the liquidity trap for several inflation targets and the analysis of the optimal inflation target. Section 5 concludes.

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[4] In the spirit of Svensson (2001).

[5] This is only a technical assumption. One can conceive alternative forms of public expenditures that yield a positive return.

[6] See Kimura *et al*. (2002) for empirical evidence on the Japanese economy.

2. Optimal inflation and the zero lower bound

2.1 Optimal inflation

When discussing the optimal inflation target it is compulsory to recall Milton Friedman (1969), who proposed that the optimal inflation rate should be negative and equal in absolute value to the real interest rate. According to the Fischer equation the nominal interest rate would then be zero and real balances would be held at a zero marginal cost.[7] This is the famous Friedman rule. The reasoning behind this is that there is a social cost associated with holding currency relative to investing it at a positive interest rate. Since the production of currency is essentially of zero cost there would be, in the words of Robert Lucas, "one of the few legitimate 'free lunches' economics has discovered in 200 years of trying".

Four years later, Phelps (1973) noted that the Friedman argument ignored the fact that inflation allows the government to extract an inflation tax through seigniorage. In the absence of seigniorage, the government will have to rely on alternative (distortionary) means of collecting income. Depending on the welfare cost of these alternative means, which depends on the tax code and the elasticities of factor supplies, the optimal level of inflation will be correspondingly higher. Cogley (1997) notes that the inflation tax may in fact have a higher distortionary cost than other forms of taxation, and argues in favor of an inflation rate of 1 percent on the basis of the econometric evidence on distortionary taxation from Mulligan and Sala-i-Martin (1997) and Braun (1994).[8] Nicolini (1997) argues for a positive inflation tax in the presence of an underground economy that the fiscal authority cannot tax otherwise. Aizenman (1987) and Vegh (1998) argue for an inflation tax based on the collection costs that are associated with other forms of taxation. Whereas these papers focus on calculating the optimal level of inflation others directly focus on the welfare implications of alternative inflation rates. Two such applications are Lucas (2000) and Wolman (1997). While Lucas argues that the reduction from the historic rate of 5 percent to 0 percent exploits most of the welfare gains relative to the Friedman optimal rule, Wolman shows how this conclusion can be turned upside down by using a different money-demand equation, i.e. he shows how for a different functional form for money demand the bulk of the welfare gain lies in reducing the inflation rate from zero to the Friedman-optimal rate of minus the real interest rate.[9]

Summers (1991) advocated a positive inflation target to deal with several "real-world problems". One of these problems[10] is that nominal interest rates are bounded at zero. Money has a pecuniary rate of return of zero (abstracting from insurance costs, storage costs and taxes) and a non-pecuniary return as a unit of account and a medium of exchange higher than other financial assets. If the nominal interest rate for a close but

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[7] Which is equal to the marginal cost of production of currency.

[8] See also Kimbrough (1986), Guidotti and Vegh (1993), Christiano, Eichenbaum, and Evans (1996), Correira and Teles (1996, 1999), De Fiore and Teles (1999) and De Fiore (2000) on the optimal inflation rate in various theoretic economies.

[9] One important caveat in calculating the welfare effects of reducing inflation to the Friedman-optimal rate from estimated (or for that matter calibrated) mony-demand specifications is that one has to extrapolate results into a range of nominal interest rates that have never been observed historically.

[10] Apart from inflation measurement bias and downward nominal wage rigidities.

not perfect substitute for money is negative, an agent can maximise returns by holding money at a zero interest rate rather than using it to buy a close substitute at a negative interest rate. In such a situation, the economy could find itself in what is called a liquidity trap.

2.2 The zero lower bound

Following Svensson (2000), "in a liquidity trap the economy is satiated with liquidity and the nominal interest rate is zero. (...) If equilibrium real interest rates are positive, equilibrium expected inflation will be negative. (...) Thus, by a liquidity trap, I mean a situation with zero interest rates, persistent deflation and persistent deflation expectations". The liquidity trap so defined is a nominal downward spiral. This is the sense in which there may exist an alternative steady state in addition to the standard one in which the inflation rate is equal to the policy target and output equals potential output.[11]

Policy prescriptions that assure the uniqueness of the standard steady state and the economy's law of motion have been advanced by a number of authors. These policies are usually ordered into three main groups: providing more liquidity to the economy, affecting expectations directly and taxing money holdings.

As to the first group, the basic idea is that the central bank may increase the monetary base by purchasing a variety of assets. For example, the monetary authority may buy Treasury bills via open-market operations (see Clouse *et al*., 2000), government bonds (see Clouse *et al*., 2000, and Bernanke, 2000), foreign currencies in exchange markets (see Meltzer, 1999, Bernanke, 2000, Clouse *et al*., 2000, McCallum, 2000, and Svensson, 2001) and private sector securities (see Bernanke, 2000, and Clouse *et al*., 2000). In addition, the central bank may lend money to the private sector (see Clouse *et al*., 2000) or may let money rain (see Clouse *et al*., 2000, Bernanke, 2000, and Benhabib, Schmitt-Grohe and Uribe, 2000a).

The second set of proposals relies on affecting expectations directly to drive the economy out of the trap. To get to this goal, the monetary authority must have the credibility that it will adhere to what it proposes and, what is more important, the credibility that it can deliver on its proposal. To gain credibility, monetary authority may adhere to a commitment to an explicit inflation target for several years into the future (see Krugman, 1998, and Bernanke, 2000), to money-growth targets (see Hetzel, 1999) or to maintain nominal interest rates at zero level after the liquidity trap has been abandoned (see Okina, 1999). Another possibility for the central bank is to write options on the Treasury bond rate that will prevail at some point in the future (see Tinsley, 1999). Inside this group, it may be useful to consider agreements with the fiscal authority to a contingency plan to be implemented immediately if a zero bound situation were to occur (see Svensson, 2001). Benhabib, Schmitt-Grohe and Uribe (2000) propose an inflation sensitive fiscal policy that calls for lowering taxes when inflation subsides and show that the rule can rule out liquidity traps by making them fiscally unsustainable.[12] The channel

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[11] See Reifschneider and Williams (2000) and Benhabib, Schmitt-Grohe and Uribe (1999, 2000a, 2000b and 2001).

[12] Since sustainability of the fiscal policy is a prerequisite for a rational expectations equilibrium, no equilibrium that would imply an unsustainable fiscal policy can exist.

through which the liquidity trap is eliminated here is basically that a decline in taxes increases the household's after-tax wealth, which induces an aggregate excess demand for goods.[13]

The third group of potential alternatives to the interest rate channel basically consists of various ways of taxing money holdings (see Keynes, 1923, Gesell, 1949, Buiter and Panigirtzoglou, 1999, and Goodfriend, 2000). Such taxes are oftentimes also referred to as Gesell taxes. By taxing money holdings, the opportunity cost of holding money is positive in a context of zero (or even slightly negative) nominal interest rates. Hence, the demand for short-term bonds would be positive since they are not taxed by the Gesell tax. The aforementioned elements enable the policy-maker to decrease the short-term nominal interest rate below zero and to avoid the liquidity trap simultaneously. The higher the tax rate on money holdings, the larger the extra room for manoeuvre provided by the tax. Nonetheless, these policy actions may be accompanied by so high administrative costs that they appear uninteresting in practice.

In summary, there are two distinct arguments that are complementary to the analysis of the liquidity trap. First, how can the likelihood of nominal interest rates dropping to zero be minimised and, second, if we do arrive at zero nominal interest rates, how can we escape from the trap. At this point it is important to note that all of the above policy recommendations assure that while we may end up at the zero bound, we do not enter the trap per se. To see this recall that the liquidity trap is defined as an alternative equilibrium – a deflationary spiral – and as such it is a problem to the extent that it would lead the economy to converge to an alternative (suboptimal) steady state. At this other steady state there could theoretically be *sunspot* dynamics of unbounded variance. As a result, all policies that allow the economy to slide inside the trap are intrinsically inefficient. Hence, the only way any policy can protect the economy from the trap is to rule it out as an equilibrium. This argument can be captured in Figure 1, which is borrowed from Benhabib, Schmitt-Grohe and Uribe (2000a), and shows the level of the nominal interest rate as a function of the level of inflation.

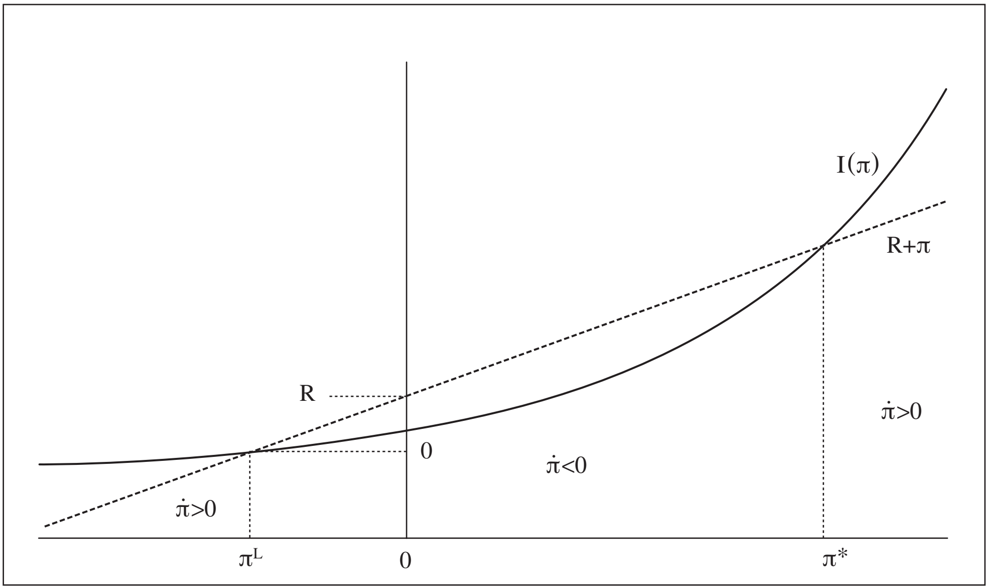
In the graph R denotes the equilibrium real interest rate as determined by the steady-state rate of time preference of the consumers, and π is the rate of inflation (varying throughout the horizontal axis). $R + \pi$ denotes the nominal interest rate defined as the rate that equilibrates the money market[14] (vertical axis) and $I(\pi)$ denotes the supply side "price", the policy rule that determines the nominal interest rate as a function of the nominal interest rate target and the state of the economy to which the policy-maker reacts (also throughout the vertical axis). Following Benhabib *et al.* (2000a) we assume that $\frac{\partial I(\pi)}{\partial \pi}\Big|_{\pi=\pi^*} > 1$, an assumption that is satisfied, for example, by the Taylor rule as a policy function (see Section 3),

$$I(\pi) = R + \bar{\pi} + \theta^{\pi} (\pi_t - \bar{\pi}) + \theta^{y} (y_t - \bar{y})$$

[13] Note that the magnitude of this effect goes back to the classical Keynes-Pigou debates (Keynes (1936), Pigou (1950)).

[14] By the Fischer equation, the nominal interest rate equals the real interest rate, R, plus the expected future inflation rate. In equilibrium, the expected future inflation rate will be equal to the rate of inflation, π.

Figure 1: The liquidity trap



where $\bar{\pi}$ and $\bar{y}$ denote the target levels (steady states) of inflation and output, respectively. In this case $\frac{\partial I(\pi)}{\partial \pi} = \theta^{\pi} > 1$ since $\theta^{\pi} = 1.5$ in the Taylor rule.[15]

Clearly, there exist two steady states. The first one is the standard case, where $\pi = \pi^* > 0$ and the nominal interest rate $I(\pi^*)$ is positive. The second one represents the liquidity trap case, where $\pi = \pi^L = -R$ and the nominal interest rate $I(\pi^L)$ equals zero. Benhabib *et al*. (2000a) demonstrate that the standard equilibrium is unstable whilst the deflationary spiral is stable. We can then uniformly represent any policy recommendation regarding escapes from the trap as a way to limit the support of the level of inflation. In fact, one way or another all policy solutions lead to violations of some transversality condition for the equilibrium associated with π_L (see Benhabib *et al.* (2000a)) or increase the lower bound on inflation beyond the level associated with the liquidity trap π_L. In the presence of the appropriate policy, the equilibrium is then unique.

2.3 How relevant is the zero lower bound?

It seems clear that the importance of the zero bound on nominal interest rates as a constraint on monetary policy depends on several factors, such as the frequency, the magnitude and the persistence of the shocks that hit the economy. To analyse the probability of being caught in the liquidity trap, researchers have followed two complementary paths: to use historical data or to rely on simulation analysis.

[15] The reason why $\frac{\partial I(\pi)}{\partial \pi} > 1$ is a particularly appropriate assumption in the case of Taylor-type policy rules is that this assumption is usually required to assure local determinacy of the economy around the standard (target) steady state.

2.3.1 Historical analysis

The main conclusion that is obtained from the analysis of historical time series is that the probability of hitting the zero bound is essentially zero for an inflation rate of 2 percent. Of course, this is a result that is conditional on an equilibrium real interest rate in line with long-run averages in industrial countries.

Clouse *et al*. (2000) review the history of nominal interest rates in the United States since 1860. They report that for the period between 1860 and 1930 short-term interest rates were well above zero despite a series of inflationary and deflationary cycles. Short-term nominal interest rates hit the zero bound by 1932 as a consequence of the deflation that began in 1929[16] (with the price level declining 25 percent between 1929 and 1932). From 1932 to 1948 nominal interest rates were below 1 percent, very close to the constraint. The authors construct a proxy for the room available to the monetary authority to diminish nominal rates in response to shocks. The Great Depression is said to stand out "not because of relative little room for easing at the outset of the downturn in 1929 but for ultimately running out of room despite the initial room to ease". Since 1950, nominal interest rates have been well above the zero bound. Also, as noted by Summers (1991), this nominal interest rate history implies that the ex-post real interest rates in the United States have actually been lower than zero in about one-third of the years since World War II.[17] Clouse *et al.* (2000) also analyse the Japanese experience as well and find that Japan in the 1990s had a delayed decline in long-term yields that was very similar to the experience of the 1930s in the United States. Figure 2 shows the path of interest rates and inflation in Japan over the nineties.

Putting the pieces together we can state that historically the nominal bound has been important in the US during the Great Depression and in Japan since mid-nineties.[18] In any event, given the shortcomings implied by a purely historical analysis to provide any policy recommendation, many studies supplement the historical analysis with a simulation study.

2.3.2 Simulation analysis

By defining artificial economies and analysing the effects of simulated shocks, researchers have found that the relationship between the inflation target and the probability for the zero bound to be binding is a non-linear one, such that as inflation approaches zero, the likelihood of encountering the zero bound increases at an increasing rate. The prevailing view seems to be that an inflation target of 2 percent would be high enough to sufficiently reduce the effect of the zero bound on the effectiveness of monetary policy.

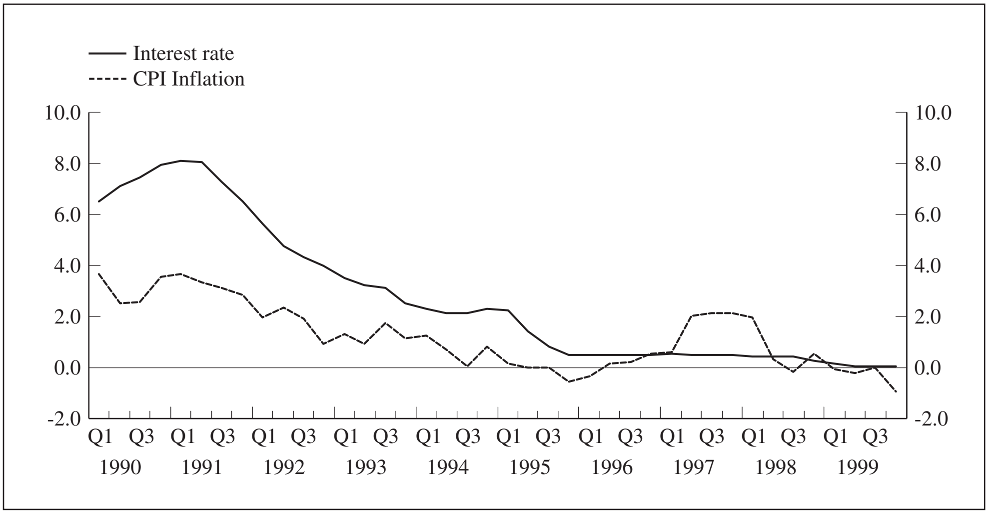
Cozier and Lavoie (1994) present a calibrated reduced-form model with an aggregate demand equation, an expectations-augmented Phillips curve, an exchange rate equation, and a forward-looking monetary policy rule. They find that the probability of falling into the trap is 3.5 percent under a 1 percent inflation target and 5 percent under a zero inflation target. Fuhrer and Madigan (1997) evaluate the zero bound importance by

[16] Actually, a mild deflation in the Consumer Price Index was already under way since the end of 1924.

[17] The real after-tax rate has actually been negative in about 75 percent of these years.

[18] In addition, the US historically has had the privilege of its currency serving as an international financial safe haven, which has resulted in lower real interest rates than in countries of similar macroeconomic performance (see Campbell (1999)), which in turns means that the issue of the zero bound is *ceteris paribus* (i.e. controlling for differences in inflation targets) of accentuated importance for the Federal Reserve Board.

Figure 2: The liquidity trap in Japan
(in percent)



comparing the response of their model (composed by a backward-looking IS curve, a Phillips curve and a monetary policy reaction function) to IS curve shocks under inflation targets of zero and 4 percent. They conclude that, under a zero inflation target, monetary policy is significantly constrained by the zero bound.

Orphanides and Wieland (1998) propose a model quite similar to Fuhrer and Madigan's but disaggregating the IS curve into its components. They use estimated shock processes and compare the variance of output under different inflation targets, finding a significant effect on economic performance if monetary authority sets an inflation target lower than 1 percent. More specifically, they consider two types of rules, attributed to Taylor (1993) and Henderson-McKibbin (1993), and find that the probability of the restriction to be binding is always higher for the latter, increasing from 10% under an inflation target of 1 percent to 30 percent as the inflation objective drops to zero. However, they find negligible risk under an inflation target of 2 percent.

Reifschneider and Williams (2000) use the Federal Reserve Board's econometric model of the US economy and reach the conclusion that the zero bound could be a significant constraint on policy in very low inflation environments. As regards the two policy rules mentioned above, they find a probability of hitting the bound of 31 percent under a zero inflation target and 7 percent under an inflation target of 4 percent when the Henderson-McKibbin rule is used. These probabilities fall to 14 percent and less than 1 percent when the Taylor rule is the policy rule. Reifschneider and Williams (2000) , as opposed to Orphanides and Wieland (1998), find that the Henderson-McKibbin rule outperforms the Taylor rule regarding output gap stabilisation[19] but at the cost of higher interest rate volatility.

[19] Reifschneider and Williams (2000) assume that the equilibrium real interest rate equals 2.5% whilst Orphanides and Wieland (1998) chose 1%. This difference is, presumably, the underlying factor behind the discrepancy.

Last but not least, Coenen and Wieland (2003) utilise a model taken from an earlier piece of research (Coenen and Wieland, 2002), which comprises three economies: the United States, the euro area and Japan. Then, they conduct a simulation exercise aiming to calculate the frequency of bind of the zero bound on the Japanese nominal interest rates. This frequency turns out to be between 5 and 10 percent when the equilibrium nominal interest rate is 4% and increases rapidly when a lower equilibrium rate is assumed.

3. A simple model

3.1 Model specification

The present example builds around the paradigm of the neoclassical synthesis (see Goodfriend and King, 1997) and is a nutshell version of a class of models that includes Yun (1996), Jeanne (1997), Gali (2001) or Christiano, Eichenbaum, and Evans (2001) among many others. Rather than deriving the model's equilibrium-defining equations here again we refer to the above papers. The linearised economy can be concisely described by four building blocks, all variables being log-deviations with respect to their steady-state values. First, an IS curve,

$$y_t = \frac{1}{-\gamma}\left[i_t - E_t\left[\pi_{t+1}\right]\right] + E_t\left[y_{t+1}\right] + g_t - E_t\left[g_{t+1}\right] + z_t \tag{1}$$

This forward-looking aggregate demand equation can be derived from the representative consumer's Euler condition imposing goods-market clearing. y_t denotes the output gap at period t, defined as the log-difference between real output and potential output (the prevalent one in the absence of nominal rigidities). π_{t+1} is the inflation rate at period $t + 1$, defined as the log-difference between prices at $t + 1$ and prices at t. g_t represents public expenditure at time t. i_t is the nominal interest rate. E_t is the rational expectations operator and γ denotes the constant risk aversion coefficient of the representative household. The IS shock z_t in this model could be interpreted as a preference shock,

$$z_t = \phi z_{t-1} + \xi_t \qquad |\phi| < 1 \tag{2}$$

Ball and Cecchetti (1990) found an empirical relationship between long-run inflation and the variance of the shocks that hit the economy. In this spirit, let's assume a linear relationship between the unconditional standard deviation of ξ_t and the absolute value of the inflation target[20] (that is equal to the steady-state inflation rate in this model).

[20] Although we consider a symmetric effect (around zero) of the inflation objective on the variance of the shock, a theoretical argument may be mentioned for negative objectives to have a larger effect than positive ones: a negative inflation target implies a larger probability for the economy to fall into the deflationary spiral. In such a situation *sunspot* shocks, whose variance is unbounded, may appear. However, *sunspot* shocks are not handled here as the fiscal stimulus is assumed to shield the economy from the deflationary risk. As regards the empirical evidence, the Japanese experience is rather uninformative about this issue. The sample period is very short on one side. On the other side, it is difficult to disentangle the source of the Japanese problem characterised by a situation of deflation amid a financial crisis and a deep process of reallocation of resources.

$$\sigma_\xi = \delta_0 + \delta_1 * abs(\bar{\pi}) \qquad \delta_0 > 0, \delta_1 > 0 \tag{3}$$

where $\bar{\pi}$ denotes the inflation objective or steady-state inflation rate. Thus, we assume that the distortions driven by inflation are minimised when the long-run inflation rate, i.e. the policy target, is zero.[21] The second building block is the New Keynesian Phillips curve,

$$\pi_t = \beta E_t[\pi_{t+1}] + \lambda y_t \tag{4}$$

where λ is known as the short-run slope of the Phillips curve. This forward-looking aggregate supply equation could be obtained from the aggregation of the firms' optimal staggered price-setting rules, assuming a linear relationship between real marginal costs and the output gap. The third block is a truncated Taylor rule,[22]

$$i_t = \max\{\theta^\pi E_t[\pi_{t+1}] + \theta^c E_t[c_{t+1}], -\bar{r} - \bar{\pi}\} \tag{5}$$

where $\bar{r}$ is the equilibrium real interest rate, c_{t+1} symbolises the consumption gap at time $t+1$ (consumption is linked to output by the goods-market clearing condition $Y_t = C_t + G_t$, where G_t denotes the level of public expenditure at time t) and (θ^π, θ^c) are the Taylor rule coefficients.[23] Therefore, the central bank would follow a forward-looking Taylor rule as long as the nominal interest rate that comes from the rule were above zero. Otherwise, the policy rate would be zero.

In order to exclude a potential deflationary steady state we simplistically could assume that whenever the interest rate is zero the fiscal authority stimulates demand directly via government expenditure. Hence, the fourth and last equation of the model is

$$g_t = \begin{cases} 0 & \text{if} \quad i_t = \theta^\pi E_t[\pi_{t+1}] + \theta^c E_t[c_{t+1}] \\ x > 0 & \qquad\qquad \text{otherwise} \end{cases} \tag{6}$$

Public expenditure is financed by constant lump-sum taxes. Taxes do not appear in the model as all variables are log-deviations from their steady-state values.

The fact that the Taylor rule is truncated is the cornerstone of our analysis for the fact that its non-linearity implies that we cannot apply standard solution techniques. To show this we will slightly have to manipulate the demand and supply equations. The Phillips curve, (4), can be solved forward to obtain,

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21 As Woodford (1999).

22 Although we recognise that standard Taylor rules are not formulated in terms of the consumption gap but the output gap, in the context of our model it seems more reasonable to include the consumption gap in the monetary policy rule. The reason is that public expenditure becomes positive only when the economy is in a very bad situation (the zero bound is binding) and, therefore, an interest rate hike induced by positive expected public expenditure is the last thing the economy is claiming for. The results are qualitatively similar when the consumption gap is replaced with the output gap.

23 Despite the fact that this truncated Taylor rule is not microfounded, it can be seen as a rather good approximation to the behaviour of the central banks in major industrialised countries (see Clarida, Gali and Gertler, 1998).

$$\pi_t = \lambda \sum_{s=0}^{\infty} \beta^s E_t y_{t+s} = E_t \left[\frac{\lambda}{1-\beta L^{-1}} y_t \right] \tag{7}$$

where L denotes the lag operator. Likewise, we solve the IS curve, (1), forward, which yields

$$y_t = E_t \left[\frac{1}{1-L^{-1}} \left[\frac{1}{-\gamma} (i_t - \pi_{t+1}) + z_t \right] \right] \tag{8}$$

Finally, we substitute for future π_t from (7) into (8) to obtain

$$y_t = E_t \left[\frac{(1-\beta L^{-1})}{(1-\alpha_1 L^{-1} - \alpha_2 L^{-2})} \lambda \left(\frac{1}{-\gamma} i_t + z_t \right) \right]$$

where $\alpha_1 = 1 + \beta + \lambda$ and $\alpha_2 = -\beta$. This equation means that output today is a forward-looking ARMA(2,1), a weighted average of expected future demand shocks and interest rates. As said above, we cannot use standard system-reduction techniques to solve this problem for any given point in time since today's actions are weighted averages of two alternative monetary policy regimes, with weights that depend upon today's economic state.

In this model there is only one economic shock, ξ_t, the shock to the IS curve. This shock is termed *fundamental*. It is the only shock that can affect the economy when the economy is outside the trap (i.e. when the Taylor rule is active). But there is a second shock, which can be labelled as a *sunspot* shock, that might affect the economy if it is inside the liquidity trap. This shock is not linked to the fundamentals of the economy (even though its dynamics are) and is therefore termed *nonfundamental*. These *sunspot* shocks may turn out to appear because the monetary policy rule is passive at zero and the rational expectations equilibrium is not unique when the economy may be caught in the liquidity trap. To restore uniqueness, expansionary fiscal policy is assumed to take the economy out of the trap in this model. Therefore, s*unspot* shocks do not play a role anymore.

3.1.1 The effects of a fundamental shock if there is no trap in the model

Let's start considering two extreme cases. First, we will assume that there is no liquidity trap in the model (the inflation target is high enough). In this case, a positive demand shock results in an increase in consumption and inflation. Given the Taylor rule this leads to an increase in nominal and real interest rates. It is this increase along with the decaying effect of the demand shock that drives the economy back to the steady state.

Figure 3: Response to a positive shock (no trap)

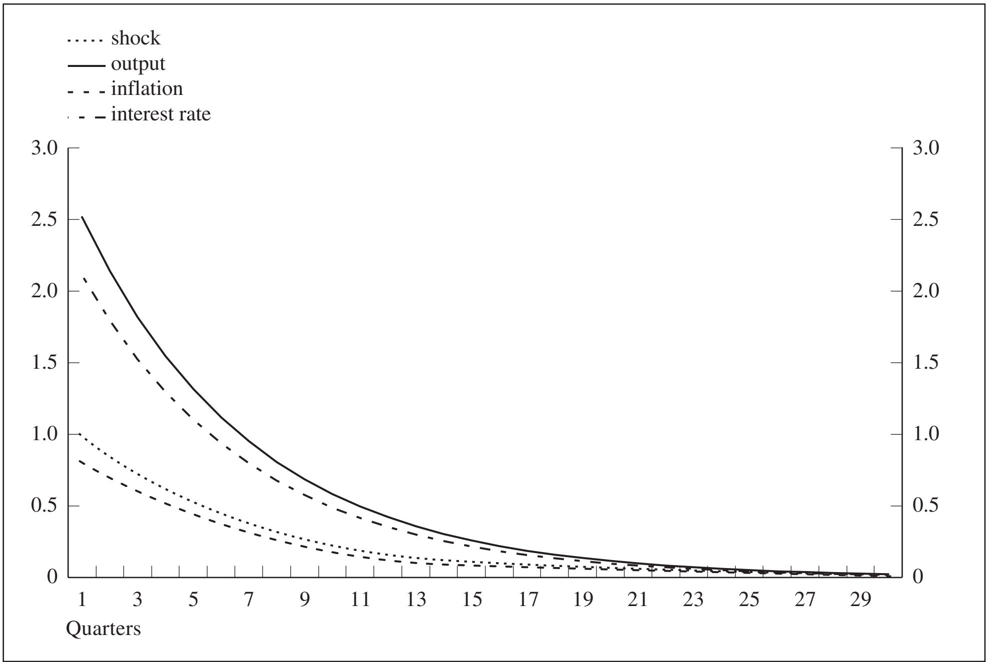


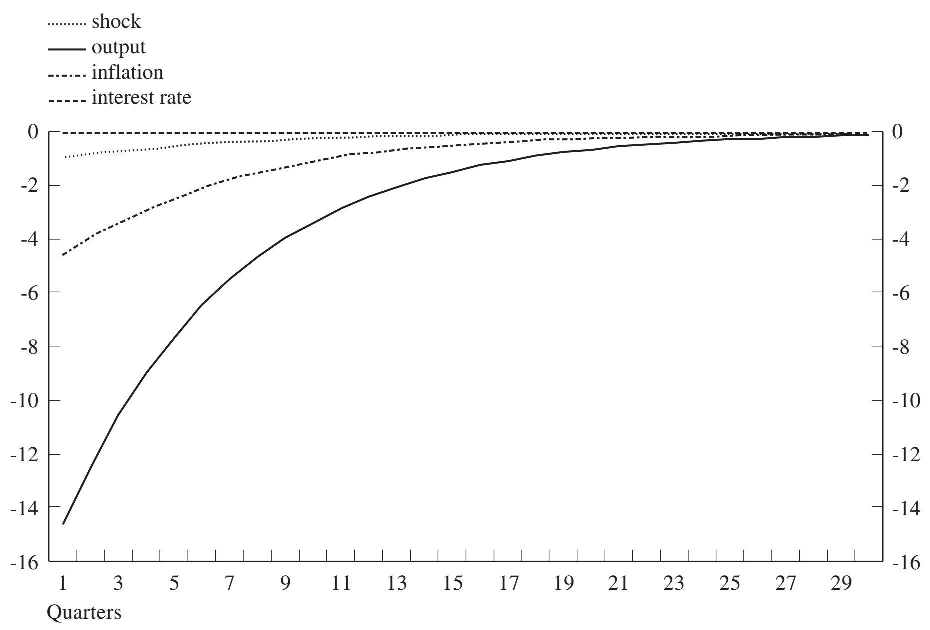
Figure 3 plots the impulse-responses. The local dynamics here are the same as around the standard steady state.

3.1.2 *The effects of a negative fundamental shock if the economy is always in the trap*

The second extreme case is to assume that the economy is in the trap and it will remain there forever. In this case, monetary policy is ineffective and public expenditure does not help to stabilise the economy because $g_t = E_t[g_{t+1}] = x$, for every t.

Further, the passivity of policy means that the economic structure does not yield enough transversality conditions to pin down all economic variables as functions of the demand shock alone. Instead, the state vector is composed out of the economic state variable, which is the demand shock, as well as an additional *canonical* state variable that is constructed as a linear combination of economic variables and can be given the interpretation of a variable capturing the expectational state of the economy. Other than in the standard case, where expectations are uniquely defined by the current economic state variable of the system, we here have a case where expectations have marginal causal power. Since the law of motion of the state vector does not have a diagonal transition matrix, a shock to demand will affect this second state variable dynamically and will have a total effect on the economy that is given by the combined effect of these two variables.

Figure 4: Response to a negative shock (always in the trap)



However, since this extreme case will be ruled out once the economy is able to escape out of the trap, the *canonical* state variable is assumed to be zero every period and the effects of a *fundamental* (negative) shock can be seen in Figure 4. The responses of the macroeconomic variables are much larger than before, since neither monetary policy nor fiscal policy are able to provide the mechanisms needed to smooth the path of the economy.

3.2 Model solution

We here report the main steps that allow us to numerically approximate the model solution. The solution involves three fundamental steps and is essentially a parameterised expectations version of the weighted residual method (see Christiano and Fisher, 1997). First, we have to approximate the mappings from the state of the economy to consumption and inflation respectively. Second, to weigh the loss function over the grid of the state. And third, to find starting values for the procedure, calibrate some parameters and minimise the loss function to compute the others.

a) Mapping functions

The model is a forward-looking rational expectations model, which means that today's actions are functions of the entire future path of shocks hitting the system. From the perspective of the representative consumer and firm, this means that their optimal consumption and pricing decisions depend on future shocks as well as the form of monetary policy in action at all points in time in the future. We thus have to calculate the state-depending probabilities of the two possible events: "at the bound at point $t + s$" and "not at the bound at point $t + s$". These probabilities depend on the state of the economy today, t, which in turn allow us to weigh the two macroeconomic regimes that pin down the optimal consumption and pricing decisions. In other words, the model solution should involve the two macroeconomic regimes which could be in place at all points in time from today on. What is known is that optimal consumption and pricing are expectations of functions of these future regimes and they have to be measurable with respect to the time-t state variable z_t and the inflation target $\bar{\pi}$.

We now proceed as follows. First, we define a grid Ω^z on z_t over which to evaluate the model solution. Then, for every $\bar{\pi}$, we approximate the functions that determine the parameters that map the state into consumption and inflation.

$$\begin{aligned} c_t &= f_c(z_t, \bar{\pi})z_t \\ \pi_t &= f_\pi(z_t, \bar{\pi})z_t \end{aligned} \tag{9}$$

These approximations are done assuming that the mapping is a combination of the linear mapping functions under the two extreme cases analysed above: "the economy never ends up in the trap" and "the economy is always in the trap" ,

$$\begin{aligned} f_c(z_t, \bar{\pi}) &= \varpi(z_t, \bar{\pi})c(1) + (1 - \varpi(z_t, \bar{\pi}))c(2) \\ f_\pi(z_t, \bar{\pi}) &= \varpi(z_t, \bar{\pi})\pi(1) + (1 - \varpi(z_t, \bar{\pi}))\pi(2) \end{aligned}$$

where $c(1)$ denotes the constant coefficient of the linear mapping function for the case "never in the trap" and by analogy $c(2)$ is the constant coefficient of the linear mapping function for the case "always in the trap". Hence, the responses of consumption and inflation are going to lay somewhere in between these two extreme cases, depending on the state of the economy and the inflation target chosen.

The weight $\varpi(z_t, \bar{\pi})$ is allowed to vary depending on the values of z_t and $\bar{\pi}$. The lower z_t or $\bar{\pi}$, *ceteris paribus*, the lower $\varpi(z_t, \bar{\pi})$. We made use of tenth-order Chebyshev polynomials[24] to capture the non-linearities stemming from the monetary and fiscal policy rules,

$$\varpi(z_t, \bar{\pi}) = chebyshev\left(\frac{z_t - z_{\min}}{2z_{\max}}, \bar{\pi}\right)$$

where *chebyshev*(•) symbolises the 10th-order Chebyshev polynomial fitted under the inflation target $\bar{\pi}$, and $z_{\min}$ and $z_{\max}$ are the smallest and largest values for z_t we consider. These bounds are symmetric around zero ($z_{\min} = - z_{\max}$) and their values are chosen to define an interval covering more than 99.80 percent of the probability mass of the state variable.[25] Therefore, according to the interpretation of $\varpi(z_t, \bar{\pi})$ provided above, this function is expected to be increasing in z_t and to shift upwards when the inflation target $\bar{\pi}$ augments.

[24] The appeal of Chebyshev polynomials consists on compelling the approximation error to be arbitrarly small as the order of the polynomial augments.

[25] If at any point during the simulations the state variable moves below (above) the lower (upper) bound we simply set it equal to the lower (upper) bound.

b) Loss function

Then, we calculate the percentage errors of the aggregate demand and supply equations over the grid Ω^z. Therefore, we define the following loss function L for the grid point ω_z and the set of parameters ψ.

$$\psi = [\ \overline{\pi}, \gamma, \phi, \delta_0, \delta_1, \beta, \lambda, \theta^\pi, \theta^c, \overline{r}, x, \varpi(\bullet)]$$

$$L(\psi, \omega_z) = norm \begin{bmatrix} \frac{1}{\gamma}[i_t - E_t[\pi_{t+1}(\psi, \omega_z)]] - E_t[\Delta y_{t+1}(\psi, \omega_z)] + E_t[\Delta g_{t+1}] - \omega_z \\ \pi_t(\psi, \omega_z) - \beta E_t[\pi_{t+1}(\psi, \omega_z)] - \lambda y_t(\psi, \omega_z) \end{bmatrix}$$

As the model is not linear, the expectations about future economic variables are not trivially computed. The right way of proceeding is the following: given a grid point ω_z, an additional grid of shocks is defined, Ω^ξ. For each grid point ω_z and each point over Ω^ξ the trajectories of the relevant variables are computed. Finally, uncertainty is integrated out by means of Gaussian quadrature.

Next, we have to decide how to weigh the loss function at the various points of the grid. To this effect the related literature on functional approximation[26] proposes a variety of ways such as collocation, squared residuals, etc. In general there is no natural answer to the question of how to best weigh the losses over the grid. In the minimisation step we compute the euclidean norm of the loss function values over Ω^z, i.e.

$$L^m = \|L(\psi, \omega_{z_{min}}), \ldots, (\psi, \omega_{z_{max}})\| \tag{11}$$

c) Calibration and minimisation routine

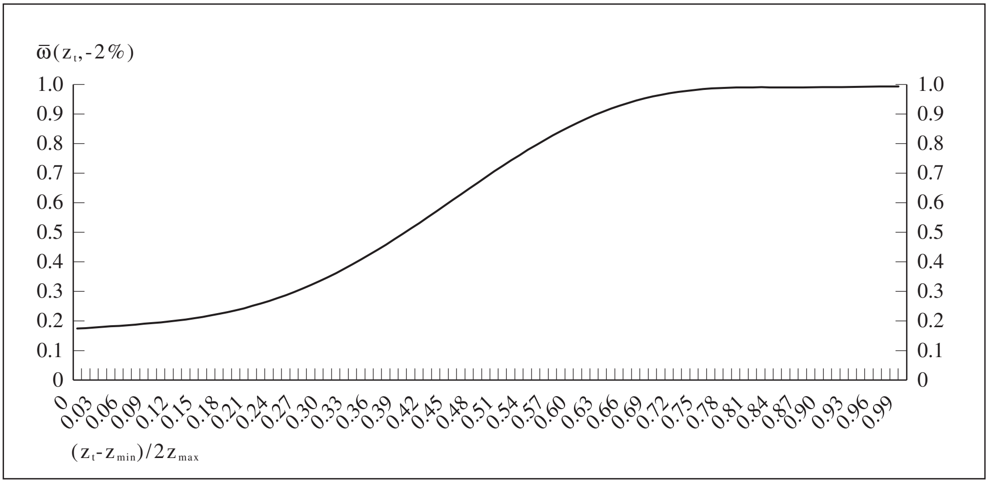
Table 1: Calibration of the model

Parameter	γ	ϕ	δ_0	δ_1	β	λ	θ^π	θ^c	$\overline{r}$	$\varkappa$
Value	3	0.85	0.0036	0.07	0.995	0.05	1.5	0.5	0.02	0.03

The final step is to calibrate some parameters and compute the others by loss function minimisation. Table 1 shows the values assigned to the calibrated parameters. γ represents the constant relative risk aversion coefficient. We set it equal to 3 to obtain a larger degree of risk-aversion than the one implied by log-preferences.[27] ϕ is the AR(1) coefficient of the stochastic process of the demand shock. We calibrate it equal to 0.85 to obtain the degree of persistence observed in reality for output and inflation. δ_1 is set equal to 0.07, based on the results reported by Ball and Cecchetti (1990) and δ_0 is assigned the value 0.0036 to match the output gap standard deviation after World War II in major industrialised countries with the average inflation rate in the euro area after the ECB was founded. β is the intertemporal discount factor. It is set equal to 0.995, since each period of time in the model represents a quarter. λ is the slope of the Phillips curve. It is assigned a small value (0.05) consistent with the estimated degree of price stickyness

[26] Judd (1996 and 1998), McGrattan (1999).
[27] This value is consistent with the findings reported by Hamada (1997) and Guo and Withelaw (2001).

Figure 5: Weighting function ($\bar{\pi}$ = –2%)



in major industrialised countries.[28] The nominal interest rate rule parameters (θ^{π}, θ^{c}) are calibrated following Taylor (1993) i.e. (1.5,0.5). The equilibrium real interest rate ($\bar{r}$) is set equal to 2%. However, due to the large degree of uncertainty surrounding the value of this parameter, we also report the main results of the paper when the equilibrium real rate is assumed to be 3% (see Appendix A). The public expenditure parameter is assigned the value 0.03, consistent with the constraint on fiscal deficits imposed by the Stability and Growth Pact (3 percent of GDP per year).[29]

Finally, we compute the parameters of the Chebyshev polynomial by means of minimising the loss function (11) under each inflation target $\bar{\pi}$,

$$\psi^* = \min_{\psi} \| L(\psi, \omega_{z_{min}}), \ldots, (\psi, \omega_{z_{max}}) \|$$

Computationally we do this by using the Levenberg-Marquardt algorithm. The inflation target varies from –2 percent (the so-called Friedman rule) to 4 percent. Since with one state variable the problem is computationally very manageable, we use a grid of 25 points for the state space and another grid of 25 points for the Gaussian quadrature procedure to integrate uncertainty out. The next section reports our numerical results.

4. Main results

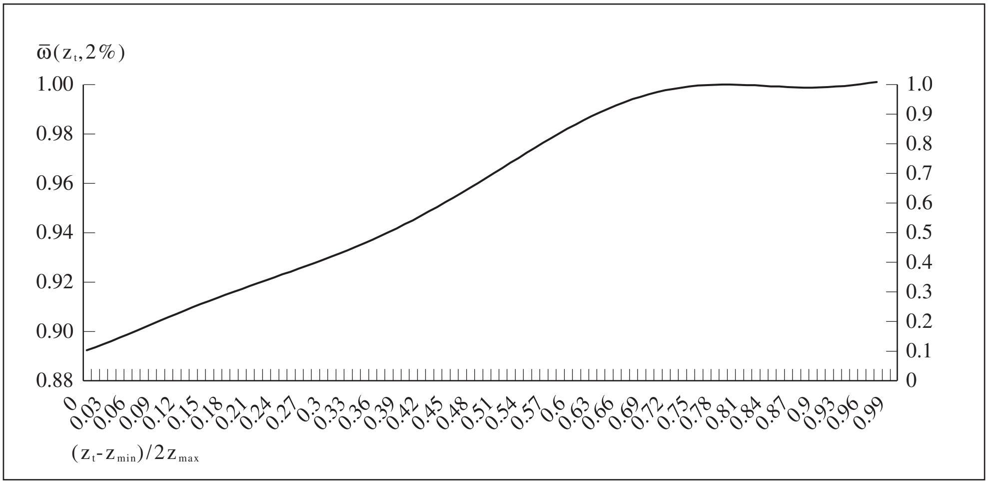
4.1 Reduced-form coefficients

Figure 5 plots the value of the weighting function $\varpi(z_t, \bar{\pi})$ as the state variable z_t varies (under $\bar{\pi}$ equal to –2 percent, the Friedman rule). Not surprisingly, $\varpi(\bullet)$ increases when

[28] See Lansing (2001) or Roberts (2001). This value of λ is consistent with the range reported by McCallum and Nelson (2000) for the impact of the output gap on inflation.

[29] Note that the level of potential output is normalised to 1.

Figure 6: Weighting function ($\bar{\pi}$ = 2%)



the state of the economy improves. Moreover, the non-linearity implied by the zero lower bound on nominal interest rates turns out evident.

Figure 6 charts the same plot but now $\bar{\pi}$ is set equal to 2 percent. As expected, a higher inflation target shifts the weights upwards since it reduces the likelihood of hitting the zero bound.

These exercises illustrate that our reduced form equations behave in an appropriate manner. Therefore, we can make use of them to analyse the relevance of the zero bound on nominal interest rates under different inflation targets.

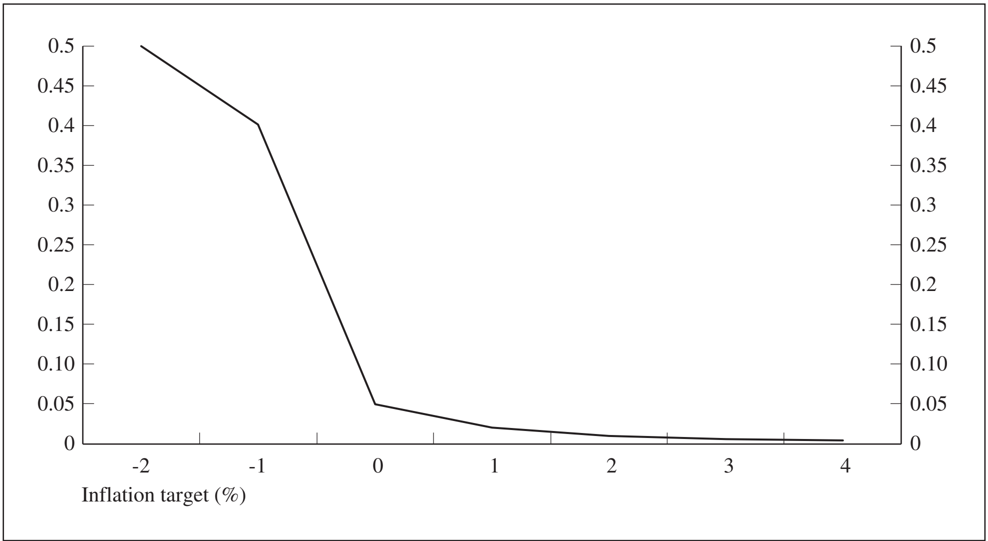
4.2 The probability of hitting the zero bound

Figure 7 shows the probability of hitting the zero bound implied by our model.[30] Like other scholars, we find that the probability increases more than proportionally when the inflation target decreases. When the equilibrium real interest rate is assumed to be 2 percent, this model implies that the probability of hitting the zero bound becomes negligible only under inflation targets above or equal to 1 percent (the results under the assumption $\bar{r}$ = 0.03 are reported in Appendix A).

For comparison, recall that Orphanides and Wieland (1998) report that the probability of the zero bound to be a binding constraint to nominal interest rate rules in the US is negligible under inflation targets around 2 percent in their model. These authors report results of an estimated backward-looking sticky-price model under two alternative policy rules, the Henderson and McKibbin rule and the Taylor rule, which is also the one we use. Relative to the latter the former has both a higher coefficient on the

[30] This probability is computed by starting 40 simulations of 2500 periods each from the deterministic steady state. We then drop the first 250 data points to limit the dependence on initial conditions and calculate the fraction of times that the zero lower bound was binding. Exact quadrature-based methods were also used, leading to very similar results.

Figure 7: Probability of hitting the zero bound



output gap (2 instead of 0.5) and on inflation (2 instead of 1.5). They find that the probability of hitting the bound is strictly higher under the Henderson and McKibbin rule, increasing from essentially zero percent under an inflation target of 2 percent to 10 and 30 percent as the inflation target drops to 1 and 0 percent (under the Taylor rule they report 0, 3 and 16 percent respectively). Nonetheless, they rely on linear methods to conduct their simulation exercises. This is not correct since the model is not linear once the zero bound on the nominal interest rate is introduced.

On the contrary, we correctly take into account the non-linear feature of the model when solving it. Interestingly, we do find smaller probabilities: around 5 percent for the non-negativity constraint to be binding when the inflation target is zero, and decreases to 2 percent and 1 percent when the target raises to 1 and 2 respectively.

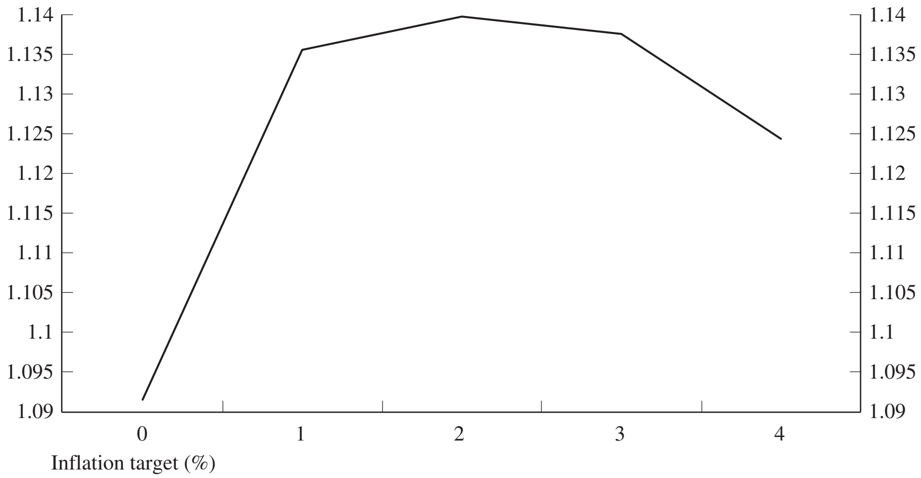
4.3 The inflation targets and welfare

To run a welfare analysis, the first requirement must be a utility function. We consider here a standard constant relative risk aversion functional form consistent with the equations presented above. Thus, the one-period utility function of the representative consumer is given by

$$U(C_t) = \frac{1}{1-\gamma} C_t^{1-\gamma} \tag{12}$$

where C denotes household consumption, defined by the goods-market clearing condition $Y = C + G$ (there is neither investment nor foreign sector in the economy). A second-order Taylor approximation around the stochastic steady state yields the following expression for the expected utility,

Figure 8: Welfare gains relative to the Friedman rule (output gap standard deviations)



$$E[U(C_t)] \simeq \frac{1}{1-\gamma}C_{ss}^{1-\gamma} - \frac{\gamma C_{ss}^{-\gamma-1}}{2}E\left[(C_t - C_{ss})^2\right] \tag{13}$$

where C_{ss} represents the steady-state consumption level. Equation (13) may be divided into two parts. On the one hand, a higher level of steady-state consumption implies a higher expected utility. In our economy, public expenditure is useless to the representative household but drains scarce resources that constrain the steady-state consumption. Therefore, this term is expected to increase when the inflation target increases as the probability of falling into the trap decreases.

On the other hand, a higher consumption variance reduces the expected welfare, since the representative agent is risk-averse ($\gamma > 0$). Regarding this, there are two different effects in our model. A higher inflation target means a higher variance of the exogenous shock and thus a higher consumption variance. However, at the same time, a lower inflation target means that monetary policy may become ineffective for some periods of time, increasing macroeconomic fluctuations. Moreover, if the economy hits the zero bound, public expenditure increases rapidly, reducing consumption and increasing consumption variance. The final effect depends on these trade-offs.

We now compute the steady-state welfare by means of Gaussian quadrature. Given that the law of motion of the state vector is univariate Markovian, this is a very efficient way to compute the entire distribution of the economy. For a generic function $g(Y)$ of the variables of the economy, Y, we compute the expected value as follows

$$E[g(Y)] = \int g(Y(z))dF(z) \simeq \sum_{\omega_z \epsilon \Omega^z} g(Y(z_{\omega_i}))\vartheta_{\omega_z} \tag{14}$$

where $F(z)$ denotes the cumulative distribution function of the state vector, z, and ϑ_{ω_z} denotes the appropriate weight associated to the grid point ω_z on the state grid Ω^z, which in our case is obtained from the Legendre's formula.

When the equilibrium real interest rate is assumed to be 2 percent, the final effect is depicted in Figure 8. It shows the welfare gains (in output gap standard deviations) with respect to the Friedman rule. Three conclusions may be drawn: first, to target a zero inflation rate is far from maximising welfare. Second, it could be seen that the welfare-maximising inflation target implied by the model is around 2 percent. At this point, the trade-off is exploited optimally. And third, welfare losses of moving between 1 percent and 3 percent are relatively small.[31]

However, if the equilibrium real interest rate is set equal to 3%, the above-said results change and the welfare maximising inflation target turns out to be zero (see Appendix A). As pointed out above, given the large degree of uncertainty surrounding the estimates of the equilibrium real interest rate, a welfare-maximising central bank, in the context of this model, should weigh these two different scenarios when choosing the quantitative definition of its policy objective. Indeed, a risk-averse policy-maker would presumably buy insurance by means of attaching a higher weight to the "2% real rate" scenario.

Naturally, the results obtained in this paper just like the results obtained in the other studies cited above are only of practical importance to the degree that the theoretical economies capture relevant features of real-world economies. While the model of this paper is very simple, it captures most of the features of the latest generation of New-Keynesian sticky price models. As such, it is an interesting benchmark against which we can compare larger models using the techniques outlined in this paper. More importantly, the central element of our analysis is the mechanism implemented to escape from the trap. In our case fiscal policy assures the existence of a unique equilibrium, which we then approximate. This equilibrium has as central feature deficitary spending that is effective instantaneously and lasts only while the nominal interest rate is zero. This means that, in our simple theoretical world, fiscal policy helps to re-boost the economy as soon as monetary policy becomes ineffective.

In order to introduce a higher degree of realism into our model we may want to add a number of features that are characteristic for government spending and that are generically cited by opponents of fiscal stimulus packages. First, fiscal policy is subject to well-known decision and implementation lags. As a result the timing of the action is an issue. Second, once the stimulus package is decided upon, the amount chosen may be inadequate, thus failing to achieve the policy's objective, or overshooting the goal. The latter combined with the lagged response might well lead to economic instability in the sense of generating undesirably persistent economic fluctuations. Finally, the experience in all of the major economies over the past century has shown that government spending, while relatively easy to increase, has proven to be notoriously difficult to decrease. As a result, the negative effects of government spending (here simply modelled through its wastefulness, but ignoring the distortions introduced through the tax system) might well amplify the overall cost of fiscal policy to a multiple of the cost here calculated. All these considerations may imply that our calculated optimal inflation target might well be biased towards zero, because losses of falling into the liquidity trap could be underestimated. However, we also could consider public expenditure not being completely useless, but entering into the utility function with a coefficient less than one.

[31] This a common feature to most exercises that use second order Taylor approximations to standard utility functions.

In this case the bias works on the opposite direction with the final effect depending on the values of the parameters of the model.

4.4 The bias stemming from the linear approach

As mentioned above, previous research on liquidity traps and the zero bound on nominal interest rates[32] is characterised by applying linear techniques to obtain the model solution, i.e. to find the set of equations that drive the behaviour of the key macroeconomic variables under the rational expectations assumption. However, once the non-negativity constraint is taken into account, the model becomes non-linear. As a result, these widely-used linear techniques lead to a bias when calculating the first moments of the unconditional distribution of the variables included into the model.

The intuition may be set out by the following example. In the vicinity of the zero bound on nominal interest rates, the effects of a positive shock on the economy are smaller in magnitude than the ones caused by a negative shock, because in the latter situation the probability for the central bank to have enough room for manoeuvre to implement an appropriate reduction in the policy rate decreases. A linear solution method implies that both effects are quantitatively identical. Nevertheless, this is no longer true in the context of the zero bound. We quantify this bias by calculating the first moments of the linear and non-linear approximations by quadrature.

Table 2: Bias arising from using (wrong) linear model solution methods instead of non-linear methods.

	$\bar{\pi} = 0\%$	$\bar{\pi} = 1\%$	$\bar{\pi} = 2\%$	$\bar{\pi} = 3\%$	$\bar{\pi} = 4\%$
Mean of c_t	+ 0.15%	+ 0.12%	+ 0.10%	+ 0.08%	+ 0.02%
Mean of π_t	+ 0.05%	+ 0.04%	+ 0.03%	+ 0.03%	+ 0.01%

Table 2 summarises the results for the means of c_t and π_t. Each entry represents the difference between the corresponding moment calculated by solving the model as it were linear minus the one calculated by using the non-linear technique proposed here. For example, if the inflation target were 0%, the (wrong) linear method implies a consumption average 0.15 percentage points larger than the one obtained by applying the non-linear method. As expected a priori, this bias increases as long as the inflation target decreases and, therefore, the probability of hitting the zero bound is higher (e.g. if $\bar{\pi}$ were –1%, the bias would be around +1%). Finally, as could be inferred from Table 2, the bias surrounding the mean of the inflation rate is quantitative smaller.

[32] See, for example, Orphanides and Wieland (1998) and Reifschneider and Williams (2000).

5. Conclusions

This paper studies the question of the quantitative relevance of the zero lower bound within the framework of a standard New-Keynesian sticky-price model. In order to assure the global uniqueness of the steady state we assume that otherwise neutral fiscal policy becomes expansionary at the zero lower bound.

The value added by the paper is twofold. On the one hand, it allows for the reaction of the economy to a shock to be state-dependent. This is specially true in the context of the zero bound on nominal interest rates since the degree of effectiveness of the monetary decisions is very limited when interest rates are close to zero. On the other hand, this paper embeds the relationship between the inflation rate and the volatility of the shocks, widely documented in the literature, in an otherwise standard model with nominal rates bounded at zero.

The results of the paper depend upon the value we choose to calibrate the parameters of the model. Indeed, these results are sensitive to the assumption on the equilibrium real interest rate. If this parameter were calibrated to be equal to 2% we would draw two main results from the model: first, the likelihood for the non-negativity constraint on nominal interest rates to be binding upsurges non-linearly when the inflation target decreases, increasing rapidly as the inflation target drops below 1 percent and being around 5 percent under an inflation target of zero. Second, the simple model we have presented here implies that 2 percent would be the inflation target that would maximise the expected utility of the representative consumer.

However, if the equilibrium real interest rate were set equal to 3%, the probability for the zero lower bound to be binding would fall to the vicinity of zero under inflation targets equal to or larger than zero. Indeed, the welfare-maximising inflation target turns out to be zero. Hence, since the degree of uncertainty surrounding the estimates of the equilibrium real interest rate is non-negligible, a benevolent policy-maker which aims to maximise the expected welfare of the representative consumer, ought to attach some weights to these two alternative scenarios (among others) when facing the decision of choosing the quantitative definition of its policy objective. Indeed, a risk-averse policy-maker would presumably buy insurance by attaching a higher weight to the “2% real rate” scenario.

Furthermore, this model does not take into account all possible economic costs that may be connected with an inflation rate different from zero (inflation premia, tax distortions, redistribution effects...) and that could point to the optimality of a lower inflation target. Moreover, if public expenditure were assumed to provide utility to the agents or the fiscal authority were allowed to adopt preemptive measures to avoid the zero bound situation, the welfare-maximising inflation target would tend to fall. On the other hand, a more realistic implementation of the fiscal sector, characterised by slow government action and bureaucratic problems, may turn the zero-interest rate situation even less desirable, pointing to the optimality of an even higher inflation target. The final effect remains unknown at this stage.

Further research may point to calculate the welfare-maximising nominal interest rate rule in the vicinity of the zero bound. This rule should be asymmetric (since the rule becomes useless below certain threshold) and state-dependent, i.e. the coefficients of the policy rule ought to be allowed to change as long as the nominal interest rate is falling towards zero. Under the optimal monetary policy rule, the welfare-maximising inflation objective very likely will be lower than otherwise.

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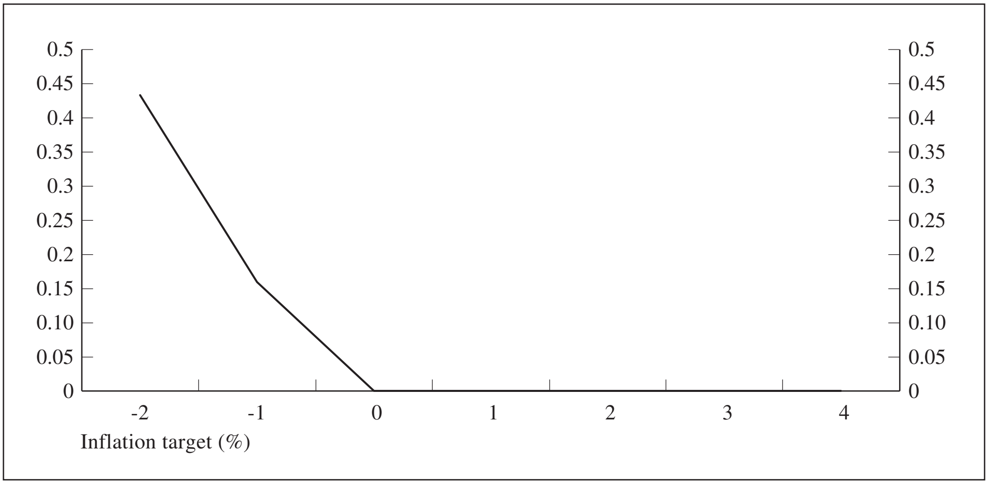
A. Main results under a different assumption on the equilibrium real interest rate

This appendix reports the main results of the paper under the assumption of a higher equilibrium real interest rate: 3 percent.

A.1 The probability of hitting the zero bound

Figure Al shows the probability of hitting the zero bound under inflation targets between –2 and 4 percent when the equilibrium real interest rate is set equal to 3 percent. As expected, the probabilities are much lower than previously reported, since the buffer the policy-maker enjoys is much larger. In particular, the likelihood for the non-negativity constraint to be binding falls below 0.1% under inflation targets equal to or larger than zero. Note that Figure Al is not the result of just shifting Figure 7 to the left, since this model takes explicitly into account the link between the long-run inflation rate and the variance of the shocks.

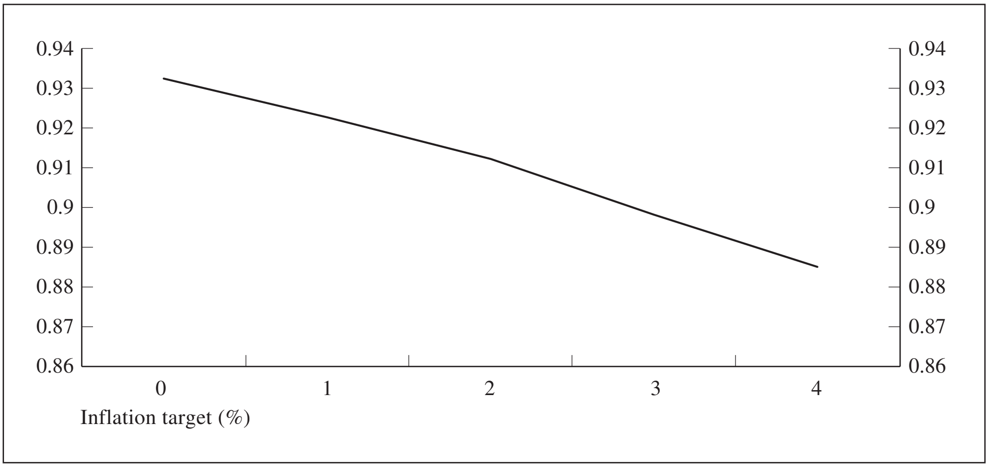
Figure A1: Probability of hitting the zero bound ($\bar{r}$ =3%)



A.2 The welfare-maximising inflation target

Figure A2 depicts the welfare-based comparison (in terms of relative gains with respect to $\bar{\pi} = -2\%$) of the non-negative inflation targets when the equilibrium real interest rate is equal to 3 percent. Not surprisingly, the welfare-maximising inflation target implied by the model falls with respect to Figure 8 because the probability of hitting the zero bound and thereby the cost of choosing a low inflation target is smaller now. Indeed, the welfare-maximising inflation target turns out to be zero. In other words, when the equilibrium real interest rate is 3 percent, the trade-off presented in this paper disappears as the zero lower bound is almost never binding under non-negative inflation targets.

Figure A2: Welfare gains relative to a -2% inflation target ($\bar{r}$=3%, output gap standard deviations)



8

The role of money in monetary policy making*

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1. Introduction

Inflation is a monetary phenomenon. Monetary growth in excess of increases in the public's demand for money balances will eventually decrease the purchasing power of money or, equivalently, raise the general price level. The long-term relationship between money and prices has been a cornerstone of monetary economics for several centuries (e.g., Hume, 1752) and has been documented for many countries and many eras (e.g., McCandless and Weber, 1995).

While recognition of this empirical regularity is almost ubiquitous within the economics profession, substantial controversy persists about the usefulness of the relationship between money and price in understanding, predicting and controlling inflation, and thus about its relevance for the design and implementation of monetary policy. Such controversy continues to be reflected in the ongoing debate about the appropriate design of monetary policy strategies.

Following the unacceptably high rates of inflation observed during the 1970s, many leading central banks adopted intermediate targets for monetary growth as the centrepiece of their monetary policy strategies. However, in the more benign inflationary environment of the 1990s, the role played by monetary aggregates in the policy framework of many central banks has diminished. By the end of the century, Laurence Meyer (2001), a member of the Federal Reserve System's Board of Governors, was able to assert *"… money plays no role in today's consensus macro model, and it plays virtually no role in the conduct of monetary policy, at least in the United States."* Nonetheless, other central banks give monetary analysis a much more important role in their formulation of monetary policy. Notably, the European Central Bank (ECB) has accorded *"a prominent role to money"* within its monetary policy strategy (ECB, 1999a,b; Issing, et al., 2001).

To the casual observer, the suggestion that monetary developments are not an important component of monetary policy-making sounds odd. As reflected in ECB (2000), Selody (2001) and King (2002), central banks generally adopt the view that monetary developments should not be ignored since – at a minimum – they offer an additional source of information which can help improve the robustness of monetary policy decisions (cf. Pill, 2001). This notwithstanding, much – although not all – recent academic discussion of monetary policy has neglected or ignored monetary aggregates.[1] This contrasts with the seminal work of monetarist economists such as Milton Friedman, who saw monetary dynamics as central to understanding the inflation process (e.g., Friedman and Schwartz, 1963). In the light of the contrast between these two branches of the literature, the prominent role of money in the ECB's monetary policy strategy[2] has been the subject of an ongoing debate in both academic and policy circles.

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[1] Analysis conducted in the context of strategies based on inflation targeting or Taylor rules are illustrative of this approach.

[2] The reference value and monetary analysis more generally form the money pillar of the ECB's strategy (ECB, 1999a and 2000). Much of the academic criticism of ECB's assignment of a prominent role has arisen in the context of the so-called "new neoclassical synthesis" view of the macroeconomy (Goodfriend and King, 1997). In this context, monetary aggregates are not seen as playing an active role in the transmission mechanism of monetary policy and, as such, should not play an important role – still less a "prominent role" – in the formulation of monetary policy decisions.

Against the background of a more general discussion of the role of money and monetary analysis in monetary policy making, this paper discusses conceptual and empirical aspects of the role of money in the conduct of monetary policy. Three related aspects – which are not mutually inconsistent – of the role of money in monetary policy making can be distinguished.

First, monetary aggregates might be useful to proxy for variables that are unobservable or observable only with time lags. Thereby money can contribute information for assessing the appropriate *stance of monetary policy,* which is not included in simple interest rate rules. A simple comparison between the short term rate maneuvered by the central bank and some conventional interest rate benchmark, say based on a Taylor rule, may often be a very inaccurate measure of the prevailing monetary conditions as perceived by market participants.. There are at least two dimensions to this signaling and proxying role of money. One such dimension is related to the fact that the construction of summary indicators for economic slack or overheating is subject to considerable dispute. Therefore, policymakers' knowledge of the output gap may not at all be superior to their knowledge of money velocity behaviour, and so they may find it useful to consult money-growth data as an early indicator of the prevailing economic conditions. Another aspect of money as an incremental gauge of the posture of policy becomes apparent in times of financial turbulence.

Second, and related to the above discussion, money may play an important structural role in the transmission mechanism of monetary policy to the price level. The importance of such transmission channels is essentially an empirical question, and may vary over time or even prove to be episodic. As discussed by King (2002), money and credit would play an important role if *imperfections in the financial sector* (i.e. borrowing and liquidity constraints) permit changes in the structure of balance sheets to influence yields and spreads in a manner that is relevant for intertemporal economic behaviour, such as pricing, consumption, saving and investment decisions.[3] Should such effects prove important, neglecting monetary dynamics in the formulation of monetary policy decisions will come at a potentially large cost. Some commentators cite the recent prolonged Japanese recession as an example of such costs, on the basis that asset market dynamics in Japan were driven or accommodated by a monetary policy that neglected monetary and financial developments.

Finally, money can provide *a nominal anchor for the economy*. A monetary policy that responds to monetary developments – in addition to the fundamental shocks which hit the economy from time to time – can help to rule out destabilising explosive paths for inflation expectations that could be triggered and sustained by self-fulfilling expectations.

Of course, experience in the conduct of monetary policy over many decades has demonstrated that reliable guideposts come and go, sometimes requiring policy makers to review and adjust their theories, procedures and operating methods. This notwithstanding, there are many reasons why the role of money in monetary policy making has proved durable. The remainder of the paper, in reviewing these reasons, is organised as follows.

[3] Note that situation constitutes a violation of the Modigliani / Miller theorem, which states that the financial structure of a firm or household should not affect its value and thus its economic decisions and behavior.

Section 2 surveys the empirical properties of money, focusing on results for the euro area. While much of the evidence relates to the indicator properties of monetary dynamics for inflation (rather than investigating structural models of the transmission mechanism), this section nevertheless offers broad empirical support for the incorporation of monetary analysis into the monetary policy making process.

Section 3 reviews a number of conceptual arguments in favour of assigning a prominent role to money in the formulation of monetary policy. In large part, these arguments follow from the view that money provides a nominal anchor to the economy, which helps avoid instability in the economy by ruling out indeterminacy or ambiguity in the determination of the price level.

Section 4 discusses how monetary analysis can be combined with analysis of demand and supply interactions and cost pressures to arrive at a single policy decision regarding the level of short-term interest rates. This discussion takes as its starting point uncertainty about the role of money in the transmission mechanism of monetary policy. A well-designed monetary policy should acknowledge this uncertainty, but nevertheless ensure that monetary developments are not ignored or neglected in the design of policy decisions.

While this paper cannot (and does not attempt to) resolve all issues related to the role of monetary developments in formulating monetary policy, it does provide empirical, conceptual and practical support for assigning money an important role in monetary policy decisions in the euro area. These are summarized briefly in Section 5, which offers some brief concluding remarks.

2. Empirical foundations

Since the ECB and the single monetary policy have been assigned the primary objective of maintaining price stability in the euro area, monetary developments should only influence monetary policy decisions insofar as they provide information that furthers the achievement of that objective. In other words, monetary developments are important for monetary policy decisions to the extent that they cause, help to predict or are otherwise associated with price developments such that they should play a role in monetary policy decisions.

Ideally, the relationship between monetary and price developments would be explored in the context of a structural model with well-developed micro-foundations. Unfortunately, notwithstanding ensuing discussion, structural models of monetary and financial interactions that are both sufficiently empirically relevant and conceptually appealing to be used as a guide to monetary policy decisions have yet to be developed. While considerable progress is being made in the field of monetary dynamic general equilibrium (DGE) models, their practical relevance for policy making awaits further tests.

Consequently, in practice, empirical assessments of the relationship between money and prices are based on semi-structural or reduced form models such as money demand equations, VARs or reduced form indicator relationships. The remainder of this section reviews the application of such approaches to euro area data.

Table 1: Summary of studies of the long-run money demand equations for euro area M3

	Sample	Aggregation method	Income elasticity	Interest rate (semi) elasticity	Other variables in longrun money demand equation	Weak exogeneity
Coenen and Vega, 1999	1980:4-1997:2	Sum logs of national components	1.14	-0.820 (on the spread between the long-term and short-term interest rate)	inflation, with a coefficient of -1.462 (interpreted as a measure of opportunity cost)	output, inflation, short-term interest rate, long-term interest rate
Brand and Cassola, 2000	1980:1-1999:3	Sum national components at irrevocable fixed exchange rates	1.33	-1.608 (on the long-term interest rate)	none (estimated as a system with the yield curve and Fischer parity conditions)	none
Calza, Gerdesmeier and Levy, 2001	1980:1-1999:4	Sum national components at irrevocable fixed exchange rates	1.34	-0.86 (on the spread between the short-term market interest rate and the own rate on M3)	none	output

Sources: Coenen and Vega (1999), Brand and Cassola (2000), Calza et al. (2001).

2.1 Stability of the relationship between money and prices

The stability of the relationship between the money stock and the price level is typically evaluated in the context of a money demand equation, which relates money to prices and other key macroeconomic variables (such as real income and interest rates). Stability is assessed using cointegration techniques (see Engle and Granger, 1987, and Johansen and Juselius, 1990), which test whether a stable long-run relationship among the levels of the variables exists.

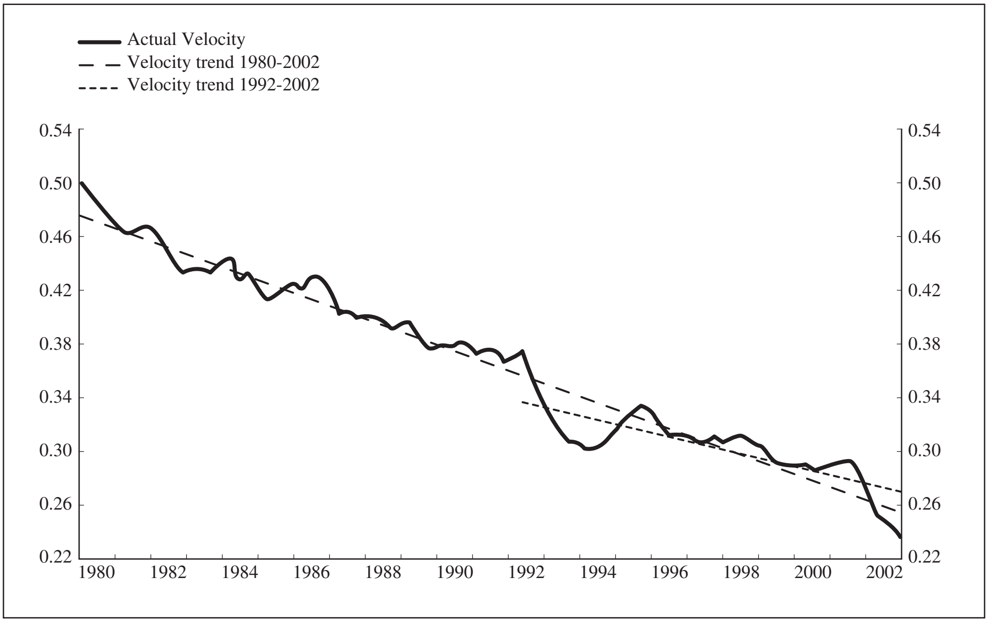
A number of such studies have been undertaken on euro area data. Since cointegration techniques require long data samples, these investigations rely largely on data for the euro area prior to Monetary Union constructed from pre-existing national monetary series. In addition to the usual concerns regarding the stability of economic relationships in the face of a regime change such as the introduction of the single monetary policy, the empirical analysis thus faces additional, though unavoidable, uncertainties regarding the quality of the data and the appropriate aggregation technique.[4]

Three major studies of the demand for the broad monetary aggregate M3 in the euro area have been prepared and published by ECB staff (see Coenen and Vega, 1999, Brand and

[4] However, these concerns apply to all data series for the euro area in the period prior to the introduction of the euro. In practice, the quality of the monetary data is thought to be at least as high as other series.

Cassola, 2000, and Calza et al., 2001).[5] The main results of these papers are summarized in Table 1. While the approaches vary in detail,[6] all three studies find a stable long-run demand for euro area M3, i.e. a cointegrating relationship involving money, the price level, national income and some opportunity cost variables is obtained.[7] The intuition behind this finding is powerfully illustrated in Chart 1, which shows the income velocity of circulation for euro area M3 in the period 1980-2002. The steady and smooth decline in M3 velocity over this period reflects the stability of the estimated money demand equations.

Chart 1: M3 velocity trends for the euro area (log levels)



Sources: ECB (M3) and ECB calculations based on Eurostat data (GDP).
Note: Velocity is measured as the ratio of nominal GDP to M3. The underlying quarterly series are seasonally adjusted and constructed by aggregating national data converted into euro at the irrevocable exchange rates applied as from 1 January 1999 and as from 1 January 2001 in the case of Greece. The M3 series is based on the headline index of adjusted stocks (for further details, see the technical notes in the "Euro area statistics" section of the ECB Monthly Bulletin). M3 quarterly data are averages of end-month observations.

5 Euro area M3 is defined as the following liabilities of euro area monetary financial institutions (MFIs) held by euro area residents: currency in circulation; overnight deposits; deposits with agreed maturity up to 3 years; deposits redeemable at notice up to 3 months; repurchase agreements; money market fund shares/units and money market paper; and, debt securities with maturity up to 2 years.

6 Such as in the choice of interest rates used to measure the opportunity cost of holding money, in the aggregation technique used to construct the euro area back data, in the sample period investigated or in the specification of the equation.

7 More recent stability tests have confirmed the long-run stability conditions of the demand for M3 in the euro area. See, among others, Brand *et al.* (2002) and Bruggeman *et al.* (2003).

Therefore, in contrast to some results obtained in other G7 economies (such as the United Kingdom and the United States), the evidence in favour of a simple and stable long-run relationship between broad money and the price level in the euro area over the last two decades appears robust.[8]

Stracca (2001) has also investigated the properties of a Divisia monetary aggregate for the euro area. Divisia aggregates weight the different components of monetary aggregates according to their "moneyness", with the weights being related to the opportunity cost associated with holding the monetary asset rather than a non-monetary asset bearing a market return. Stracca finds a stable demand for a euro area Divisia monetary aggregate, thereby demonstrating the robustness of the results outlined above to different aggregation techniques.

All in all, the stability of euro area money demand relationships suggests that a path for the evolution of the money stock can be derived which, conditional on developments in other macroeconomic variables, is consistent with the maintenance of price stability over the medium term.

2.2 Leading indicator properties of money for price developments and macroeconomic outcomes

Given the lags in monetary transmission, a monetary policy aimed at the maintenance of price stability must be forward-looking. Leading information on future price developments is therefore crucial. Current monetary developments may contain information about future price developments, i.e. money may be a leading indicator of inflationary or deflationary pressures. It is important that such forward-looking information is incorporated into the monetary policy making process.

Money may also contain leading information on other macroeconomic variables that – although not constituting the ultimate objective of monetary policy – will influence the future course of the economy and, eventually, price developments. Such information is also central to monetary policy decisions, since it will influence the magnitude and timing of policy actions.

Several studies by the staff of the ECB have investigated the leading indicator properties of monetary developments in the euro area. For example, in the context of the money demand studies reported above, Brand and Cassola (2000) find that neither inflation nor aggregate demand are weakly exogenous to their money demand system, suggesting that monetary developments will help to predict these variables. Trecroci and Vega (2000) extend the Coenen / Vega money demand framework and also find that money helps predict future inflation. [9] Broadly speaking, these results are consistent

[8] These results support the a priori intuition that the demand for broader monetary aggregates is more likely to be stable than that of narrow monetary aggregates, since the former internalise the substitution between different categories of monetary asset that may create instabilities in the latter. This notwithstanding, money demand equations for euro area M1 also show surprising stability, albeit with less conventional specifications. Stracca (2000) investigates various specifications for the opportunity cost term and finds that a stable demand for M1 can be estimated if the interest rate semi-elasticity is allowed to vary with the level of interest rates.

[9] For a review of the monetary tools used at the ECB, see ECB (2001a) and Masuch *et al.* (2001).

with those reported by Gerlach and Svensson (2002) for euro area M3. In the context of a P* model (see Hallman et al., 1991), Gerlach and Svensson (2002) show that the so-called real money gap – a measure of the monetary disequilibrium relative to a stable long-run money demand equation – helps to predict future price developments.

A comprehensive assessment of the leading indicator properties of money in the euro area is offered by Nicoletti-Altimari (2001). Following the approach proposed by Stock and Watson (1999) for forecasting inflation in the United States, this study focuses on the out-of-sample forecasting performance of potential indicator variables.

A brief summary of the main results from this paper is presented in Table 2. The numbers in the table show the ratio of the forecast errors of a specific indicator model relative to those of a benchmark model, which captures inflation as a pure autoregressive process. A number greater than one therefore indicates a poor model, while a number less than one is associated with a model that performs better than the benchmark.

Using Table 2 (and, more generally, Nicoletti-Altimari's (2001) results), a number of conclusions can be drawn. First, there is considerable evidence that including monetary indicators improves the out-of-sample forecasting performance of a pure autoregressive model of price developments. Second, the performance of money-based indicators relative to other indicators (such as estimates of the output gap or cost pressures) improves as the horizon of the forecast lengthens. Third, it is noteworthy that (nominal) M3 growth offers the best relative forecast performance at the longest (three-year ahead) horizon. Finally, various other monetary indicators – including measures of monetary growth, estimates of monetary disequilibrium (like the P* indicator) and indicators based on the components (e.g. M1, M2) and counterparts (notably loans to the private sector) of the broad monetary aggregate M3 – also appear to exhibit leading indicator properties for price developments. As a result, a composite monetary indicator which combines information from all these measures could be constructed which would outperform any individual measure.[10]

These results point to monetary developments being an important indicator of medium-term trends in price dynamics in the euro area. Given the necessarily medium-term orientation of monetary policy,[11] they suggest that monetary indicators should be given an important role. On the basis of the indicator results, one can construct money-based forecasts of future price developments. Although, as with any single forecast, these money-based projections do not provide a sufficient basis for monetary policy decisions,[12] such information can be an important input to the monetary policy process, e.g. for cross-checking results obtained on the basis of structural macro-econometric models.

[10] Very favorable leading indicator properties of broad monetary aggregates for inflation developments at medium term horizons in the euro area are also found by Gottschalk et al. (1999) and Cristadoro et al. (2001). Brand et al. (2003) document leading indicator properties of M1 with respect to real activity.

[11] Implied by Friedman's famous "long and variable lags" in the transmission mechanism of monetary policy actions to the price level.

[12] In particular, since the money-based projections are not derived from a structural model of the economy, they do not offer a basis for calibrating the magnitude of the appropriate interest rate response to counter emerging inflationary or deflationary pressures.

Table 2: Leading indicator of properties of monetary variables for HICP inflation in the euro area

This table reports the ratio of the MSE of the out-of-sample forecasts for the model including the indicator variable to the MSE of the simple univariate time series model of inflation.

The sample period is 1992:1 - 2000:3.

Variable		Transformation	Horizon in quarters			
			1	4	8	12
Univariate model, for reference (% RMSE)			0.50	0.62	0.70	1.02
M1		DLN	0.98	1.04	1.05	0.95
M2		DLN	0.98	0.92	0.89	0.90
M3		DLN	0.90	1.29	0.98	0.43
Credit		DLN	0.93	0.90	0.74	0.58
Money gap	BC	LN	1.05	1.02	0.87	0.64
	CV	LN	1.11	1.05	1.31	1.46
P-star	BC	DLN	0.86	0.76	0.60	0.80
	CV	DLN	1.08	0.98	0.97	1.08
Output gap	LN	1.14	1.01	0.96	0.78	
Unemployment		L	0.90	0.82	1.36	0.88
Unit labour costs		DLN	1.09	0.94	0.87	1.20
Effective exchange rate		DLN	1.20	1.14	1.03	1.04
Oil prices	DLN	1.37	1.05	0.99	1.81	

Notes: Transformations: D = first difference; LN = logarithm; L = level. BC is the Brand and Cassola (2000) model; CV is the Coenen and Vega (1999) model.
Source: Nicoletti-Altimari (2001), Table 1a, p. 39.

Other studies (reported briefly in Masuch et al., 2001) also point to money have leading indicator properties for other key macroeconomic variables. In particular, annual growth rates of M1 have been found to help predict future developments in real activity about one-year ahead.[13]

[13] In addition to the formal econometric studies discussed above, central banks' staff normally undertake a regular detailed analysis of monetary data. This analysis extracts the information from monetary developments that is relevant for monetary policy decisions, and thus tries to identify special factors or portfolio shifts which distort the relation between money and prices. A detailed discussion of the framework used for this analysis in the case of the ECB – including the judgmental and institutional analysis that complements econometric techniques – is provided in Masuch et al. (2001). It is noteworthy that central bank staff who closely monitor developments in financial and banking markets are often in a position to interpret and correct "headline" monetary developments using "off-model" information that is not incorporated into econometric studies. Such analysis therefore often adds to the policy-relevant information in monetary developments, extending their relevance beyond what would be suggested by the econometric studies reported above alone.

This discussion therefore suggests that – at least on the basis of euro area monetary aggregates – empirical support exists for the following assertions: First, a stable long-run relationship between money, prices and a small number of other key macroeconomic variables exists; second, monetary developments are leading indicators of future price developments, especially at longer horizons.

2.3 Money as a proxy for variables measured with a lag

Research on Taylor rules has emphasised the importance of 'real time' data uncertainty for monetary policy decisions. In particular, a number of studies of the United States have found that uncertainty arising from revisions to output gap and inflation estimates may lead to a significant deterioration in the performance of Taylor-like monetary policy rules (see Orphanides, 2000). Less energy has been devoted to investigating money's potential role as an information variable in this context. However, if measures of money are subject to fewer revisions – and on average of lesser magnitude than estimates of real output – monetary aggregates may play a significant role in providing timely and 'steady hand' information about the current state of the economy.

In a recent paper, Coenen et al. (2001) pursue this avenue of research. In a model with rational expectations, nominal inertia and an apparently totally passive status of money – along the lines of the New Keynesian benchmark model discussed in Section 3 below – monetary developments are shown to be of great help to the policy maker, since money balances react to the 'true' level of income, whereas the central bank is assumed to receive only a noisy measure of output. To be sure, the extent to which monetary data enhance the available information set depends crucially on the effort that monetary authorities exert in collecting monetary statistics and undertaking monetary analysis.

2.4 Money as a proxy for unobserved variables: monetary and financial conditions

The money stock can serve as a proxying index also along a different dimension. In a recent paper, Nelson (2002) emphasises the effects of monetary policy upon a whole 'spectrum of rates' – over and above that manoeuvred by the central bank – as the driving force within the transmission mechanism. However, a large part of the complete set of yields that matter for aggregate demand is unobservable to monetary authorities. Hence, if the demand for money can be thought of as a function of a broad set of yields besides those observed in securities markets, then movements in money aggregates would convey information that the central bank would not otherwise be able to extract from alternative indicators.

In fact, the historical association between protracted episodes of money growth in excess of some sustainable reference rate and the build-up of financial imbalances and asset price bubbles can probably be interpreted in this light. In periods of financial turbulence the implicit rate at which market participants discount future expected earnings from asset portfolios may vary in ways that are both unpredictable and unobservable to monetary authorities. In these circumstances, a simple comparison between the short term rate manoeuvred by the central bank and some interest rate benchmark, say based on a Taylor rule, may not be an accurate measure of the prevailing monetary conditions as perceived by market participants. By contrast, monetary quantities – primarily due to their link to credit – have a powerful (incremental) role to play as indicators of the actual stance.

Issing (2002) brings some suggestive evidence to this effect. He analyses three past episodes which, in hindsight, are regarded as having involved large, if unintentional, monetary policy mistakes. In all three cases he investigates whether a policy taking the quantity theoretic equation seriously, and using a money stock indicator as a gauge for the prevailing conditions, could have been instrumental in yielding a better macroeconomic outcome.

Chart 2, which we borrow from that contribution, depicts the evolution of some key indicators in the 1920s and early 1930s in the US in the face of a major build-up and subsequent collapse of equity prices. The excess money measure used in the Chart is defined as the difference between the actual growth rate of nominal broad money and the rate that would be implicit in the quantity relation with real income growing at its potential rate, inflation at the central bank's implicit objective, and velocity at its long-term trend.[14]

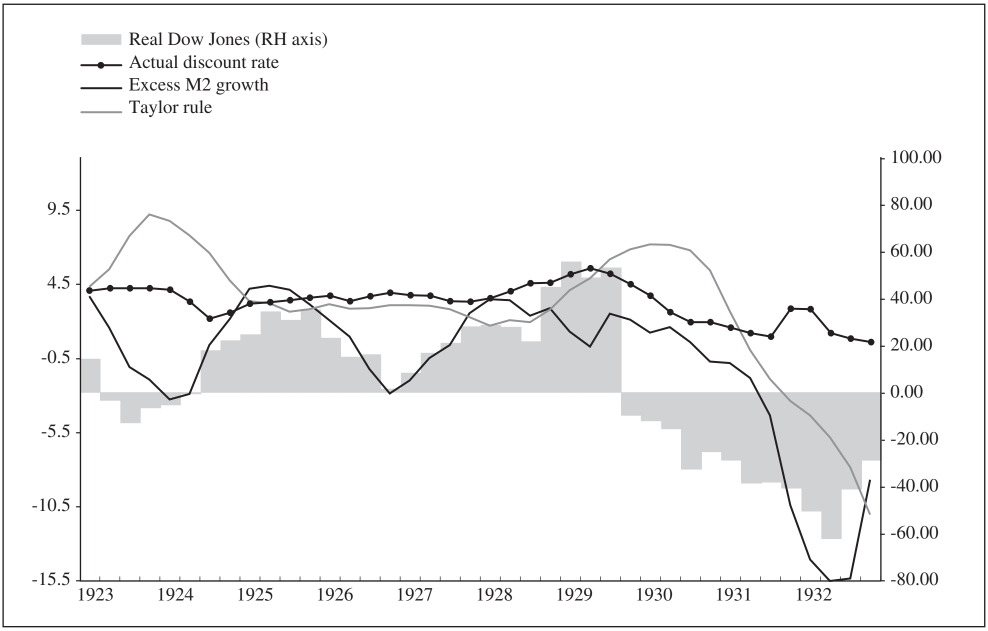
Notwithstanding its purely descriptive nature, this exercise is instructive. It suggests that a quantity measure would have conveyed information which was not forthcoming from a pure analysis of the interest rate used by the Fed in its operations. It shows that, had the Fed looked at a measure of excess money growth, had it not rejected the then novel normative framework offered by the quantity theory of the business cycle, it would have probably realised that monetary policy was too lax, not too tight, for much of the 1920s.[15] Intriguingly, the measure of excess money growth appears to move in sympathy with the profile of the histograms which represent the growth rates of real stock prices in New York. It becomes positive – and significantly so – in those years in which the market is most buoyant. And it turns negative when the market pauses or falls. Perhaps, one can conclude, money was growing too fast in the years immediately preceding the crash, compared to the long-term necessities of an inflation-free economy operating at potential. Perhaps, that excess of monetary injection was spilling over into the purchase of financial assets. However, looking at the discount rate only, to the exclusion of the monetary indicator, and measuring the historical path of the discount rate against the benchmark provided by the Taylor rule, one would draw the opposite indication. The extent of the abrupt policy reversal in the first half of 1929, which many contemporary observers quote as a primary cause of the disorderly fall in the market, is also more apparent from the quantitative than the interest rate indicator. [16]

[14] Excess money growth is defined as Δ_4 e = Δ_4 m-[Δ_4 p*+ Δ_4 y*]+Δ_4 v*, where Δ_4 denotes the four-quarter difference operator and m, p*, y* and v* stand for (logs of) the actual stock of M2, the price objective, real potential GDP, and long-term velocity of circulation, respectively. See the footnote to the Chart for further clarifications.

[15] That the stance of policy may have been too lax in the later phase of the asset price build-up of the 1920s, besides being a long-standing contention of some prominent representatives of the Austrian School at the time, has been recently remarked by Bordo and Jeanne (2002).

[16] Recent results documented in Christiano, Motto and Rostagno (2003) confirm that a money base-supply rule – reacting predominantly to various sources of money demand shocks – could have largely prevented the Great Depression.

Chart 2: The US in the 1920s: Excess money growth, real asset price growth and monetary policy (year-on-year changes)*



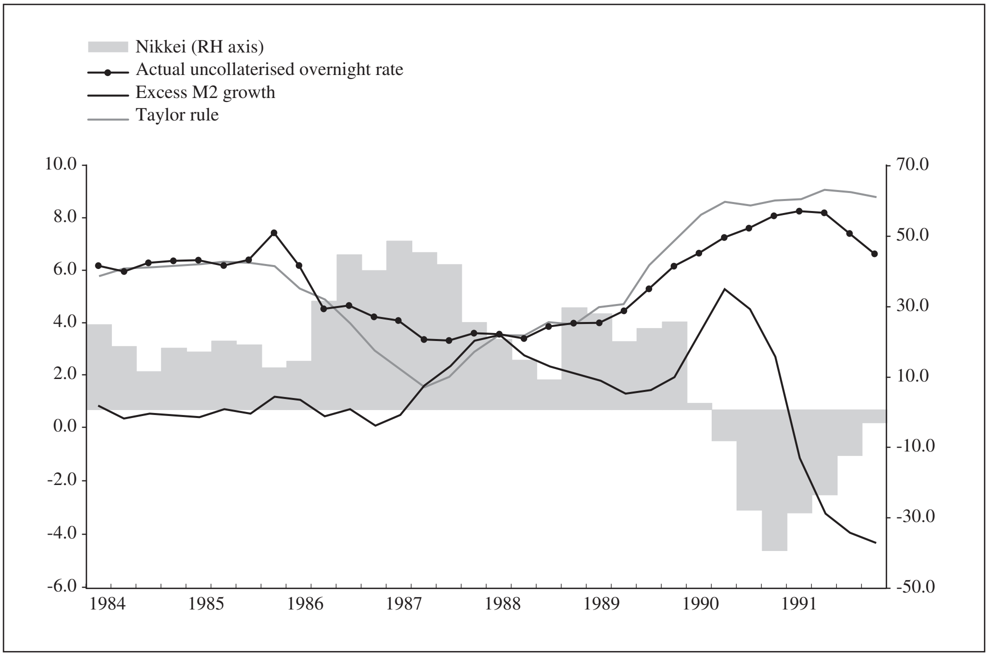
Sources: Issing (2002)

(*) Note: Excess money growth is defined as Δ_4 e = Δ_4 m-[Δ_4 p*+Δ_4 y*]+Δ_4 v*, where Δ_4 denotes the four-quarter difference operator and m, p*, y* and v* stand for (logs of) the actual stock of M2, the price objective, real potential GDP, and long-term velocity of circulation, respectively. The price objective is normalised to 1, potential output is obtained applying an HP-filter to actual real GDP, trend velocity for 1923-1930 is constructed by interpolating a linear trend to realised velocity over 1921-1929, and by imposing a structural break afterwards to reflect the sharp contraction in nominal GDP, primarily led by a fall in producer prices. The Taylor rule has been calibrated to an equilibrium real interest rate equal to the average real discount rate observed in the first two quarters of 1923, and imposing an inflation coefficient 1.5 and an output gap coefficient of 0.5.

A similar picture emerges from the Japanese data (Chart 3). While a Taylor rule would have signaled an appropriate-to-tight stance of policy until well into 1989, excess money was building up in the second half of the 1980s, finally at an accelerating pace.[17] Apparently, the Bank of Japan had expressed early concerns that rapid money growth might predispose the ‘dry wood’ needed to set the asset market on fire. But probably no tightening – in excess to that already apparent in the data – could have been justified to the public on the back of persistently subdued inflation and growing measures of productivity. Again, it seems that a monetary policy gauge focused on inflation and a measure of slack only – to the neglect of money – would have failed to sound the alarm.

[17] McCallum (2000) confirms the good fit of a Taylor rule to the actual policy orientation of the Bank of Japan in the 1980s. He also finds that a rule involving a target for base money growth would have provided important insights to the policy-makers in those difficult circumstances.

Chart 3: Japan in the 1980s: Excess money growth, real asset price growth and monetary policy (year-on-year changes)*



Sources: Bank of Japan and ECB staff calculations.

(*) Note: Excess money growth is defined as $\Delta_4 e = \Delta_4 m\text{-}[\Delta_4 p^*+\Delta_4 y^*]+\Delta_4 v^*$, where Δ_4 denotes the four-quarter difference operator and m, p^*, y^* and v^* stand for (logs of) the actual stock of M2+CDs, the price objective, real potential GDP, and long-term velocity of circulation, respectively. The Bank of Japan implicit inflation objective has been set equal to an yearly rate of 1.7 per cent (the average of the Japanese CPI inflation between 1984 and 1991), potential output is obtained applying an HP-filter to actual real GDP, trend velocity is constructed by interpolating a linear trend to realised velocity over a 20-year period starting in 1980. The Taylor rule has been calibrated to an equilibrium real interest rate equal to the average real un-collateralised overnight rate observed in the first two quarters of 1984, and imposing an inflation coefficient 1.5 and an output gap coefficient of 0.5.

Furthermore, alternative indicators, such as private credit, may at times outperform broad money in signaling that observed swings in asset prices are abnormal and may prelude to financial distress.[18]

Of course, at times shocks to money demand may obscure the message that money indicators convey. Therefore, it is crucial that central banks are able to filter crude monetary data in order to extract the underlying signal of future risks to prices.

[18] The close correlation between domestic credit growth and the change in (a composite indicator of various) real asset prices is stressed in a recent contribution by Borio and Lowe (2002).

3. Conceptual considerations

The basic theoretical justification for assigning a prominent role to money in a monetary policy strategy lies in the following fact: it is simply impossible to observe high and sustained inflation without systematic monetary accommodation. Similarly, a prolonged and substantial deflation requires monetary contraction.

What is meant by "monetary accommodation"? In the past, this concept has often been identified with a central bank's adoption of an interest rate rule. In other words, rather than pursuing a quantitative target for money, the central bank sets an operational target for a nominal short-term interest rate. In a famous article, Sargent and Wallace (1975) challenged this practice on the basis that such a regime leaves the price level indeterminate and would thus tolerate (or even trigger) prolonged periods of high inflation.

However, following McCallum (1981), it was recognized that "monetary accommodation" was not synonymous with an interest rate rule *as such.* In particular, McCallum showed that an interest rate feedback rule would not lead to nominal indeterminacy if the rule was defined so as to have an impact on, say, the price level in the upcoming period. McCallum showed that monetary authorities could set monetary policy in terms of an interest rate, provided that the way in which the policy interest rate was maneuvered reflected a concern about the future evolution of some nominal magnitude.[19]

However, this line of analysis suggested that the 'nominal magnitude' did not necessarily need to be money. It led to the conclusion that central banks could adopt a policy rule whereby the policy interest rate fed-back from a set of endogenous variable indicators, but *not including money.* Such a moneyless framework still provided the economy with the anchor that it needed for nominal values to be pinned down.[20]

Formulated in this manner, McCallum's result had far-reaching consequences for the theory and practice of monetary policy. It gave rise to the flourishing literature on interest rate rules for monetary policy, which constitute one building block of what Goodfriend and King (1997) have named "the new neoclassical synthesis" in macroeconomics, and others the "New Keynesian model". This framework maintains that it is, in general, possible to develop guidelines for monetary policy aimed at price stability without having to specify policy in terms of a monetary aggregate.

To be sure, the guiding principles stemming from this framework exhibit recognizable 'monetarist' features: they are wedded to neoclassical reasoning; they are built on the presumption that inflation is ultimately a monetary phenomenon, which can ultimately be governed by the central bank given the latter has the power to supply base money and thus to set the overnight interest rate; and, they recommend making low and stable inflation the primary objective of monetary policy. Nevertheless, this approach departs decisively from the heart of monetarism by rejecting the monetarists' practice of organizing monetary analysis largely in terms of the interplay between the supply of money and the demand for real balances.

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[19] This insight was subsequently refined by Woodford (2003, Chapter 2), who argued that, in order to pin down prices, the central bank need not adjust its interest rate instrument in response to *nominal* quantities. All is needed is a reaction function linking the policy interest rate to *endogenous* variables. More on this below.

[20] Woodford (2003, Chapter 2), in particular, raises this point with force.

Therefore, while recognizing the validity and robustness of the long-run link between monetary growth and inflation, prominent contributors to this branch of literature argue that money should not be assigned a special status in the monetary policy making process. Monetary policy should not pay special attention to developments in monetary aggregates because the observed long-run relationship between money and prices says nothing about the direction of causality running between them (Galí, 2001). In this context they argue that, paying excessive attention to monetary developments simply exposes monetary policy decisions unnecessarily to the vagaries of money demand.

Against this background, the scope of the remainder of Section 3 is rather limited. Working *within* the new neoclassical synthesis framework briefly outlined above, the section evaluates whether the strong policy conclusions drawn above are justified. This discussion is organized in two parts. First, we outline the basic new neoclassical synthesis model. Second, we show that within this environment a class of popular rules that do not include money can give rise to self-fulfilling fluctuations.

3.1 A non-monetarist model

An extremely simplified version of the new neoclassical synthesis model can be reduced to these three summary conditions.[21]

$$y_t = \gamma_0 - \gamma_1 (i_t - \mathrm{E}_t \pi_{t+1}) + \mathrm{E}_t y_{t+1} + \mathrm{e}_t \quad (1)$$
$$\pi_t = \delta_0 \mathrm{E}_t \pi_{t+1} + \delta_1 (y_t - y^*) + \mathrm{u}_t \quad (2)$$
$$(m_t - p_t) = \eta_0 + \eta_1 y_t - \eta_2 i_t + \mathrm{z}_t \quad (3)$$

where other than the short-term nominal interest rate under the control of the central bank, i_t and the inflation rate, π_t, all variables are expressed in logarithms. y_t is output; p_t is the price level, m_t is (base) money and e_t, u_t and z_t are stochastic error terms. $\mathrm{E}_{t\text{-}1}x_t$ represents the expectation of x_t at time t-1, where t is (discrete) time.[22]

Equation (1) (with γ_0 and γ_1 both positive) is a dynamic stochastic IS curve which can be derived from the Euler condition associated with the representative household's savings decision by imposing standard market clearing conditions. It states that output y_t is related (negatively) to the contemporaneous real interest rate and (positively) to expectations of future output conditions.

Equation (2) (with $\delta_1 > 0$ and $0 < \delta_0 < 1$) is a forward-looking Phillips curve, which can be derived from optimal pricing decisions of monopolistically competitive firms facing constraints on the frequency of future price changes. The current rate of inflation responds to expectations of future inflation and the current level of resource utilization, as proxied by the output gap. Equation (3) is a money demand relation, which is obtained from the optimal marginal conditions on consumption and money holdings, assuming money provides liquidity services that are valued by the agent along with consumption goods. It states that real money balances vary positively with income and negatively with the nominal interest rate.

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[21] Seminal examples of this line of thought can be found in Woodford (1997 and 2003, Chapter 4), Goodfriend and King (1997), Clarida, et al. (1999 and 2000) and McCallum (2001) and the rightly celebrated book by Taylor (1999).

[22] The contemporaneous inflation rate is defined as $\pi_t{,}= \mathrm{p}_t - \mathrm{p}_{t\text{-}1}$.

Expressions (1) and (2) are central to the new neoclassical synthesis view of macroeconomics. Assuming a household utility function that is additively separable between consumption and real money balances, these two equations describe the dynamics of inflation and output as a function of the short-term nominal interest rate *only*. Except for the nominal interest rate term appearing in (1), the system is block-recursive: the transmission mechanism of monetary policy operates solely via prices (the cost of borrowing), and not via quantities (e.g. the availability of credit or money holdings).

In principle, the first two equations could be made entirely autonomous, provided the interest rate maneuvered by the central bank is itself made insensitive to any magnitude which does not appear in either (1) or (2). A very general formulation of such a rule is provided below:

$$i_t = \Phi\,(y_t, \mathrm{E_t}\, y_{t+1}, \pi_t, \mathrm{E_t}\, \pi_{t+1}, \mathrm{e}_t, \mathrm{u}_t) \qquad (4)$$

where, notably, the set of indicators deemed relevant for policy does not include $(m-p)_t$.

Assuming this policy rule performs well – in a sense to be made explicit shortly – "the monetary sector becomes basically an afterthought to monetary policy analysis. The familiar LM curve only serves the purpose of determining the quantity of money given the price level, real income, and the nominal interest rate" (Kerr and King, 1996). In this context, expression (3) would appear superfluous. It only serves to specify the quantity of money needed to clear the money market at the interest rate dictated by the policy rule. Monetary dynamics are thus irrelevant to the determination of price developments and should not concern a central bank aiming at price stability.

Taking these results at face value, the autonomous (or moneyless) policy rule (4) is both analytically convenient and capable of simplifying the task confronted by a central bank. However, this prima facie view is insufficient.

3.2 Is money useful as nominal anchor?

Technically, it is not sufficient to demonstrate that a moneyless rule exists which is *consistent* with a particular desired equilibrium. One has also to demonstrate that the desired outcome is the *unique* equilibrium associated with that rule. In other words, one has to demonstrate that the posited policy rule avoids situations in which the central bank, quite unintentionally, permits economic fluctuations (and, in particular, deviations from price stability) which arise solely from self-fulfilling expectations. If a policy rule were to tolerate these situations, not only would the response of the economy to exogenous (fundamental) shocks be indeterminate, but endogenous variables might also start reacting to random variables unrelated to the structure of the model (leading to 'sunspot equilibria' where outcomes are determined solely by self-fulfilling private expectations).

Such a situation would clearly pose a severe problem for central banks: Apparently well-designed rules would not ensure price stability, at least under a sufficiently wide range of conceivable circumstances. This observation is what motivates the quest for uniqueness of equilibria in monetary models and gives justification to the role money can play as a nominal anchor in monetary economies.

3.3 Two money-less rules

The literature has pursued two different specifications of the autonomous or moneyless policy rules discussed above.

3.3.1. Target rules in a linear-quadratic policy problem

According to the target rule approach, the interest rate rule for monetary policy is defined implicitly as the solution to an optimization problem facing the central bank. In the literature it is often assumed that the central bank selects its interest rate policy by minimizing a loss function expressed in terms of the deviations of inflation and output from mandated objectives (π^* and y^*), taking the structure of the economy as given.

$$L = {}^1/_2\, E_t \{ \Sigma_{j=0,\infty} \beta^j [(\pi_{t+j} - \pi^*)^2 + \lambda(y_{t+j} - y^*)^2] \} \tag{5}$$

In most applications, the central bank finds the interest rate path which minimizes a quadratic loss function expressed in terms of deviations of objective variables from target (5), subject to the linear constraints (1) and (2) of the new neoclassical synthesis model (hence "linear-quadratic").[23] λ is the relative weight attached to output stabilization in the central bank's policy preferences.[24] Can this linear-quadratic policy regime inoculate the economy against the risks of chronic instability which have been briefly described at the outset of sub-section 3.2?

The answer is: Not always, at least under rational expectations. Under this regime, equation (4) takes the following form:

$$i_t = \chi_0 + \chi_1 e_t + \chi_2 u_t \tag{4a}$$

for an appropriate specification of the constant term χ_0 and the reaction coefficients χ_1 and χ_2. However, as proved by Woodford (1999) and Svensson and Woodford (2003), the model defined by (1), (2) and (4a) admits a large multiplicity of bounded solutions in the hypothesis that private expectations fully internalize the authorities' reaction function (4a) as part of the policy regime which they face. These include both solutions implying different equilibrium responses to fundamental shocks (e_t and u_t), and solutions involving responses by the central bank to non-fundamental states of the economy, such as sunspots in private expectations.

At root, this multiplicity result stems from: first, the rational expectations definition of an equilibrium, which, by itself, makes the economy particularly sensitive to revisions in expectations; and, second, the possibility that a policy of elastic currency leads the private sector to actually *act* on those expectations by drawing more or less money from

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[23] Formulating the problem using this linear quadratic specification has presentational and computational advantages. In particular, it yields linear policy rules which are invariant to (additive) uncertainty, i.e. they exhibit so-called certainty equivalence. However, it is not sure whether such a loss function is a good approximation for central banks in practice. This is particularly relevant for central banks which have a price stability objective or a clear inflation target and no or only subordinated mandate to simultaneously contribute to output smoothing.

[24] The linear quadratic (or "target rule") approach to monetary policy has been strongly advocated by Svensson (1999).

the central bank at the fixed policy rate. In such an environment, a policy rule like (4a) – which specifies each period's nominal interest rate as a function solely of exogenous states or shocks – does not provide the economy with a defense against off-equilibrium revisions in expectations.[25 26]

To conclude this sub-section, rules derived within the target rule framework (whereby the monetary authority reacts to the fundamental shocks hitting the economy) do not appear to pass the test of uniqueness. Rather, in extreme circumstances, they could lead to bursts of inflation deriving from self-fulfilling changes in expectations.[27]

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[25] Two issues related to the characterization of target rules given above need to be kept distinct. One issue is whether a reaction formula such as (4a), which results from the solution to the linear-quadratic dynamic programming problem represented by (1), (2) and (5), can be consistent with an optimal equilibrium in which inflation remains solidly anchored around the target value p* and inflation and output evolve solely as a function of the fundamental shocks identified in the structural representation of the model: e_t and u_t. A distinct issue is whether such situation is the unique possible non-explosive solution to the equilibrium conditions which can be supported by a reaction rule such as (4a). Or there may exist other possible equilibria which are equally consistent with (4a) but imply (undesirable) dynamics of the model state variables, whereby these variables fluctuate in unpredictable ways in response to the fundamental shocks (and, in addition, may also respond to non-fundamental shocks which have no analytical representation in the equations describing the structural dynamics of the model). In this respect, one should bear in mind that many numerical experiments available in the literature on the performance of target rules of the sort described in Section 3.3.1 are either conducted on the basis of backward-looking models, or – in case they use a purely forward-looking structure as in the text above – do not explicitly tackle the issue of uniqueness or, similarly, assume that private expectations do not internalize (4a) when forming expectations of policy action. An example of the first approach is Rudebusch and Svensson (1999), which will be further discussed in Section 4 below. An example of the second approach is Clarida et al. (1999) and Jensen (2002a). These two papers are briefly discussed in footnote 28. It should also be borne in mind that the failure of a rule like (4a) to induce determinacy is not confined to the case of rational expectations. Evans and Honkapohja (2001) discuss the case in which private agents revise expectations according to an adaptive learning mechanism while the central bank solves its model under a rational expectations assumption. They show that in this case private expectational errors – due to learning – do not receive an adequate response by the central bank, which only reacts to the fundamental shocks, u_t, and e_t. Hence, expectational errors of the past tend to become ingrained and lead to a process of cumulative divergence of the economy from the rational expectations equilibrium.

[26] Woodford (2000b) discusses analytical ways to circumvent indeterminacy problems in purely forward-looking inflation targeting environments of the type expounded in this Section. These solutions generally involve recourse to optimal delegation schemes whereby the loss function assigned to the central bank is modified relative to the one which reflects the 'true' preferences of society – a function of quadratic deviations of output from potential and inflation from target, such as in (5) – by inclusion of additional lagged values of target variables. The purpose of these additions is to induce an implied reaction rule which makes the nominal interest rate a function of lagged endogenous variables in addition to the terms figuring in (4a). Dependence of the reaction function on such variables is a necessary – though not sufficient – condition for determinacy. Examples of such delegation schemes include the options of charging the central bank with stabilization of the price level – rather than inflation rate – as in Vestin (1999), and the proposals to include a nominal output growth term (see Jensen, 2002b) or an interest rate smoothing term (see Woodford, 1999) in the central bank's assigned loss function. Svensson and Woodford (2003) take a step further by exploring history-dependent variants of inflation targeting which are inherently robust to multiplicity problems. They conclude that robustness of this kind can be achieved within an inflation forecast targeting universe only at the cost of contaminating the dynamic optimisation analytics of a pure targeting procedure with elements of commitment to an instrument rule of the type that is discussed in the text under Section 3.3.2. In particular, they show that a way to achieve determinacy is to amend the general targeting procedure described in the text with a commitment to a particular direct interest rate response, whereby the central bank reacts to deviations of private expectations of inflation and output gap from the central bank's forecasts. The relative intricacy of this solution, however, seems at odds with the simplicity and transparency of inflation targeting in its pure original incarnation described, say, in Svensson (1997 and 1999).

3.3.2 Moneyless instrument rules: The Taylor principle

A second family of policy rules which can 'close' the model without reference to condition (3) are those in which the policy interest rate is made a direct function of endogenous variables, such as inflation and output (e.g. Taylor, 1993).

Recent variants of this approach typically use expected (instead of realized) inflation, as in the following specification:

$$i_t \;=\; r^* + \pi^* + \alpha\,(\mathrm{E_t}\,\pi_{t+k} - \pi^*) + \beta\,(y_t - y^*) \qquad (6)$$

where r^* is a parameter of the system (the equilibrium real interest rate) and k is some forecasting horizon deemed relevant for monetary policy.

Clarida, et al. (1999, 2000) provide a thorough investigation of the properties of a system in which the central bank behaves according to (6). They conclude that a sufficient condition for the rational expectations equilibrium to be unique in a macroeconomic model similar to (1) through (3) is that the interest rate instrument be made to increase more than one-for-one in response to increases in forecast inflation, i.e. $\alpha > 1$.[28, 29] The numerical constraint that $\alpha > 1$ has come to be known in the most recent debate as the *Taylor principle*, as it was first conjectured in the seminal Taylor (1993) article.

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[27] A distinct issue is whether a target rule such as the one described in this Section – and involving a monetary policy reaction function of the type represented in (4a) – is welfare optimizing or can be found to be dominated by an alternative rule obtained under precommitment.. As shown in Woodford (1999), discretionary policymaking in a model incorporating forward-looking behavior is indeed typically characterized by a stabilization bias, i.e. it may lead to a sub-optimal degree of pro-activism in the central bank response to shocks (via (4a)). Therefore, when agents' decisions depend on their expectations of the future state of the economy – as in the model sketched in (1)-(2)-(3) – there are gains to be had from a more inertial pattern of response. Woodford (1999) and Svensson and Woodford (2003) investigate various mechanisms which can induce inertia in discretionary monetary policy making, among which they propose a number of optimal delegation schemes whereby the central bank is assigned an appropriately modified loss function. More recently, Söderström (2001) has investigated whether assigning the central bank a loss function which includes a term in money growth can indeed induce the type of inertial behavior which can be expected to enhance welfare. Since money is demand determined in his model, its rate of growth is related to the change in the nominal interest rate and the growth rate of output. Therefore, he concludes: "a suitably designed target for money growth may introduce inertia into the discretionary policy rule, leading to improved outcomes." He also notes that "this mechanism is entirely due to money being related to other variables in the economy, and not due to any indicator role for money."

[28] Bernanke and Woodford (1997) come to broadly the same conclusions using a model similar to (1) and (2) but with a slightly modified timing of price revision by firms.

[29] Strictly speaking, Clarida, Galí and Gertler (1999 and 2000) find that $a > 1$ is a sufficient condition for determinacy only when $b=0$ and the stabilising threshold of a dips below unity as b increases. They also establish an upper bound for a beyond which determinacy conditions are violated. This upper bound is well above the numerical value for a which was conjectured by Taylor (1993) to be stabilising. However, the result of Clarida et al. and the similar result of Jensen (2002a) – within an inflation forecast targeting environment similar to the one expounded in Section 3.3.1 – that determinacy can be achieved in a forward-looking model by postulating that the central bank is committed to a rule that makes the policy interest rate a sharply increasing function of expected future inflation has been questioned by Svensson and Woodford (2003). They contend that such a monetary policy reaction function may not be "a fully operational specification of the monetary policy rule […] as the central bank's instrument is expressed as a function of endogenous variables (conditional expectations of future inflation and output) that themselves depend upon current monetary policy. In practice, the bank would have to forecast the paths of the endogenous variables, given its contemplated action. This forecast should depend only upon information about the exogenous disturbances, and the bank's contemplated policy; thus, an operational version of the policy rule, in which the central bank's procedure is completely specified as an algorithm, is equivalent to a rule that sets the nominal interest rate as a function of the exogenous disturbances, and leads to indeterminacy."

The issue in this sub-section is thus whether this policy prescription – which suggests that it is sufficient for central banks to ignore money and set interest rates solely on the basis of non-monetary indicators – is robust across a sufficiently broad array of variations to the basic model sketched above. The answer developed here is once more: No, at least under rational expectations. In what remains of this sub-section we shall therefore review the cases in which the *Taylor principle – by itself – fails to deliver a unique and determinate solution to the policy problem* of keeping macroeconomic magnitudes safely anchored to the stated objectives of policy.

a) The Taylor principle with a non-Ricardian government

The macroeconomic model described by equations (1), (2) and policy rule (6) is not only moneyless: it also lacks any form of interest-yielding public liability. This is difficult to justify since, in general, the nominal interest rate set by the central bank will affect the terms at which the public debt is rolled over.

Only if the fiscal authority always stands ready to adjust its primary surplus in response to any past development which caused a deviation between the actual stock of public debt and some specified long-term target can the relationship between interest rate and public finances be ignored. For this to be the case, any interest rate increases implemented by the central bank in pursuit of price stability would have to be accompanied by an appropriate fiscal response to offset the consequences of higher real borrowing costs on the rate at which public debt is accumulated (e.g. in case of higher real interest rates, the primary surplus would have to increase). Leeper (1991), in a seminal contribution, defined such fiscal arrangements as 'passive'. More recently, Woodford (2000a) refers to such accommodating fiscal regimes as of a 'Ricardian' type.

In a less-than-Ricardian fiscal regime, the macroeconomic system (1) through (3) is *incomplete*. One needs to augment it with the government flow budget constraint to check the determinacy conditions. However, the conditions turn out *not* to be satisfied if the inflation coefficient in (6) is above unity.[30]

Moreover, Woodford (2000a) has shown that even the existence of a debt limit that *eventually* constrains the growth of public debt is not sufficient for the fiscal regime to qualify as 'Ricardian' in Woodford's sense. If the fiscal authority is ultimately committed to modify its course once some extreme debt limit is breached, but is nonetheless less than forthcoming in reacting to changes in monetary policy *before* that limit is approached, then a monetary policy rule embodying the Taylor principle (like (6)) would *not* – by itself – guarantee price stability. As shown by Woodford, in these circumstances, the equilibrium would be characterized by an inflationary spiral, in which progressively higher rates of inflation lead to higher real interest rates, hence higher rates of growth of nominal government liabilities, which in turn lead to higher rates of inflation.[31]

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[30] Technically, the system would then have four equations: (1)-(2)-(3) and the flow budget constraint of the government. It can then be shown that, with a less than Ricardian fiscal authority, one needs $\alpha<1$ in order to obtain two stable and two unstable eigenvalues. The latter are needed because the set of endogenous variables include two pre-determined and two 'jump' variables.

[31] The irony to this is that a monetary policy rule that would conventionally be thought to be anti-inflationary may instead lead to an inflationary spiral when combined with an unsuitable fiscal policy. A monetary policy episode which could confirm this perverse dynamics was studied by Loyo (1999).

These findings suggest that a monetary policy regime which blindly responded to inflation forecasts and the output gap while respecting the Taylor principle would wind up accommodating inflationary developments. Asset *stocks,* e.g. money, by contrast, may be a useful source of information for monetary policy makers which helps to stabilise the economy.

b) The Taylor principle with liquidity constraints

As we argued above, expressions (1) through (3) constitute a reduced-form representation of an underlying money-in-the-utility structural model with a zero cross partial derivative between consumption and real balances. A key issue, which we have left in the background so far, is what measure of money appears in the utility function.

In the conventional specification discussed above, the implicit assumption is that the liquidity services which are valued by the representative agent are associated with the real money balances the agent holds at the end of the period *after* all market transactions have already been concluded. This seemingly innocuous timing assumption has a very important implication: goods can be exchanged for other goods and for bonds without the intermediation of money.

However, money is typically seen as distinct precisely because it acts as a medium of exchange. In other words, the conventional new neoclassical synthesis model – in the version above – does not seem adequately to capture the fundamental rationale which underlies the demand for a non-remunerated asset like money, i.e. while inflicting a cost in terms of forsaken interest, money helps to facilitate a number of transactions which would not otherwise be possible. Holding currency *before* commencing trading may be what provides agents with the utility services which motivate a monetary economy in the first place.

Carlstrom and Fuerst (2001a) amend the model to allow for a genuine transactions role of money. They assume real money balances enter the utility function at the *beginning* of the period, before trade in goods takes place. The Taylor principle does not survive this amendment for a model calibration similar to that used by Clarida et al. (2000). The same result – that real determinacy requires an inflation coefficient in (6) below unity – is derived by Christiano and Rostagno (2001a and b) and Benhabib et al. (2001c). The first two papers use a suite of cash-in-advance and limited participation models with flexible prices and an elastic labor supply. The latter paper uses a money-in-the-production-function framework. All papers uncover indeterminacy and/or equilibrium cycles under a rule embodying the Taylor principle.

Here, again, a minor (timing) modification to the underlying framework suffices to overturn the basic policy message. A monetary policy blindly following the Taylor principle and ignoring monetary developments is associated with an indeterminate equilibrium, where the economy is left without an anchor and fluctuates unpredictably around the 'virtuous' equilibrium.

c) The Taylor principle from a global perspective

It should be emphasized that expressions (1) through (3) are derived by linearizing a set of non-linear optimal conditions around a non-stochastic steady state. However, any analysis based on linearization must be interpreted as being local in a neighborhood of the steady state and only valid under sufficiently small perturbations of the system. How small must the perturbations be to justify such a local analysis?

An emerging strand of literature has started to investigate the properties of Taylor rules such as (6) from a global perspective, i.e. removing the assumption that perturbations are necessarily small. Benhabib et al. (2001a), for example, convincingly argue that the standard practice of studying monetary models in a small neighborhood of the steady state can generate a misleading impression about the set of possible equilibrium outcomes. In particular, even in cases in which rules embodying the Taylor principle guarantee uniqueness of the rational expectations equilibrium *locally*, they may fail to do so *globally*. They construct a money-in-the-utility model which closely resembles the one underlying (1) through (3) and impose a monetary policy reaction function which explicitly acknowledges the zero lower bound on nominal interest rates.[32] They find that the mechanical implementation of a Taylor-like monetary policy rule founded on the Taylor principle *per se* can trap the economy in perverse dynamics. Along these trajectories, explosive inflation expectations – even if divorced from underlying economic fundamentals – end up being systematically validated by the central bank.[33] In other words, they uncover an uncountable number of equilibrium trajectories – invisible from the point of view of the conventional local analysis – which originate in a vicinity of the 'virtuous' steady state, and finally converge to a situation in which the nominal interest rate is zero and the monetary policy becomes ineffective.

All that is needed for the economy to start the slide towards the lower bound is that agents come to expect – for some reason – the economy to enter a deflationary phase. In these circumstances, interest rates are constantly being lowered in response to the observed fall in price inflation, and in an attempt to reverse the persistent decline in inflation. However, these efforts are to no avail, because expected future inflation may fall – along a possible equilibrium trajectory – at the same time and ex-ante real interest rates are not reduced and continue to be high enough to restrain demand despite falling prices.[34]

3.3.3 Caveats

Are the sort of multiplicity and stability problems associated to money-less policy rules something which real-world central banks should worry about? Or are they to be confined to the realm of analytical curiosa? In particular, is it likely that some sort of horse-race dynamics between an always proactive central bank and constantly over-pessimistic private sector expectations may finally ensue which can lead the economy to spiral down to the lower bound? The judgement is still pending and different leading authors hold quite diverging views on this issue of policy relevance. McCallum (2001)

[32] The 'lower bound problem' arises from the fact that in a monetary economy the central bank cannot engineer negative nominal interest rates as long as its counterparts retain the option to hold zero-interest currency.

[33] In other words, an "expectational bubble" can emerge in the price level if the central bank pursues a Taylor-like rule with an inflation coefficient greater than unity.

[34] Is this scenario, in which monetary authorities and the private sector in a sense 'chase each others' along a sliding path to zero interest and negative inflation rates a reasonable description of what could happen? Some scholars argue that it is, at least in the case in which the 'way to go' between the target stationary equilibrium and the 'liquidity trap' stationary equilibrium is sufficiently short and the Taylor coefficient on inflation in the monetary authorities' reaction function is sufficiently large. Benhabib *et al* (2001) describe the current situation in Japan possibly as the outcome of such perverse dynamics.

maintains that conclusions based on bubbles and indeterminacy arguments are of dubious merit and many of these vanish under a minimum-state-variable criterion for equilibrium selection. Woodford (2003, Chapter 2), on the opposite side, takes these problems seriously. For example, while conceding that "the economy can only move to one of [the downward-spiralling] alternative paths if expectations about the future change significantly, something that one may suppose should not easily occur," he acknowledges that "one must worry that a large shock could nonetheless perturb the economy enough that expectations settle upon another equilibrium."[35]

At the very least, a central bank should note that perverse inflation dynamics have been encountered in simulation exercises of calibrated models used widely in the literature. For example, Rudebusch and Svensson (1999) acknowledge that their experiments with simple versions of Taylor rules such as (6) imply that "nominal interest rates would be negative a non-negligible portion of the time." They go on to say that: "intuitively, with an estimated equilibrium real funds rate of 2.5 percent, if inflation ever falls to, say, –3 percent, then, with a zero nominal funds rate, the real funds rate is still restrictive, so the output gap decreases and inflation falls even further."

Christiano and Gust (1999) show that the set of policy elasticities to inflation and the output gap under which a Taylor-like rule becomes a source of instability within a limited participation model – with a cash-in-advance timing – is much broader than for conventional specifications of sticky-price and money-in-the-utility models.[36] Experiments conducted on the basis of an 'eclectic' macro-model proposed by Christiano et al. (2001) – conflating different sources of nominal frictions, liquidity effects and consumption and investment inertia in a rich stochastic general equilibrium context – confirm that forward-looking proactive Taylor rules produce excess volatility. The same indeterminacy problems are encountered by Levin et al. (2001) for forecast-based Taylor rules at horizons exceeding one year ahead across a number of competing models incorporating rational expectations, short-run nominal inertia and long-run monetary neutrality.

This evidence, of course, releases a warning signal in a central bank profoundly concerned about the robustness of its policy course. At the very least, the theoretical and simulation results surveyed in this subsection suggest that decision-makers should broaden – rather than narrow – the set of indicators which they routinely look at to inform decisions. Identifying moneyless policy rules – in the sense defined above – for the sake of parsimony may not be a useful exercise. Moreover, the consequences of adopting a rule narrowly focused on a handful of indicators to the exclusion of others

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[35] The emerging strand of literature on adaptive learning is also split. Bullard and Mitra (2000) find that under a forward looking Taylor rule such as (6) the equilibrium with adaptive learning is determinate. By contrast, Carlstrom and Fuerst (2001b) demonstrate the existence of learnable sunspots equilibria in a cash-in-advance model when both the central bank and the private agents learn adaptively. They also prove that, when the central bank is subject to a learning process, while private sector expectations are always rational, sunspots equilibria are always learnable, and thus are indeed a cause for concern.

[36] The limited participation model introduces a friction into the workings of the financial markets to the extent that, due to rigidities in portfolio adjustments, a monetary injection at time t is disproportionately absorbed by financial intermediaries and thus channeled to finance investment rather than consumption. This assumption is what allows the model to generate an impulse-response pattern whereby a surprise monetary injection is followed by a fall in the equilibrium nominal rate of interest (liquidity effect) and a rise in output. By contrast, these features are not easily reproduced by competing new-neoclassical models, which postulate various sorts of price rigidities. A description of this type of models is provided by Christiano *et al.* (1997).

may turn out to be unpleasant. Whether money could help in this quest for a broader perspective, even within seemingly money-less models, is the subject of the next Section.

3.3.4 Addressing the pathologies associated with moneyless rules

Monitoring monetary developments can protect the economy against some of the pathologies associated with moneyless monetary policy rules described in Section 3.3 above. Although there are parameterisations and timing assumptions in variants of the new neoclassical synthesis model under which conventional Taylor rules lead to good macroeconomic outcomes, other plausible parameterisations and timing hypotheses exist in which these moneyless policy rules may lead to bouts of inflation or deflation. At root, this is because moneyless interest rate policy rules can – under the latter assumptions – be supported by various rates of monetary growth. Each of these money growth rates is associated with a different real outcome for the economy. A central bank concerned with robustness should adopt a monetary policy strategy that would *also* be effective with regard to its objectives if the economy were better described by the latter set of model assumptions than the former. Such an approach would thus seem to rule out the adoption of moneyless Taylor-like rules.

In circumstances where conventional moneyless rules fail, a policy of money growth monitoring can, in effect, provide the economy with an anchor. Christiano and Rostagno (2001a and b), for example, postulate a policy framework in which a Taylor-rule based strategy is followed as long as money growth falls within a specified target range. If that target is ever violated, however, the Taylor rule is abandoned in favour of a Friedman-like constant money growth rule.[37] They show that the latter escape clause can provide the plain Taylor reaction function with the 'servomechanism' needed to remove the undesired trajectories – to which the Taylor rule may lead – from the space of possible events.[38]

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[37] This policy is shown to be benign and non-interfering with the operation of the Taylor rule in case of a model à la Clarida et al (1999 and 2000). On the other hand, it would improve economic performance substantially, by eliminating undesired equilibria, if the economy were to be better represented by a cash-in-advance model.

[38] It is open to debate whether the switch from a Taylor rule to a Friedman rule would involve a change in the operating procedures used by the central bank, i.e. whether the central bank would have to renounce its practice of setting a target for a short term interest rate (in a way consistent with the Taylor-rule prescriptions) and begin announcing short-run targets for money growth. In the latter case, it would appear to be of relevance to ensure that the aggregate for which a target is announced is controllable by the monetary authorities with a sufficient degree of precision. Historical experience is indeed consistent with the notion that a switching rule of the type discussed in Christiano and Rostagno (2001a) may be implemented both by a continuation of the interest-rate-centered operating procedure and by a change in the operating procedures in favor of one centered on money quantities. Meyer (2001a), for example, explains that when the Federal Reserve started setting short-term targets for M1 in January 1970 – reflecting disappointment with recent macroeconomic performance – it established them in the form of the two-month (in 1975 extended to annual) target growth rates. The federal funds rate was then calibrated to a level estimated to be consistent with hitting the broad money growth target. Conversely, when in October 1979 – out of fears that inflation may have gotten out of control – the Fed embarked on a decisive policy of monetary contraction, it seemed natural to mark the policy change with a discontinuation of the practice to set a target for the funds rate. However, the need to express the money target in terms of a broad aggregate did not seem to pose a problem of controllability of the new target. Meyer states that: "Policy was implemented during this period by estimating the total reserve growth [i.e. the intermediate target for the narrow monetary aggregate under authorities' control] necessary to meet the money growth target [for the broader official target aggregate] and by >>

The more extreme pathologies associated with non-linearities can also be cured by a suitable transition to a different operating scheme centred upon the targeting / control of monetary aggregates. Benhabib et al. (2001b) study the virtues of such a switching regime in the context of providing insurance against the liquidity trap. Svensson (2001) also appeals to the standing possibility for a central bank, at any time, to abandon a Taylor rule and start expanding the money stock by means of purchases of foreign exchange.[39] Eggertson and Woodford (2003), more recently, build on the same monetary-fiscal regime studied in Christiano and Rostagno (2001a) and achieve the same conclusion. Perverse self-fulfilling deflationary equilibria – which can establish themselves in a world in which the lower-bound occasionally binds – can be ruled out through a suitable switch to a money base-supply rule that – in case of emergency – is called upon to support the central bank's price level target. The switch is also in the spirit of Christiano and Rostagno: the rule specifies a particular level of excess supply of base money in the case the zero bound binds. But it lets the monetary base be endogenously determined by the central bank's "normal time" policy rule – price level targeting in Eggertson and Woodford (2003), a Taylor rule in the other paper – in all other circumstances.[40]

The key message contained in some of these contributions is that the announcement of a definition of price stability – or, alternatively, an inflation or price level target – while a major constituent element of a monetary framework founded on price stability, does *not* in itself constitute a sufficient guarantee that such objective will be attained, unless the announcement is supported by a stabilizing 'rule' which specifies the central bank moves conditional on protracted deviations from equilibrium. This rule is the second major element needed to anchor expectations. Underlying this logic is a sharp distinction between an *equilibrium condition*, an *objective of policy*, and a fully

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[38] >> holding to the associated path for non-borrowed reserves. In the process, the federal funds rate was free to move to whatever level would be consistent with the money growth objective over time." Meyer's rationale for the switch of focus in policy which occurred in 1979 seems to be consistent with the story told in Christiano and Rostagno (2001a, p. 8). He argues that "monetary policy was focused on steadily reducing inflation, and policymakers were less certain about what increase in nominal and real interest rates would be required to achieve the objective of reducing inflation than they were about the money-inflation relationship." This is a rather vivid manner to describe the role of money in 'emergency' situations in which policymakers find alternative money-less rules a less reliable guide for policy adjustment.

[39] Other papers rely on the argument that other policies (e.g. fiscal policy) could be used to stimulate the economy in a deflationary situation.

[40] As in Christiano and Rostagno (2001a), Eggertson and Woodford (2003) impose a fiscal regime which prevents the fiscal authority from undoing – by running appropriate budget surpluses – the quantitative easing effected by the central bank while at the zero lower bound. The anticipation that the excess money base created in the deflationary situation for the purpose of sustaining the price level along a steady path will not be removed from the system at a later time helps focus agents' expectations on the restoration of price stability. As explained in Christiano and Rostagno (2001a), this policy regime rests on the assumption that fiscal authorities have no incentive to signal a commitment to run as large budget surpluses in the future as needed to prevent *total* nominal liabilities (government bonds *plus* base money) from growing unboundedly. Note that this assumption departs from the definition of a 'Ricardian' government that is given, for example, in Woodford (2000a). However, it appears to be better fit to present-day fiat currency regimes where 'governments' are held responsible for paying back bonds in currency – and thus may want to ensure that bonds do not grow too fast. But they are not expected to also redeem currency in any commodity species – and thus may not consider a disproportionate growth in base money as a *fiscal* problem. Under a commodity-currency regime, in contrast, a Woodford (2000a)-type definition of 'Ricardianness' may be more appropriate.

operational specification of the *monetary policy rule*. A target for inflation or for a price level may be an equilibrium condition (i.e. a state of affairs that one observes ex-post). It may be announced as the objective of policy (i.e. a central bank may choose to announce, say, an inflation or price level target as the medium-term aim of its policy). But it will never constitute an operational version of a strategy, i.e. a complete description of the bank's decision procedure as an algorithm for action. The latter can only be described in terms of how the bank intends to steer its *instruments of policy* (i.e. either a short-term interest rate or some measure of the stock of outside money in circulation) in the face of the various contingencies, as the situation may dictate. And, notably, it is the expectation of a systematic response of such instruments to off-equilibrium states which is key in sustaining a virtuous equilibrium. Ultimately, it is the off-equilibrium prescriptions of a policy framework – of any type – which make the framework credible.

The fact that such off-equilibrium prescriptions may involve a distinctive role for monetary aggregates, as information variables and triggers of action, as well as possibly as an instrument of policy alternative to the short-term interest rate is no accident. Take the example of the liquidity trap. In Krugman's (1998) words: "A liquidity trap involves a type of credibility problem. A monetary expansion that the market expected to be sustained (that is, matched by equiproportional expansions in all future periods) would always work [in lifting the economy off the trap]. If monetary expansion does not work, if there is a liquidity trap, it must be because the public does not expect it to be sustained." The threat to abandon a 'money-less' interest-based policy rule and to switch to a monetary policy rule involving the implementation of a constant rate of growth for the money base – as in Christiano and Rostagno (2001a) – serves precisely this purpose. To make that monetary expansion credible the central bank needs to provide a detailed operational specification, i.e. a complete description of the way the central bank will manage its instrument of policy from the time in which the zero lower bound is hit onwards. This operational specification has to make clear that the money supply will have to be increased by enough to render that equilibrium untenable, so that expectations will have to coordinate on a different equilibrium, namely the one dictated by the central bank's objective. [41]

4. Robustness and the role of monetary developments in monetary policy rules

4.1 Models of monetary policy transmission and their implications for monetary policy rules

The preceding Section has demonstrated that apparently small deviations from the benchmark New Keynesian macroeconomic model may have profound implications for the design and conduct of monetary policy. At the theoretical level, when conventional monetary policy rules are employed, such deviations from the benchmark model permit

[41] The above notwithstanding, there are other solutions to the instability or indeterminacy problems associated with conventional moneyless policy rules, which do not require explicit reliance on monetary aggregates. Money-less rules providing off-equilibrium responses to non-fundamental shocks to expectations are proposed in Svensson and Woodford (2003) within the context of inflation targeting procedures. We refer the reader to footnote 25 and 26 for a brief discussion of these rules.

indeterminacy and multiplicity of equilibria. In practical terms, this suggests that the mechanical pursuit of Taylor-like rules for monetary policy exposes an economy to the risk of significant instability and substantial deviations from price stability.

The pathologies associated with indeterminacy and multiplicity are not the only implications of varying the assumptions underlying the standard model. Variations to the benchmark New Keynesian model also have implications for the transmission mechanism of monetary policy and thus for the performance of any given monetary policy rule against the loss function described by equation (5). For example, if the assumption that money balances and consumption are weakly separable in the utility function (implicit in the standard New Keynesian model) is relaxed, money balances will enter both the dynamic IS and Phillips curve equations (relationships (1) and (2) respectively). Similarly, adopting the Carlstrom and Fuerst (2001a) cash-in-advance timing assumption will result in a role for monetary dynamics in the transmission process. In either case, the performance of monetary policy rules which are designed to preserve price stability around the steady state defined by the linearised relationships analogous to (1) through (3) will be affected by how the central bank chooses to vary the short-term interest rate in response to monetary dynamics.[42]

At this stage, one does not need to stake out a definitive position regarding these underlying and rather technical assumptions about how money balances enter the representative agent's utility function in a dynamic general equilibrium model. Such assumptions are anyway hard to distinguish or verify empirically. One can simply argue that, in pursuing their objective of price stability, monetary policy makers would be ill advised to rely *solely* on the results of the benchmark New Keynesian model, which appear rather fragile in the face of small (and difficult to reject) variations to the underlying economic structure. In other words, central banks should not ignore completely the insights provided by variations to the benchmark model – especially those which give some role to money – given the long and influential pedigree of money-based analysis in monetary policy design and implementation.

All models are necessarily an abstraction from, and thus a simplification of, reality. Each model emphasises some aspects of the monetary policy transmission process, while obscuring others. In some circumstances, the simplifications implied by the benchmark New Keynesian model may provide a better insight into the challenges facing monetary policy. Other circumstances may favour analyses conducted using variants of that benchmark model, which give a more important role to monetary and financial dynamics in the transmission process. Relying on one model to the exclusion of all others appears misguided.

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[42] Comparing these variants with the benchmark New Keynesian model, one might argue that two distinct characterizations of monetary policy transmission exist (Engert and Selody, 1998). One tradition (embodied in the work of monetarists, such as Milton Friedman and reflected in the variant models discussed in the main text) views money as central to the determination of the price level. Monetary dynamics therefore play an *active* role in the transmission mechanism. The other tradition (reflected, for example, in the benchmark model) characterizes price dynamics as an outcome of interactions between supply and demand and cost pressures. Within this paradigm, monetary developments do not play an active role in monetary policy transmission, but rather reflect the evolution of the arguments of money demand. Money therefore plays a *passive* role in price level determination. However, in the latter framework money may be a good indicator of future prices to the extent that it reflects underlying trends in nominal GDP.

Policy makers therefore need to integrate analysis conducted using a variety of macroeconomic models into a single process for taking monetary policy decisions. This has led to broad acceptance of the view that central banks should base their policy decisions on a suite of models and tools, rather than relying on a single model for policy advice (e.g., Bank of England, 1999, Pill, 2001, and Selody, 2001).

At the very least, the number of variants to the benchmark New Keynesian model used for the analysis of monetary policy reflects substantial continued uncertainty surrounding the monetary policy transmission mechanism. A well-designed monetary policy rule or strategy has to confront and overcome this uncertainty.

A substantial literature has considered the conduct of monetary policy in the face of uncertainty (e.g., ECB / CFS, 2000). With regard to uncertainties about the structure of the economy (typically labeled model or paradigm uncertainty), McCallum (1988) has suggested the following approach. In his view, a well-designed monetary policy rule should "perform well" across a set of plausible competing reference models that spans a broad spectrum of model uncertainty. Levin et al. (2001) have implemented this approach for New Keynesian models of the U.S. economy. The models investigated by Levin, et al. are estimated using different data and with somewhat different specifications, but are all essentially of the benchmark type.[43]

However, following Selody (2001), it is natural to extend McCallum's robustness criterion to encompass analysis under a broader set of variants of the benchmark New Keynesian framework, rather than focusing solely on that benchmark to the exclusion of other models. Therefore, effective monetary policy should perform well in a variety of models of the transmission mechanism, spanning those where money has a structural role in dynamic IS and / or Phillips curve equations and those where it does not (ECB, 2000).[44]

Drawing on the work of Gerdesmeier et al. (2002), the remainder of this Section investigates these issues. To illustrate our analysis we use two very simple analytical models, which are described in the Appendix. The benchmark model embodies output gap and Phillips curve equations; the other is a simple P* framework (Hallman et al., 1991).[45]

As described in Section 2, the available empirical evidence for the euro area suggests that the money stock has a stable relationship with the price level (conditional on developments in other macroeconomic variables) and exhibits leading indicator properties for inflation. In the context of the analysis presented here, it is particularly noteworthy that the P* model has empirical support in both the euro area (e.g., Gerlach and Svensson, 2002) and also – albeit more controversially – in the U.S. (e.g., Orphanides and Porter, 2001). While certainly not conclusive, such evidence offers some

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[43] More recently, Levin and Williams (2002) have extended their approach to an analysis of forward and backward-looking Phillips curve models of U.S. monetary policy.

[44] One might argue that this approach involves giving preference to monetary policy rules or strategies that avoid bad outcomes (i.e., instability or indeterminacy of the price level) even in adverse circumstances. This follows Brunner and Meltzer (1968) who – anticipating by some thirty years Hansen and Sargent's (2000) application of robust control theory to monetary policy – advocate monetary targeting on the basis that it provides the least harmful policy framework given the uncertainty surrounding the structure of the transmission mechanism.

[45] The specification of the passive money model is a simplified version of the model estimated by Rudebusch and Svensson (1999) (and subsequently employed by Levin and Williams, (2002), The specification of the active money P* model is that suggested by Svensson (2000).

loose empirical support for the plausibility of variants to the benchmark New Keynesian model that give some role to monetary variables in the transmission process.

In the manner of Rudebusch and Svensson (1999), both the benchmark and P* models are kept extremely simple for expositional purposes.[46] In particular, we choose to use backward-looking specifications, thereby avoiding many of the problems of determinacy and instability discussed in Section 3. Moreover, by using linearized models around a carefully selected steady state, we limit ourselves to discussion of small perturbations from an equilibrium associated with price stability. We thus focus on how monetary policy should respond to economic shocks (including monetary shocks) in the vicinity of this desired steady state, given uncertainty about the transmission mechanism.

Following much of the recent academic literature, we characterize monetary policy within our simple analytical framework as a contingent policy rule for short-term nominal interest rates.[47] Our analysis then proceeds in two steps. First, we discuss the role of monetary developments in optimal interest rate policy rules within the P* model, which here is seen as representing a variant of the benchmark model where money enters the Phillips curve equation and thus has an active role in the transmission mechanism. The resulting policy rule is compared with the optimal rule derived from the benchmark approach. Second, we discuss how monetary developments should affect interest rate decisions when policy makers entertain both the benchmark model and variants to it, as McCallum's robustness criterion requires.

4.2 Optimal policy rules in the two models – The role of monetary developments

Adopting the quadratic central bank loss function that has become standard in the academic literature (expression (5)), conventional techniques can be used to derive optimal monetary policy rules for the two models considered here. Given the simplicity of the models, these rules can be expressed as linear functions of the four state variables: inflation; the output gap; and current and lagged values of the real money gap.[48] These rules are shown in the Appendix. In the main text we summarize some of the simple but important results that follow from this exercise.

Once money enters the structural equations of the transmission mechanism, monetary developments are an argument of the optimal policy rule. Svensson (1997) has shown that optimal monetary policy should respond to the determinants of inflation, not inflation itself. Within the variant to the benchmark model where money enters the Phillips curve, monetary developments are a determinant of price dynamics and thus

[46] Rudebusch and Svensson (1999) argue that using simple, backward-looking linear models of the transmission mechanism is preferable for expositional purposes because well-known optimal control techniques (Sargent, 1987) can be applied straightforwardly, increasing the transparency of the results.

[47] Of course, as a practical matter, we would not advocate mechanical pursuit of such a policy rule by central banks, since the exercise of informed judgment is a crucial component of any policy regime. Nonetheless, analytical exercises involving monetary policy rules constitute a useful reference point for policy analysis, giving the basis for a systematic (if not rule-bound) policy making process (cf. ECB, 2001c).

[48] As in Gerlach and Svensson (2002), the real money gap is defined as the difference between the observed real money stock and the real money stock consistent with real output at potential and income velocity at its long-run equilibrium level.

should influence interest rate decisions that aim to maintain price stability. By the same token, monetary developments do not affect price dynamics in the (backward-looking) benchmark model. Optimal monetary policy for that model will thus be independent of monetary dynamics.

However, even within the variant to the benchmark model where money plays a role in the Phillips curve, the optimal monetary policy cannot be characterized *solely* as a response to monetary developments. The influence of monetary developments on interest rate decisions should be *conditional* on developments in other macroeconomic variables. In other words, variables such as the output gap and inflation also enter the optimal monetary policy rule in variants to the benchmark model (when represented by the P* model). This result has a number of practical implications.

First, as shown by Svensson (2000), even the simple P* framework adopted here does not necessarily provide support for naïve characterizations of monetary targeting. (Intuition would anyway not suggest favoring monetary targeting within the benchmark New Keynesian framework.)

In other words (and adopting the terminology suggested by Svensson (1999), even in the context of a simple P* model, the optimal monetary policy rule is neither a simple money-based instrument rule of the form:

$$i_t \quad = \quad \varphi\,[(\ln \mathbf{M}_t \;-\; \ln \mathbf{M}_{t-1}) \;-\; k\,] \tag{7}$$

nor an intermediate monetary targeting rule defined (implicitly) as the solution to the following problem:

$$\textit{minimise} \quad \mathrm{E}_0\; \Sigma\, [(\ln \mathbf{M}_t \;-\; \ln \mathbf{M}_{t-1}) \;-\; k\,]^2 \tag{8}$$

subject to the constraints implied by the structure of the underlying economic model.[49]

Indeed, as shown in the Appendix, even in the simple models considered here, the performance of pure money-based rules such as (7) and (8) appears quite poor.[50] Pure money-based rules do not come close to mimicking the optimal policy rule in *either* the benchmark model *or* variants to it.

Second, the bivariate relationship between monetary dynamics (in particular, monetary growth) and optimal monetary policy (captured by the level of short-term nominal interest rates) is complicated by developments in other variables, and is therefore likely to be complex. On this basis, one should not anticipate a simple linear unconditional relationship between interest rates and monetary growth. Table 4 shows the bivariate correlations between inflation, monetary growth and interest rate in stochastic simulations of the two models, assuming the central bank follows the associated optimal policy rule. The bivariate correlations between monetary growth and interest rates are quite low, reflecting the complex and conditional nature of this relationship.[51]

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[49] k is a benchmark rate of monetary growth, for example that consistent with the maintenance of price stability over the medium term.

[50] Given the trivial nature of the models, it is hard to assign an economic meaning to the values of the loss function in terms of some more fundamental welfare measure. In other words, their ad hoc nature means that micro-founded welfare criteria are not available.

[51] Interestingly, this correlation is even lower in the active money P* model than in the passive money framework.

Finally, the analysis in the Appendix demonstrates that the relationship between optimal interest rate decisions and monetary developments is shock specific. In both simple models of monetary transmission entertained here, the bivariate relationship between monetary growth and interest rates depends on whether there is a demand shock, a supply shock or a monetary shock. In response to some shocks, the optimal monetary policy response in the face of rapid monetary growth may be a large immediate rise in interest rates. In response to other shocks, the optimal monetary policy response in the face of rapid monetary growth may be smaller and more gradual. Indeed, in some contexts, faster monetary growth may be associated with no interest rate change or even an interest rate cut.[52] Again, this suggests that interest rate changes should not be mechanically linked to monetary growth and that the bivariate relationship between interest rate changes and monetary dynamics may be complex if the optimal policy rule is being followed.

Table 4: Bivariate correlations in simulations of the two models in the appendix under optimal rules

a) *Output gap model*

	Inflation	Monetary growth	Interest rates
Inflation	1		
Monetary growth	0.77	1	
Interest rates	0.40	0.35	1

b) P model*

	Inflation	Monetary growth	Interest rates
Inflation	1		
Monetary growth	0.86	1	
Interest rates	0.16	0.22	1

Another implication of the shock-specific behavior of money is that monetary developments can help identify the nature of shocks and thus prompt an appropriate interest rate response. This is a necessary component of optimal policy in the P* model, where monetary shocks have an impact on price dynamics. However, even in the benchmark New Keynesian model where money plays no role in the transmission process, cross-correlations in the dynamic responses of money and other macroeconomic variables imply that monetary dynamics can help to identify the nature of the shocks. They can thus provide information useful to policy makers who would optimally respond in a shock-specific manner. Money may therefore prove to be a useful indicator even in the benchmark New Keynesian framework. This is the essence of the Coenen et al. (2001) result reported in Section 2.

[52] This is, of course, simply an implication of the need to condition the interest rate decision on other variables in addition to money.

4.3 Formulating rules that perform well in both paradigms

Gerdesmeier et al. (2002) consider the design of monetary policy rules where, because of uncertainty about which model or variant is most realistic or relevant, policy makers entertain a variety of models of monetary policy transmission. As one would expect, they show that monetary developments should influence monetary policy decisions when money plays an active role in the monetary transmission mechanism within at least one of the models being considered.

This conclusion is intuitive. However, Gerdesmeier et al. (2002) obtain a number of other, less obvious results. Within their framework, they show that monetary developments play an important role in interest rate decisions (in the sense that the coefficient on the real money gap in the favored monetary policy rule is large) even when the weight accorded to the variant of the benchmark model (captured by the P* specification) is relatively low. The intuition behind this result is as follows. Gerdesmeier et al. (2002) minimise a weighted average of the losses in the two models. Ignoring monetary developments in the P* model may be costly, because a crucial determinant of price dynamics is being ignored. At the same time, allowing a role for monetary dynamics in the benchmark model may be relatively benign. Even in the benchmark model, monetary dynamics are associated with developments in the output gap, inflation and interest rates, which are themselves determinants of inflation within that model. Monetary developments may therefore capture information in other, policy-relevant variables.[53] As a result, the costs of ignoring money in the P* variant to the benchmark model may rise more rapidly than the benefits of ignoring money in the benchmark framework. This leads to a relatively prominent role for money in a policy rule that addresses model uncertainty across the P* and benchmark specifications.

Gerdesmeier et al. (2002) also show that their favored monetary policy rule implies larger responses to all state variables (including the real money gap, the monetary argument in their policy rule) than would be implied by alternative approaches, such as averaging the optimal rules from the two models (i.e., analyzing the benchmark and variant models without reference to one another) or deriving an optimal rule from a hybrid framework that averages the two models (i.e., obscuring the distinction between the benchmark and its variant).[54]

Although the conditional response of interest rates to monetary developments may be large, this does not imply that the unconditional volatility of interest rates under the

[53] For example, the real money gap is positively related to the output gap. If interest rates rise in response to a positive money gap (as the P* model would require), they will implicitly rise in response to an output gap (as the passive money framework would require). The loss associated with responding to the money gap in the passive money paradigm therefore may be modest.

[54] This result runs counter to the conclusions of Brainard (1967) inter alia, which suggest that uncertainty about the structure of the transmission mechanism should lead to attenuated monetary policy responses. Gerdesmeier et al. (2002) offer the following intuition. The Brainard result follows from the possibility that structural uncertainty renders inflation uncontrollable using an interest rate instrument. In such circumstances, changing interest rates would simply destabilize other variables such as the output gap without helping to maintain price stability. If such a scenario is possible, monetary policy responses will be attenuated to avoid the destabilizing impact of such a policy. However, in the Gerdesmeier et al. (2002) framework, controllability is possible in both the benchmark model and its variant. The issue is not whether the system is controllable, but rather the channels through which control is exercised. In this environment, monetary policy responses are stronger than in the Brainard framework.

policy rules analysed by Gerdesmeier et al. (2002) will be higher than for other policy regimes. As discussed above, interest rates also respond to variables other than money. In practice, developments in money may therefore be offset by developments in other arguments of the policy rule, such as inflation and/or the output gap, resulting in modest unconditional interest rate volatility.

The Gerdesmeier et al. (2002) paper thus leads to three conclusions. First, once variants to the benchmark New Keynesian model are entertained, monetary developments may influence monetary policy decisions. Second, the role accorded to monetary dynamics in formulating interest rate decisions may be relatively large, even if the weight accorded to the variant model that emphasizes the role of money is modest. Third, on occasion arguments of the monetary policy rule will point in different directions. The output gap may suggest a rate increase, while monetary dynamics suggest a rate cut. This should not be seen as a shortcoming of the approach. Indeed, the role of the monetary policy rule is precisely to provide a framework for reconciling and combining the information in various indicators into a single robust interest rate decision.

5. Concluding remarks

Much recent academic literature on monetary policy has suggested that monetary aggregates should not play a large role in monetary policy decisions. Within the so-called new neoclassical synthesis or the New Keynesian model, monetary developments are not seen as playing an active role in the transmission mechanism of monetary policy. Monetary policy rules advocated by adherents of these models are often moneyless – they suggest that central banks can neglect or even ignore monetary developments when taking interest rate decisions. Moreover, many prominent empirical studies, in particular for the US, have concluded that the demand for money is unstable in both long and short runs and that monetary developments largely constitute “noise” which policy makers would do well to ignore.

This paper has challenged these very strong – and, in our view, erroneous – conclusions.

On empirical grounds, we survey a large literature which supports the view that money both has a stable relationship with prices in the euro area and exhibits leading indicator properties for future price developments, at least in the euro area.

On conceptual grounds, we note that monetary policy regimes which neglect monetary developments are prone to expectational instability – a practical, as well as theoretical, problem, which may lead to threaten the maintenance of price stability. Broadly speaking, these results follow from the observation that monetary policy regimes which ignore money may lack a nominal anchor.

On empirical and practical grounds, we suggest that monetary developments contain information about the state of the economy which – regardless of whether money plays an active role in the transmission mechanism of monetary policy – should be integrated into the policy making process. Of course, in models where money does play an ‘active’ role, monetary dynamics necessarily enter optimal policy rules.

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Appendix: Model uncertainty and monetary policy rules

a) The output gap model

In its simplest form, the "output gap model" (henceforth OGM) (representative of the benchmark view of monetary policy transmission) can be presented as:

$$y_t = \lambda\, y_{t-1} - \delta\,(i_{t-1} - E_{t-1}\pi_t) + \varepsilon_{s,t} \tag{9}$$

$$\pi_t = \pi_{t-1} - \beta\,(y_{t-1} - y^{*}_{t-1}) + \varepsilon_{s,t} \tag{10}$$

where y is the output gap; i is the short-term nominal interest rate under the control of the central bank; π is inflation and ε_d and ε_s are demand and supply shocks respectively. For notational simplicity, the variables are de-meaned and de-trended, such that potential output is zero (cf. Rudebusch and Svensson, 1999).

To facilitate comparisons with the P-star model discussed below, a money demand equation is appended to the basic OGM. The money demand equation is "appended" in the sense that price and output dynamics are fully determined by equations (9) and (10): this is why the OGM represents the benchmark view of monetary transmission. This money demand equation has a standard error correction specification, shown below.

$$\Delta(m-p)_t = \phi\,\Delta(m-p)_{t-1} - \vartheta\,((m-p)_{t-1} - y_{t-1} + \gamma\, i_{t-1}) + \varepsilon_{md,t} \tag{11}$$

b) The P* model

The P* model (representative of variants to the benchmark view of monetary policy transmission) can be summarized by the following system of equations (where the notation is the same as above, with i^* the nominal short-term interest rate holding in steady state equilibrium with price stability, normalized to zero) (cf. Hallman, et al., 1991; Svensson, 2000):

$$y_t = \lambda\, y_{t-1} - \delta\,(i_{t-1} - E_{t-1}\pi_t) + \varepsilon_{s,t} \tag{12}$$

$$\Delta(m-p)_t = \phi\,\Delta(m-p)_{t-1} - \vartheta\,((m-p)_{t-1} - y_{t-1} + \gamma\, i_{t-1}) + \varepsilon_{md,t} \tag{13}$$

$$\pi_t = (1-\omega)\,\pi_{t-1} + \omega\,\Delta p^{*}_{t-1} - \mu\,(p_{t-1} - p^{*}_{t-1}) + \varepsilon_{s,t} \tag{14}$$

$$p^{*}_t = m_t - y^{*}_t - \lambda i^{*} \tag{15}$$

c) Central bank preferences

Consistent with the academic literature, the objectives of the central bank are summarized by the loss function (5), which is used here for illustrative purposes. Note that this loss function assumes a steady state rate of inflation of zero, which – in the context of this framework – corresponds to the central bank's definition of price stability.

d) Analysis

Using conventional techniques (as discussed, for example, in Rudebusch and Svensson, 1999), each model can be solved to find the “optimal monetary policy rule” which minimizes the loss function (5). As discussed in the main text, this rule (and the results it obtains) can then be compared with simple money-based rules, such as those defined by (7) and (8).[55] This exercise is presented in Table 5.

Table 5: Performance of optimal and money-based rules in the two models in the Appendix

		Output gap model	P* model
Optimal rule			
Coefficient on:	y_t	10.051	7.358
Δp_t	10.512	8.472	
	$(m-p)_t$	0	15.386
	$(m-p)_{t-1}$	0	-12.118
Loss with optimal rule		**6.309**	**8.836**
Simple money-based instrument rule			
Response parameter	φ	2.135	1.906
Loss with simple money-based instrument rule		**15.589**	**24.959**
Simple intermediate monetary targeting rule			
Loss with simple intermediate monetary targeting rule		**23.909**	**24.652**

Notes: Because of the de-meaning and de-trending of all variables, all steady states have been normalized to zero.

Table 4 (see main text) shows the bivariate correlations between short-term nominal interest rates, inflation and monetary growth in the two simple models, under the assumption that the optimal rule described in Table 5 is followed. These results are discussed in the main text. Note that, counter to intuition, the contemporaneous correlation between optimal interest rate changes and money growth is higher in the benchmark model (rather than the variant P* model where money enters the Phillips curve and thus plays an active role in monetary transmission).

[55] For the simple money-based instrument rule (1), the response parameter φ is chosen so as to minimize the central bank’s loss function described by equation (5).

Table 6 describes the policy rule that minimizes the average central bank loss over the two models presented above and permits comparison with the optimal rule for each of the two underlying models. This rule is one variant of the monetary policy rules analysed in Gerdesmeier et al. (2002) that attempt to address the problem of model uncertainty, i.e. the need to arrive at a *single* interest rate decision on the basis of analysis in *both* the benchmark model and in the variant of it. As noted in the main text, the response of interest rates to monetary developments (i.e., the response coefficients on the money gap in the policy rule) is large. Moreover, these coefficients are greater than the average of the two corresponding coefficients in the individual underlying models. The intuition behind these results is discussed in the main text.

Table 6: Coefficients and performance of rule that minimizes average central bank loss over the two paradigms

	Bayesian rule weighting loss functions (q = 0.5)	OGM optimal rule	P* optimal rule
Coefficient in weighted rule on:			
$(y - y^*)_t$	9.572	10.051	7.358
Δp_t	9.481	10.512	8.472
$(m - p)_t$	9.525	0	15.386
$(m - p)_{t-1}$	-8.190	0	-12.118
Loss in OGM	7.096	6.309	9.210
Loss in P* model	9.456	12.673	8.836
Mean loss	8.276	9.491	9.023
Maximum loss	9.456	12.673	9.210

Note: The rule described in this table minimizes the average central bank loss over the two paradigms (summarized by the two models), i.e. min $L = 0.5 \times L_{OG} + 0.5 \times L_{P*}$.

The parameter calibrations used to undertake the exercises reported in this Appendix are shown in Table 7.

Table 7: Calibrated values for the model parameters

Parameter	Calibrated value	Economic interpretation
λ	0.9	Output persistence.
δ	0.1	Real interest rate elasticity of aggregate demand.
β	0.1	Sensitivity of inflation to the output gap.
ϕ	0.6	Persistence of real monetary growth.
υ	0.1	Error correction coefficient in money demand equation.
γ	0.25	Long-run interest rate elasticity of money demand.
ω	0.5	Weight on lagged inflation in P* inflation equation.
μ	0.2	Error correction coefficient in P* inflation equation
$\Sigma_{OG} = \Sigma_{P*}$	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$	Covariance matrix of the structural economic (demand, supply and money) shocks. (For simplicity, a diagonal matrix with unit variances is assumed for both models.)
ψ	0.5	Relative weight on inflation variance in the central bank's loss function.

In synthesis, in both of the models introduced in this Appendix, the adoption of a monetary policy rule that preserves price stability ensures that monetary growth will fluctuate around its steady state rate (i.e., M3 growth oscillates around the reference value). This is a direct implication of the observation that the optimal policy rule in both models will render the economic system stable if it is to preserve price stability. Yet if the underlying monetary policy rule adopted by the central bank does not preserve price stability[56], then monetary growth diverges from the steady state (i.e. the reference value) in both models.

[56] In the output gap model, it is sufficient to choose a monetary policy rule with a coefficient less than unity on inflation, such that the real interest rate does not rise in response to an inflationary shock (cf. Clarida et al., 1999). In other words, violating the Taylor principle is sufficient to induce instability. This condition is not sufficient in the P* model: a rule that preserves price stability may have a coefficient less than unity on inflation in this context.

9

Why has broad money demand been more stable in the euro area than in other economies? A literature review*

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1. Introduction

The existence of a stable relationship between money and prices is generally regarded as a prerequisite for the use of monetary aggregates in the formulation of monetary policy. The stability of such relationship is usually assessed in a money demand framework. Following the pioneering work by Bekx and Tullio (1989) and Kremers and Lane (1990), a substantial empirical literature on European money demand has accumulated.[1] While these studies have differed in a number of respects, notably country coverage, data definitions and econometric methodology, the emerging consensus has been that it is possible to estimate stable money demand models for groupings of European countries. More recently, several recent studies by ECB staff have concluded that it is possible to model broad money demand in the euro area as a stable function of prices, GDP and interest rates.[2]

The findings for the euro area as a whole contrast with those for several foreign individual countries, where money demand functions have been in some cases subject to structural breaks. This has contributed to generating doubts about the usefulness of monetary aggregates in the conduct of monetary policy in those countries. The empirical evidence of the superior stability performance of euro area money demand relative to other economies gives rise to the question of whether the failure of money demand functions in non-euro area countries can be explained by country specific factors. Section 2 of this paper looks at country-specific factors for three countries identified in the literature as cases of failure of money demand, namely the US, UK and Japan. In Section 3 the paper surveys the different arguments explaining the superior stability of euro area money demand functions, recalling the existing evidence in support or against such arguments. Some conclusions are provided in Section 4.

2. Money demand (in)stability in the US, the UK and Japan

The US money demand (M2) appeared to be stable until the early nineties, when a structural break occurred. The stability of M2 demand up to the early 1990s is supported by several studies (see for instance Carlson and Parrott, 1991, Duca, 1995, Whitesell, 1997, Dotsey et al., 2000 and Carlson et al., 2000). At that time, M2 growth began to slow down despite a considerable reduction in its opportunity cost. Although part of the M2 slowdown reflected the weakening in economic activity, the magnitude of the downturn could not be reconciled with this aggregate's estimated money demand function or with the historical behaviour of its income velocity.

The clear instability in M2 demand in the beginning of the 1990s has given rise to many different explanations as to the causes of the structural change. In the literature, some authors have attributed the break in money demand to financial innovation, noting that the period of "missing M2" occurred at a time when households increased their investments in bond and stock mutual funds (see Mehra, 1997). This is supported by the empirical work of Duca (1995) who has shown that the behaviour of an extended

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[1] See Browne, Fagan and Henry (1997), Filosa (1995) and Golinelli and Pastorello (2002) for detailed surveys.

[2] See Coenen and Vega (1999), Brand and Cassola (2000) and Calza, Gerdesmeier and Levy (2001) for M3 and Stracca (2000) for M1.

monetary aggregate corresponding to M2 plus mutual bond funds would be somewhat easier to explain than that of M2.

However, other authors have argued that the instability in the demand for M2 was related to problems in US financial institutions and therefore constituted a specific factor of the US with no implications for money demand in other economies. In particular, some authors have linked the slowdown in M2 demand to capital difficulties in depository institutions, especially thrift institutions, in the early 1990s. For instance, Lown, Peristiani and Robinson (1999) argue that capital constraints at banks and thrifts were an important factor underlying the anomalous relationship between M2 velocity and its opportunity cost. According to these authors, the downward shift in M2 was the result of the lack of incentives of these institutions to take on further funds given that they were restricted in terms of the expansion of their lending activity. Therefore, in order to avoid increasing their liabilities, these institutions induced lower deposits by granting less favourable conditions on deposits. After correcting for this effect, Lown, Peristiani and Robinson (1999) conclude that, in the absence of financial sector difficulties, M2 would have remained a useful indicator.

Other authors take an intermediate position arguing that the effect of financial innovation on M2 in the early 1990s was stronger than would have been the case in the absence of the financial difficulties in depository institutions. As noted by Carlson et. al (2000), the restructuring of depository institutions seems to have acted as a catalyst for the development of mutual funds in the US, particularly of bond funds, which in turn caused M2 demand instability. Thus, it remains difficult to ascertain whether the instability in M2 demand in the US resulted from a single factor or instead only came about due to the combination of both contemporaneous factors.[3]

Reflecting the finding of instability in money demand in the US in the early 1990s, the literature on the use of money has evolved in different ways. A first strand of the literature has looked at ways of improving money demand models, while a second strand of research has turned into the investigation of the usefulness of money as an indicator for the conduct of monetary policy (regardless of whether or not its demand function is unstable).

As regards the first type of studies, it should be noted that, although the information content of money in the United States has been distorted for a relatively prolonged period, more recently there has been growing evidence that money demand in the US is behaving in line with past trends. For instance, Whitesell (1997) and Carlson and Schwartz (1999) find that notwithstanding the shift in M2 velocity in the early 1990s, the standard determinants of money demand (nominal GDP and the opportunity cost of money) are able to reasonably explain the behaviour of M2 since then. The estimates of Orphanides and Porter (2001) suggest that the shift in M2 velocity was an upward level shift and that in the late 1990s velocity was returning to past trends. Furthermore, they argue that the upward level shift in M2 velocity could have been detected in real time by using a smooth trend. In addition, Carlson et al. (2000) show that while the M2 money demand relation broke down around the 1990s (due to a permanent upward shift in

[3] Mehra (1997) mentions other special factors that have been cited as contributing to money demand instability in this period: the credit crunch, the downsizing of consumer balances by using M2 balances to pay off debt, rising deposit insurance premiums and the imposition of new, high capital standards for depository institutions.

velocity that again was found to be largely over by 1994) there is strong evidence that money demand relationships for MZM (which includes M1, savings deposits, including money market deposit accounts, and both institutional and retail money market mutual funds but excludes small time deposit accounts) and M2M (=M2 less small time deposit accounts) remained stable throughout this period.

In the second approach, focused on the usefulness of money as an indicator for monetary policy, Dotsey et al. (2000) find that although the M2 demand function shows considerable variability over time, M2 contains useful information for forecasting nominal and real GDP. However, as shown by Amato and Swanson (2001), such predictive content does not seem to hold in a real time setting (i.e. taking into account the impact of redefinitions and revisions to M2 data).

In the UK M4 money demand has been traditionally difficult to model. An exception is provided by Hendry and Mizon (1998) who find some evidence suggesting that, though the velocity of money and interest rates (more precisely a measure of the opportunity cost of broad money) follow different regimes over time, there is a stable long-run relationship between these variables.

A particular feature of money demand in the UK is the significant improvement in money demand stability when estimated at sectoral level.[4] This finding could be explained by the existence of different motivations for holding broad money by households and corporations, which could lead to unstable money demand when it is estimated on the basis of aggregate data.[5]

Fisher and Vega (1993) estimate broad money demand (M4) by sector and find that, while good results can be found for the household sector, the modelling of money demand by corporations is more problematic. One possible explanation put forward for these results is the existence of differences in the motivations of households and non-financial corporations for demanding money balances. According to the study, households seem to demand monetary assets for both transaction and portfolio reasons, while the demand for money by the corporate sector (which in the study includes industrial and commercial corporations and non-monetary financial corporations) seems to be driven exclusively by portfolio reasons, thereby being potentially more volatile. Thomas (1997b) goes a step further and investigates whether different companies use money for different purposes. The author argues that, while the demand for money of non-financial corporations is likely to be related more to transaction motives, non-monetary financial corporations are likely to hold money mainly for portfolio or speculative reasons. As a result, a different modelling strategy should be adopted for each sector. Proceeding in this way, Thomas (1997a and 1997b) is able to obtain broadly stable money demand functions for each of the sectors (personal sector, industrial and commercial corporations and non-monetary financial corporations).

Fiess and MacDonald (2001) provide an alternative explanation of why the demand for aggregate M4 may be unstable while the sectoral money demand functions remain stable. According to these authors, the problem of instability is related to the fact that money demand studies model real monetary aggregates imposing long-run price homogeneity. However, according to their study, long-run price homogeneity does not

[4] The findings for the UK contrast with those of Germany, where a study by Read (1996) finds no evidence that aggregation across sectors leads to instability relative to sectoral money demand functions.

[5] It should be noted that the converse is also true, i. e. unstable money demand functions by sector could result in a stable money demand when aggregated data is used.

hold on aggregate M4 in the UK, but only holds when the data is broken down by sectors. Therefore, modelling M4 money demand by sector in the UK may be more appropriate.[6]

Finally, Astley and Haldane (1995) investigate the forecasting properties of M4 and find that this aggregate has no significant leading indicator properties for aggregate demand, which they interpret as signalling the instability of the velocity of broad money. However, the results improve when the analysis is conducted at a sectoral level.

In Japan, the money demand function for M2 appears to be difficult to model using the traditional money demand determinants. For instance, using quarterly data over the period from 1964 to 1993, Miyao (1996) finds that the real M2 monetary aggregate in Japan is not cointegrated with real output and the nominal interest rate. Underlying this failure appears to be the sensitivity of the money demand function to developments in the effective exchange rate and to wealth effects.

As regards the exchange rate, the instability in money demand in Japan appears to be associated with a strong devaluation of foreign assets denominated in yen after the Plaza accord of 1985 (see Yamada, 2000). In fact, several authors have found that, if one includes an exchange rate in the model, it is possible to find cointegration between real M2, income, the nominal interest rate and the effective exchange rate (see Bahmani-Oskooee and Shabsigh, 1996, and Yamada, 2000).[7]

As for the effect of changes in wealth, the sharp rise in land and stock prices from mid-1980s onwards and the subsequent decline constituted a major shock to money demand in Japan. Sekine (1998) addresses this issue by using as a scale variable, in addition to income, a wealth measure composed of both financial and non-financial assets (including also land and housing). The resulting money demand for M2+CDs in Japan appears to be stable for the period 1975 to 1994.

More recently, using more robust econometric methods than in previous studies, Bahmani-Oskooee (2001) finds evidence of a cointegration relation between the stock of real M2, income and an interest rate for the period between 1964 and 1996. In addition, the money demand function appears to be stable. However, given that the sample period for this study ended in 1996, the results should not be taken as valid for the more recent years. In fact, Kimura (2001) finds evidence that there is a structural break in the broad money demand function for Japan in autumn 1997 due to a shock to the financial system. The breakdown in the long-run relationship between money and income occurred during 1997 and 1998, when monetary growth continued rising despite the severe recession in the Japanese economy. The author attributed this breakdown to "financial anxieties", i.e. precautionary demand for money motivated by the fall in stock

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[6] More specifically, Fiess and MacDonald (2001) argue that the instability of the money demand has to do with an unsuccessful reduction of the variables money and prices from I(2) to I(1). Such reduction is usually achieved by imposing long-run price homogeneity. However, Fiess and MacDonald (2001) test this on broad aggregate money demand and conclude that there are still I(2) components in the data even after imposing long-run price homogeneity. By contrast, using M4 disaggregated by sectors, the authors succeed in removing all I(2) components from the system.

[7] The inclusion of the exchange rate in the money demand function can be justified by the fact that changes in the exchange rate alter the domestic value of foreign assets and therefore affect wealth (see Arango and Nadiri, 1981). In addition, expected exchange rate changes can be seen as indicative of the expected return on foreign monetary assets (in particular in the case of non-remunerated assets) and therefore should be part of the variables that influence the opportunity cost of holding domestic monetary assets (see Hamburger, 1977).

prices and concerns regarding the financial situation of firms. When the model was extended to include real stock prices and a measure of financial anxieties taken from the Tankan's Economic surveys of the financial position of firms, it was possible to obtain a stable long-run relationship between M2+CDs, real stock prices and the indicator of financial anxieties.

3. Money demand stability in the euro area

In contrast to the findings for the US, the UK and Japan, the evidence on broad money demand stability for the euro area is favourable. Several arguments have been put forward to justify why money demand functions may perform better in the European Monetary Union than those in individual countries outside it (or even in some of those inside it as shown by Fagan and Henry, 1998).

Some of the arguments relate to the relatively weaker impact on euro area money demand of general sources of instability such as financial innovation and other institutional and regulatory changes (developments in payment systems technology, financial deregulation, introduction of new substitutes for components included in the monetary aggregates, changes to the regime of remuneration on deposits, increased banking competition, etc.).[8] Other arguments refer to aggregation-related issues (see Browne, Fagan and Henry, 1997). This is not entirely surprising given that one important peculiarity of the euro area money demand functions is that, unlike those in individual industrialised countries, they are estimated using data aggregated across countries. As a result, it is possible that their superior stability properties can be to some extent explained by factors related to the aggregation procedure. In particular, three main factors have been suggested: the "averaging-out" of desynchronised national shocks, the internalisation of currency substitution and the "German size" factor.

3.1 Weaker impact of financial innovation in the euro area compared to non-euro area countries

As pointed out by Filosa (1995), the conventional wisdom at the beginning of the 1980s was that money demand functions for continental European countries enjoyed more satisfactory stability properties than their correspondents for the US and the UK because the former countries had experienced less severe financial and economic shocks than the latter. However, the process of financial innovation gained momentum throughout the following two decades, with substantial institutional changes taking place in the financial system of euro area countries. Thus, in several countries, problems of interpretation of monetary aggregates and, in some cases, of instability in money demand functions arose.

One reason why financial innovation may not have affected money demand in the euro area as a whole as strongly as in other economies is that, because innovation in the euro area regarded instruments that were close to the definition of money, central banks were able to redefine the relevant monetary aggregates to include them. Thus, by modifying the composition of monetary aggregates, central banks were able to account for the

[8] Another general source of instability relates to international developments (liberalisation of capital movements, exchange rate regime, etc.).

sources of instability.[9] In contrast, in other economies (for instance in the US) where instability originated from structural shifts towards bonds and equity funds in the composition of portfolios, such redefinition of monetary aggregates would not have been feasible given the clear non-monetary character of those instruments.[10] According to this argument, the current definition of M3 for the euro area reflects the past experience and is able to internalise the outcome of important episodes of financial innovation.

There are several examples in euro area countries of redefinitions of monetary aggregates with the aim of internalising substitution effects. In several cases these redefinitions led to an improvement in money demand stability, but in some cases such stability improvements turned out to be elusive. For instance, in France monetary aggregates were modified in 1986 to take into account the introduction of money market negotiable instruments and the particularly strong growth of money market funds. This modification brought greater stability to money demand (see Drumetz and Odonnat, 2001).[11] In Spain M3 was redefined several times and then abandoned for the aggregate ALP, standing for "liquid assets held by the public" comprising instruments contained in the national definition of M3, and purchases of short-term government securities, endorsed bills and commercial paper guaranteed by deposit institutions, non-interbank private transfers and medium and long-term securities issued by the Official Credit Institute and the specialised credit institutions.[12] However, such aggregate was so broad that portfolio motives became prevalent in driving the demand for ALP, eventually leading to difficulties in the interpretation of its behaviour (see Vega, 1998).

A second reason why financial innovation may have had a smaller impact on broad money demand in the euro area is that in Germany – the largest economy in the monetary union - the effects of financial innovation on M3 were mainly of a temporary nature and did not affect the stability of national money demand (see Issing, 1992 and 1997, and Scharnagl, 1998). In fact, according to Reischle (2001), the most important factors affecting the indicator properties of M3 in Germany were changes in tax regulations rather than financial innovation. As argued by Issing (1997), the weak impact of financial innovation on German M3 was not related to the lack of new

[9] In some cases, redefinitions of monetary aggregates involved exclusion of components. For instance, in Italy some categories of certificates of deposits were excluded from the aggregate M2 as a consequence of changes in the fiscal treatment of deposits and reserve requirements, changes in household portfolio behaviour and, eventually, currency substitution (see Altissimo et al., 2001).

[10] Data on the broad monetary aggregate M2 in the US has been subject to several re-definitions mainly in response to financial innovation and to improve the link with other macroeconomic variables (see Amato and Swanson (2001)). Nevertheless, as shown in section 2, there is strong evidence that M2 demand in the US had a structural break at the beginning of the 1990s.

[11] In Germany, although the money demand function for the intermediate target variable M3 remained stable, an extended aggregate "M3 extended" was introduced to the public in 1986 and commented regularly from 1990. This complementary aggregate included, in addition to M3, bank deposits of domestic non-banks with foreign subsidiaries and foreign branches of German banks; short-term bank bonds issued by German banks and, from August 1994 onwards, certificates of money market funds held by German non-banks. For example, this aggregate took into account the effect of the authorisation of money market funds in Germany in mid-1994, which led to a corrective downward movement in German M3 (which did not include these instruments).

[12] The problems of instability of money demand that led to the definition of the aggregate ALP were probably related to spurious financial innovation caused by changes in taxation and also to high level of reserve requirements during the 1980's and part of the 1990's which gave rise to a surge in off-balance sheet financial products.

financial products but rather a result of banks being able to satisfy the needs of the private sector with the traditional range of products and possibly a more conservative attitude of money holders in this country. This contrasts with what happened for instance in the US, where the impact of financial innovation on monetary aggregates was much more profound.

Third, the different timing and speed in financial innovation and deregulation across euro area countries (for instance in Germany capital controls were removed in the early 1980s, while in France and Italy this occurred in the late 1980s/beginning of the 1990s) probably implied that their effect on the area-wide aggregate money demand function was less important than in the individual countries concerned (see next section).

3.2 Factors related to aggregation procedure

3.2.1 The "averaging-out" of desynchronised shocks to national money demand

According to this argument, the stability of euro area money demand may be due to purely statistical factors. Shocks to individual countries forming a currency area may cause instability of the countries' individual money demand equations. However, if these shocks are *desynchronised* their effect may be to a large extent averaged out through the aggregation process, without affecting the stability properties of the aggregate money demand (see Arnold, 1994, and Arnold and de Vries, 2000). For instance, if financial innovation is not synchronised across countries, then its effect on the area-wide aggregate will be smaller than in the case of a single country, where shocks across regions are highly correlated if not identical.

Based on a cross-section estimation of money demand for 13 OECD countries, Arnold (1994) argues that the findings of a stable European money demand by several studies in the early 1990s (e.g. those by Bekx and Tullio, 1989, and Kremers and Lane, 1990) are largely dependent on the use of aggregate data and conclude that the stability of European money demand is a "statistical artefact". However, he notes that this "advantage" of aggregate data is likely to be significantly more important when modelling money demand prior to Stage Three of Monetary Union. Indeed, *"as monetary unification will lead to a centralisation of … sources of [money demand] instability"*, it is likely that following the adoption of a single monetary policy and increased economic and financial integration in Stage Three, shocks such as those arising from financial innovation will become more synchronised.[13] As a consequence, the beneficial averaging-out effect should be reduced, leading to a deterioration of the statistical properties of euro area money demand functions.

Some evidence in support of the averaging hypothesis is provided by Fagan and Henry (1998) who estimate both aggregate and individual M3H demand functions for the EU members excluding Luxembourg. The authors find many cases of negative cross-correlation between the residuals of national money demand functions (notably a correlation index of –0.40 for France and Germany), which they interpret as evidence of desynchronised shocks across countries. However, when the authors conduct a

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[13] Nevertheless, there still would remain several sources of heterogeneity due to national fiscal policies and country specific regulations.

simulation exercise under the assumption that shocks to individual countries become perfectly correlated and synchronised (which would broadly correspond to a scenario of perfect economic and financial integration), they find that the statistical properties of the European aggregate money demand function still compare relatively well (in terms of the residual standard error) with those of individual countries. This would imply that the prediction by Arnold (1994) of a significant deterioration of the stability properties of the euro area money demand equations in Stage Three may not materialise. Fagan and Henry (1998) conclude that *"a number of reasons which have been put forward to explain the better performance of the area-wide equation such as currency substitution, the operation of the ERM system, etc.… are not strictly necessary to explain the result"*.

3.2.2 The internalisation of currency substitution within Europe

A traditional explanation of the fact that aggregate estimates may be more stable than those at the country level regards the so-called "specification bias". This refers to the possibility that equations at a disaggregate level may omit relevant foreign aggregate explanatory variables, which are important for a single country. In this case, the recourse to aggregate data may lead to improved results by reducing this specification bias.

A possible source of specification bias in the case of national money demand equations is international currency substitution. This idea was first suggested by McKinnon (1982) who argued that international liquidity shifts among financially integrated countries may lead to instability in their national money demand functions. However, these shifts would not necessarily affect the stability of the multi-country aggregate money demand, as long as the currency shifts were sufficiently internalised.

Following the progressive liberalisation of capital accounts transactions during the late 1980s and early 1990s, portfolio shifts across euro area countries became rather significant. As a result, in theory it cannot be excluded that currency substitution and intra-area portfolio diversification played a role in destabilising national money demands before Stage Three, the more so as there was the possibility of portfolio shifts abroad to exploit interest rate differentials and/or expectations of exchange rate devaluations. However, since shocks to one country's money demand function were probably to some extent offset by shocks to money demand in other euro area countries, the currency shifts are likely to be partially (if not entirely) internalised within the euro area monetary aggregate.

Kremers and Lane (1990) argue that the superior performance of European-wide money demand relative to national money demand models may reflect the internalisation of currency substitution. Empirical tests on the relevance of currency substitution in the euro area have, though, produced rather mixed results. The main way of testing for the importance of currency substitution is to test whether there is a statistically significant negative cross-correlation between the residuals of national money demand equations. Angeloni et al. (1992) analyse cross-correlations of residuals of money demand equations in Italy, Germany, France, UK and Spain and find that the indices tend to be negative but hardly significant. Similarly, in her study covering Germany, France, Italy and the UK, Wesche (1997) finds that there is no significant negative cross-correlation between the residuals of national money demand functions, with the only exception of those for Germany and Italy. These results led her to conclude that the neutralisation of currency substitution *"… seems not to be the cause for the stability of a European money demand function"*.

By contrast, Lane and Poloz (1992) find evidence of a negative cross-correlation across residuals of national money demand equations in the G-7 countries. Similarly, Filosa (1995) studies money demand in Belgium, France, Germany, Italy, Netherlands and the UK and concludes that *"… currency substitution is an important feature of the financial behaviour of European countries. Failure to account for currency substitution in the estimation of individual countries' money demand equations leads to biased estimates and distorts the view of the long-run stability of monetary aggregates"*.

Another approach to test the significance of currency substitution consists of assessing whether the stability performance of money demand functions improves when monetary aggregates are extended to include cross-border deposits. If so, this may provide indications that currency substitution plays a significant role. Estimates by Monticelli (1996) and Fagan and Henry (1998) show that the stability properties of European money demand functions do not improve significantly when extended monetary aggregates are used, suggesting that currency substitution may not be a relevant issue. Angeloni et al. (1994) conclude that extending monetary aggregates to include cross-border deposits leads to a significant improvement of the stability properties only in the cases of Germany and France.

Finally, the significance of currency substitution can be tested by analysing whether the demand for money responds to expected exchange rate changes. This is because, in a regime of liberalised capital movements (such as that emerging in Europe in the 1990s), expectations of exchange rate depreciation/appreciation would imply changes in expected returns from holding foreign assets and prompt currency substitution. After using several assumptions on the expectation formation mechanism, the Deutsche Bundesbank (1995) finds only very limited evidence of currency substitution between the D-Mark and other EU currencies.

3.2.3 The "German size" factor

This argument suggests that the relatively larger stability of the European money demand is the result of the remarkable stability of money demand in Germany (Wesche, 1997). There is robust evidence that money demand in Germany has been historically stable (see, for instance, Scharnagl, 1998, and Hubrich, 1999) as well as evidence that money demand has been more stable in Germany than in other European countries (see Fase and Winder, 1996). The "German size" argument posits that, as a result of the relatively large weight of Germany in European monetary aggregates and the asymmetric functioning of the ERM (with Germany targeting the money stock and other countries targeting the exchange rate to the Deutsche Mark), the stability properties of the German money demand function may "dominate" those of the other countries, thereby leading to an area-wide stable money demand.

This hypothesis of the German "size" factor finds support in the results of Wesche (1997) who compares the stability properties of aggregate money demand using M3H in a group of countries including Germany, France, Italy and the UK with those of a money demand function for the same aggregate excluding Germany. Wesche's main finding is that money demand becomes unstable when Germany is excluded from the area aggregate. Moreover, if one also includes the countries shadowing the Deutsche Mark which also enjoyed stable money demand, such as Austria and the Benelux countries (see Hayo, 2000, and Fase and Winder, 1996, respectively), the importance of the German factor increases even more.

One interesting question that arises from this analysis is why money demand was comparatively more stable in Germany as the answer to this question may have implications for the future stability of euro area money demand. Three main arguments have been suggested to explain the superior stability of German money demand: (1) the relatively early liberalisation of the financial sector; (2) the stabilising effect of price stability; and (3) the discouragement of potentially destabilising forms of financial innovation by the Bundesbank.

As regards the first argument, Issing (1997) and Scharnagl (1998) note that the liberalisation of the financial markets and cross-border money and capital movements was largely completed in Germany by the beginning of the 1970s. This liberalisation translated into both a stable regulatory framework and relatively limited demand for those financial products, which were – by contrast - welcomed as important novelties in countries with more tightly regulated financial system. Regarding the second argument, Issing (1992 and 1997) argues that the success of the Bundesbank in maintaining price stability in Germany might have also contributed to stabilising national money demand. In particular, the maintenance of an environment of low and stable inflation (and interest rates) rendered unnecessary the introduction of new financial products aimed at hedging against inflationary risks which may have had a destabilising impact on domestic money demand. Finally, the stability of German money demand may have benefited not only from the limited demand for new financial products but from restrictions on their supply aimed at facilitating the pursuit of a monetary targeting strategy. The most relevant example regarding this issue is the lack of authorisation of money market funds before 1994 by the Bundesbank. Nevertheless, this last effect does not appear to have been very relevant, as the authorisation of money market funds in 1994 had only a temporary effect on monetary growth and money demand in Germany continued to be stable (see Reischle, 2001).

4. Conclusions

This paper reviews several arguments which explain why broad money demand functions have been more stable in the euro area than in other economies. First, some factors affecting money demand outside the euro area appear to have been country specific. Second, financial innovation has had a weaker effect on money demand in the euro area than in other economies. Third, money demand stability in the euro area is partly due to gains from aggregating data across countries.

As regards the weaker impact of financial innovation in the euro area compared with other economies, there are three possible explanations. First, financial innovation in the euro area led to substitution towards instruments that could be considered as part of money and, therefore, could be taken care of by simply redefining monetary aggregates. Second, in Germany, which is the largest economy in the euro area, the effect of financial innovation on the stability of money demand was limited. Third, the different timing and speed of financial innovation and deregulation in the various countries of the euro area spread their overall effect on the euro area aggregate over time.

Also with respect to the aggregation effect, there are three possible explanations. First, aggregation averages out desynchronised shocks to national money demand, thereby contributing to a more stable function than at national level. A second effect of aggregation is the internalisation of currency substitution in the euro area. Finally, the fact that Germany has a large weight on the area-wide M3 aggregate and that money demand function has been historically stable in that country, has also contributed to the overall stability of euro area money demand.

Several factors that have contributed to the higher stability of the aggregate money demand in the euro area than in other economies are likely to remain valid in Stage Three of EMU. First, in the euro area the share of wealth held in financial assets is smaller than in other economies, particularly in the US, where portfolio shifts to and from bond and stock mutual funds were an important source of money demand instability in the past. Nevertheless, one cannot exclude that the composition of wealth in the euro area may change in the future and that shifts to other financial assets become more important than they have been so far. In this respect, the experience since the end of 2001 illustrates that also in the euro area money demand may be significantly affected by shifts from stock markets. However, it is unclear at this stage whether such events are likely to be repeated given the truly exceptional dimension of the stock market declines and volatility over this period. A second factor is that it is likely that aggregation gains will remain as the existence of cross-country differences in fiscal policies, regulations, institutions, banking structures, etc. will continue to be a source of national idiosyncrasies.

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10

Is the demand for euro area M3 stable?*

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1. Introduction

Monetary aggregates have often been assigned an important role in monetary policy analysis by both economists and policy-makers and are believed by many to account for the nature of inflation as a monetary phenomenon in the long run. According to these ideas, periods of sustained inflation cannot occur without monetary accommodation and, ceteris paribus, sustained reductions in money growth will eventually lead to lower inflation or deflation. A close relationship between money and prices in the long run suggests that the analysis of persistent trends in money and money growth may be an important gauge for assessing the outlook for price stability.

For such analyses to be meaningful, the relationship between money, prices and a few other key macroeconomic variables needs to be stable over time and predictable in a statistical sense. One way to assess whether the stability condition is met is to check for parameter constancy in a suitably defined money demand system. Such an analysis – based on formal tests – lies at the core of this paper. The empirical literature on the demand for M3 in the euro area is already considerable. It covers various econometric approaches and sample periods, and it studies single-country and euro area-wide functions. As far as the stability issue is concerned, euro area-wide money demand equations seem, in general, to perform better than many single-country relations, see, e.g., Fagan and Henry (1998) and Golinelli and Pastorello (2002) for extensive literature reviews. The reasons for such results have been subject to much debate, see, e.g., Filosa (1995), Browne, Fagan, and Henry (1997), Dedola, Gaiotti, and Silipo (2001), and Calza and Sousa (2003) for detailed discussions. Some have put forth the possibility that money demand estimated at the euro area level may benefit from the stability property of the German money demand function.[1] Others have argued that euro area functions implicitly average out what could otherwise be the sources of money demand instability at a national level. This, in particular, applies to the case of institutional and regulatory changes, to differences in national historical developments (such as in the speed of financial innovation and deregulation), or to the effect of non-synchronous shocks that hit the euro area countries (Arnold, 1994). Similarly, as highlighted by Kremers and Lane (1990) and Lane and Poloz (1992), the focus on euro area relations may internalize the effects of currency substitution movements.[2] Along the same lines, it has been argued that a money demand relation estimated at the euro area level may help offset misspecification problems due to spillover effects like cross-border trade and capital flows. Confirming the earlier findings of Angeloni, Cottarelli, and Levy (1994), however, Fagan and Henry (1998) conclude that:

> ...a number of reasons which have been put forward to explain the better performance of the area wide equation such as currency substitution, the operation of the ERM system ... are not strictly necessary to explain the result.

While most other studies base their conclusions concerning stability on informal

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[1] Wesche (1997), for example, found that euro area money demand becomes unstable when German data are excluded from a group of countries that also includes France, Italy and the United Kingdom.

[2] McKinnon (1982) argues that while movements of liquidity among financially integrated countries may be the source of instability in national money demand functions, these need not affect the stability of the respective aggregate multicountry money demand if well internalized.

diagnostics, the present study uses formal tests, which are not only of the correct size (at least in the limit), but also do not require the sample to be trimmed, thereby making it feasible to examine the stability issue using more information.

As emphasized in the literature (e.g. Winder, 1997) national data for M3, other scale variables and interest rates need to be consistently aggregated to be appropriately used in a euro area-wide money demand study. Not only may differences in the availability of national time series be difficult to reconcile, but also the choice of a weighting scheme that suits all variables is not straightforward. The objective of using national aggregates for scale variables, in particular, makes it difficult to take advantage of the contributions of index-number theory. The aggregation adopted by Fagan and Henry (1998) rests on a fixed GDP weight index. Beyer, Doornik, and Hendry (2001), focusing on the distortions that would stem from the simple summation of historical national data due to past exchange rate changes, have constructed an index that also overcomes the difficulties that may arise from possible non-stationarities and structural breaks.

In this paper, two aggregation methods are employed in parallel. The first method uses two aggregation techniques. In the first technique, national M3 and real and nominal GDP are converted into euro at the irrevocably fixed exchange rates and then summed, while in the second national interest rates are averaged according to time-varying weights that depend on the national contributions to euro area M3. The second aggregation method adopts the index method suggested by Fagan and Henry (1998), such that all variables are aggregated according to weights that measure the share of each country in euro area GDP in 2001 at PPP exchange rates. By comparing the results from these two aggregation methods, we not only have a means for checking the robustness of the conclusions with respect to the selected technique, but also a vehicle for evaluating the importance of adopting a consistent aggregation method.

In the present paper, it is assumed that M3 is demanded as a medium of exchange, for precautionary reasons, and as a portfolio asset. Hence, a benchmark long-run money demand relation is considered in which real M3 is related to income and a vector of interest rates, composed of the short-term market rate, the long-term bond yield and the average own rate of return on M3. Furthermore, it is expected that the coefficients for income and the own rate of return are positive (non-negative), while the remaining two coefficients are negative (non-positive).

The measurement and selection of the own rate of return is an important issue addressed carefully by this paper. Since a large part of M3 is remunerated, the M3 own rate should be considered as a weighted average of the rates of return on its components. Cassard, Lane, and Masson (1994) estimated the own rate of return on money as a GDP-weighted average of the French and German own rates. Dedola et al. (2001) measured the rate of return on euro area M3 as an average of the interest rates on national M3, weighted by the shares in euro terms of national M3 in euro area M3. Calza, Gerdesmeier, and Levy (2001) constructed a M3 own rate series starting from the euro area interest rates on all M3 components from January 1990 and filled the gap for the previous period using the national interest rates of the five largest euro area countries. The euro area M3 own rate used in the current paper is constructed on the basis of national interest rate series for all components of M3 and for all euro area countries from 1980 onwards. The aggregation across countries is performed on the basis of either M3 or GDP weights.

The selection of the appropriate rates of return on the different assets alternative to M3 depends on the choice made for the own rate of M3. Among the more recent euro area studies, Coenen and Vega (2001), who assume that the own rate of M3 is approximated by the short-term market interest rate, used the spread between long and short-term rates to capture the opportunity cost of holding money. Calza et al. (2001) considered both the spread between the long-term rate and the own rate of M3 and the spread between the short-term rate and the own rate. Brand and Cassola (2000), however, remarked that since the dynamics of the spread between the long-term rate and the own rate are almost fully captured by the dynamics of the long-term rate itself, the latter could be a better proxy for the opportunity cost of M3 than any market interest rate spread. Finally, Cassola and Morana (2002) found a stable long-run money demand relation without any variable representing the opportunity cost of M3. In contrast to these studies, we let all three rates be endogenous in this paper, thus allowing the short and long-term rates (as well as inflation) to represent alternative rates of return for M3. Like Fagan and Henry (1998) and Dedola et al. (2001), however, we found that the interest rate coefficients are imprecisely estimated in all our money demand systems.

The usefulness of analyzing money demand for policy purposes depends also on our ability to separate the developments in M3 that are related to income from those that are due to other factors, as these other factors can generate shifts in the income velocity of money (see Dow and Elmendorf, 1998). In particular, this paper addresses the issue of whether euro area stock market developments affect the long-run demand for M3.

The widespread ownership of shares is still a relatively new phenomenon in most euro area countries, growing fairly significantly in the late 1990s, even though it may have reversed recently.[3] While the financial structure of the euro area is still predominantly bank-based, market-oriented instruments (and shares and other equities in particular) have become an increasingly important source of financing for corporations. Furthermore, this trend towards market-oriented financing has resulted in a growing share of these market instruments in the investment portfolios of both non-financial corporations and households. We may therefore expect that market developments affect the "store of value" component of the demand for M3 and that stock prices help to capture the wealth effects behind it.

Cassola and Morana (2002) found evidence that asset prices play an important role in the monetary policy transmission mechanism in the euro area. They study the interactions between nominal interest rates, inflation, real output, real M3 and the euro area real stock price index by means of a structural vector error correction model. Their results broadly support the view that the strong increases in euro area M3 since 2001 can be partly attributed to a temporary liquidity preference shock – that also accounts for the strong declines in stock prices around the world since March 2000 – which made investors increase their holdings of relatively liquid and low risk assets.

Stability of money demand is our main reason for investigating the importance of stock market developments. First, we let the euro area real stock price index be an additional endogenous variable, and, second, we use an estimated stock market volatility series which enters the system as an exogenous variable. In contrast to Kontolemis (2002), who found that the inclusion of a weighted average of the German and French stock price indexes in long-run money demand "produces" parameter constancy for the non-cointegration parameters, our analyses suggest that stock market variables do not seem to be relevant for this issue. Our results show that real stock prices neither seem to

[3] For detailed information, see ECB (2002).

matter for the selection of the cointegration rank (i.e. the number of steady states), nor for the estimated parameters of the cointegration relations. Given that the cointegration space is constant over time, the non-cointegration parameters appear to be constant for both the system with and the system without real stock prices. If anything, the evidence for non-constancy of the cointegration space is stronger in the real stock price system than in a system without stock prices.

One reason for investigating the effects of stock market volatility on money demand is that volatility may be a proxy for the risk investors are exposed to when holding stocks. Under risky and uncertain conditions, as for example those manifested during financial crises, recessions, structural changes, firms' expectations of future earnings may well worsen. Investors may therefore be induced to reallocate their portfolios by increasing the share of short-term money market components, thus increasing the size and possibly influence the developments of a broad monetary aggregate such as M3. In our paper we find, however, evidence that stock market volatility does not contain unique information for explaining the endogenous variables. While it is possible that the demand for broad money, especially in more recent years, has been affected by stock market developments, it is conceivable that such a phenomenon is not fully captured by simply looking at the developments in the euro area stock price index or the volatility measure we have used. These issues require further investigation that go beyond the stability analysis we focus on.[4]

The remainder of the paper is organized as follows. Section 2 deals with measurement issues and focuses on the aggregation methodologies adopted in this paper and the opportunity costs of holding money. Section 3 introduces the benchmark money demand system and the selection of basic parameters like lag order and cointegration rank. Section 4 is centred around the formal parameters constancy tests, while all results are re-examined in Section 5 using an alternative aggregation method. Section 6 presents the results when stock market variables are included in the model and, finally, a summary and the main conclusions are discussed in Section 7.

2. Measurement issues

This section is concerned with two measurement issues on which the empirical literature on euro area money demand has not reached a consensus. In order to test the robustness of the empirical evidence, one aim of this paper is to investigate these measurement issues in an encompassing framework. The first issue relates to the aggregation methodology for constructing euro area time series from the national data. The need to use a consistent aggregation method for all variables in the statistical model is emphasized in the literature (see Winder, 1997). While this is straightforward for the scale variables in the model, like money and GDP, it is not obvious how this can be accomplished for the interest rate variables. In this section, we will therefore distinguish between scale variables (denoted in national currencies) on the one hand and interest rates (denoted in percentages per annum) on the other. A second measurement issue involves the selection of both an own rate of return on euro area M3 and one or more alternative rates of return.

[4] For a recent study on M2 data for the United States, see Carpenter and Lange (2003).

2.1 The aggregation methodology

Most data for the euro area have to be constructed from national data. In this paper, euro area data cover the countries comprising the euro area at each given time, i.e. 11 member states up to December 2000 and 12 member states from January 2001 onwards, i.e. plus Greece.[5]

2.1.1 Scale variables

Since the national data on scale variables, such as M3 and GDP, are denominated in national currencies, they cannot be simply summed to obtain euro area aggregates. The choice of aggregation method, i.e. weighting scheme, is not straightforward, reflecting the problem that it is only from 1999 onwards that a single currency has been in place.

One possible method is to first convert the national data into euro by applying the so called *irrevocably fixed exchange rates*, announced on December 31, 1998 (and determined on June 19, 2000, in the case of Greece), and then sum these converted series to the euro area aggregate scale variable. This method implies using the following formula:

$$x_{F,t} = \sum_{c} w_{F,c} x_{c,t}$$

where x denotes the scale variable, t the time period, c the individual country, and $w_{F,c}$ the irrevocably fixed exchange rate for country c.

One advantage of using fixed exchange rates instead of current exchange rates is that it avoids that the aggregate series would be affected by nominal exchange rate changes that could give rise to spurious correlations, especially at times of large swings in the exchange rate. A second advantage of this aggregation method is that it is consistent with the method that is used since the start of Stage Three of EMU, i.e. simply summing the national data (already expressed in euro). The main limitation of the method is that it can only be applied to variables that are denominated in national currencies (like stocks and flows of scale variables) and therefore not to the interest rates.

An alternative aggregation method is the so-called *index method*, presented in Fagan and Henry (1998). According to this method the log-level index for the euro area scale variable is defined as the weighted sum of the log-levels of the national scale variables, where the weights, $w_{I,c}$, are the shares of the countries' GDP in euro area GDP in 2001 measured at PPP exchange rates:

$$\ln x_{I,t} = \sum_{c} w_{I,c} \ln x_{c,t}$$

This method also uses constant weights which avoids the possible spurious correlations between the euro area series due to changes in the exchange rates. In addition, it implies that the log approximation of the growth rate for the euro area series is a weighted average of the log approximation of the growth rates of the underlying

[5] Since our data begins in 1980, it follows that some of the 11 member states were not members of the European Community (EC) in the early 80s. For example, Spain and Portugal became members of the EC in 1986, while Austria and Finland joined the European Union in 1995.

national series. The weights are thus the shares of the countries' GDP in euro area GDP in 2001 (measured at PPP exchange rates). A third advantage is that this method can also be applied to the other variables in the money demand system (albeit without taking the natural logarithm). Finally, the method is consistent with the (very strong) assumption that national money demand relations have the same log-linear specification and similar parameter values across all euro area countries. It therefore facilitates a comparison between area-wide and national money demand models. The main disadvantage of the index method is that it is *not* consistent with the method used since the start of Stage Three of EMU, i.e., simply summing the national data (already expressed in euro). In addition, it does not preserve the balance sheet identities, although this has no direct implication for the money demand models estimated in this paper.

Since there are no strong arguments to prefer one aggregation method over the other, both methods will be used in this paper. The first as the primary aggregation method, and the second to check the robustness of the results.[6]

For the construction of the data on euro area M3, non-seasonally adjusted data on the national contributions to euro area M3 are used. The adjustment for seasonal and calendar effects is performed at the euro area level. The quarterly data on euro area M3 are averages of seasonally adjusted end-of-month "notional stocks" data, calculated on the basis of flow data. From October 1997 these flow data are computed by adjusting the difference between the end-of-month stocks for the effects of non-transaction related factors, i.e. for reclassification, foreign exchange revaluations and other revaluations.[7]

As can be seen in Figure 1, the use of irrevocably fixed exchange rates results in somewhat lower annual growth rates of nominal M3 than the use of the fixed 2001 GDP weights, in particular in the first half of the 80s.

The quarterly data on euro area nominal and real GDP are based on seasonally adjusted national accounts data (ESA 95) up to 1998:Q4 and on Eurostat series from 1999:Q1 onwards. For both aggregation methods the GDP deflator for the euro area is derived as the ratio of euro area nominal GDP to euro area real GDP. This implies that the national data for the GDP deflator are not taken into account. The annual growth rates of euro area real GDP seem to hardly depend on the aggregation method used (see Figure 2).

The same is, however, not true for nominal GDP. The use of the irrevocably fixed exchange rates results in somewhat lower annual growth rates for both nominal GDP and the GDP deflator than the use of the fixed 2001 GDP weights. In general, the annual inflation rate – defined as the annual percentage change in the GDP deflator – declined during most of the sample period. It is therefore not surprising that conventional unit root tests do not reject the hypothesis of a unit root in the inflation series for the sample 1981-2001. Since the second half of the 90s the annual inflation rate seems to fluctuate around 2 percent, which could be seen as an indication that the inflation series has "become stationary". The sub-sample period is, however, too short for any formal tests to provide any meaningful evidence on this.[8]

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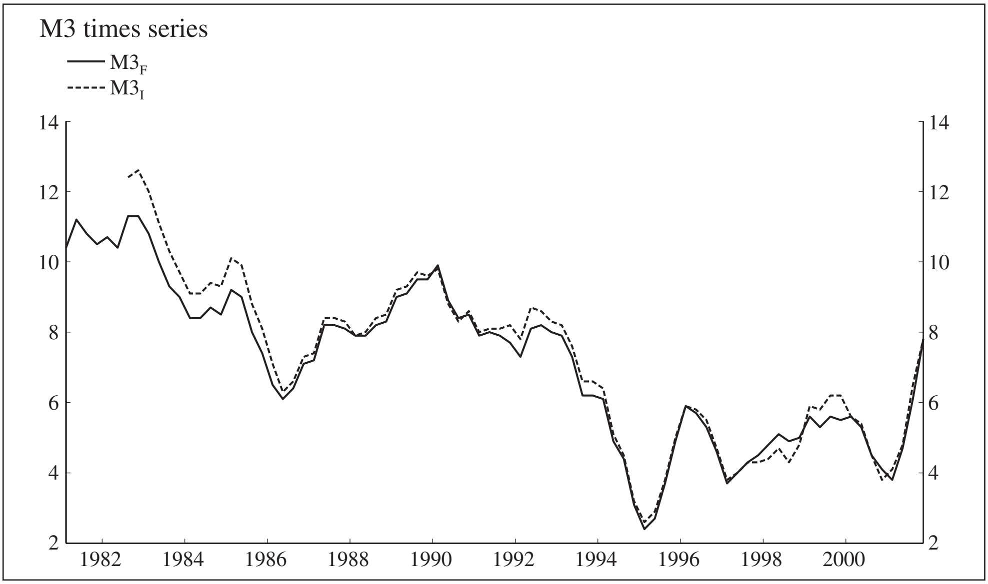
[6] See, e.g., Beyer et al. (2001), who suggest using weighted national growth rates, for yet another alternative aggregation method.

[7] For a detailed discussion of the statistical procedure and the conceptual background to these adjustments, see the box on "The derivation and use of flow data in monetary statistics" in ECB (2001).

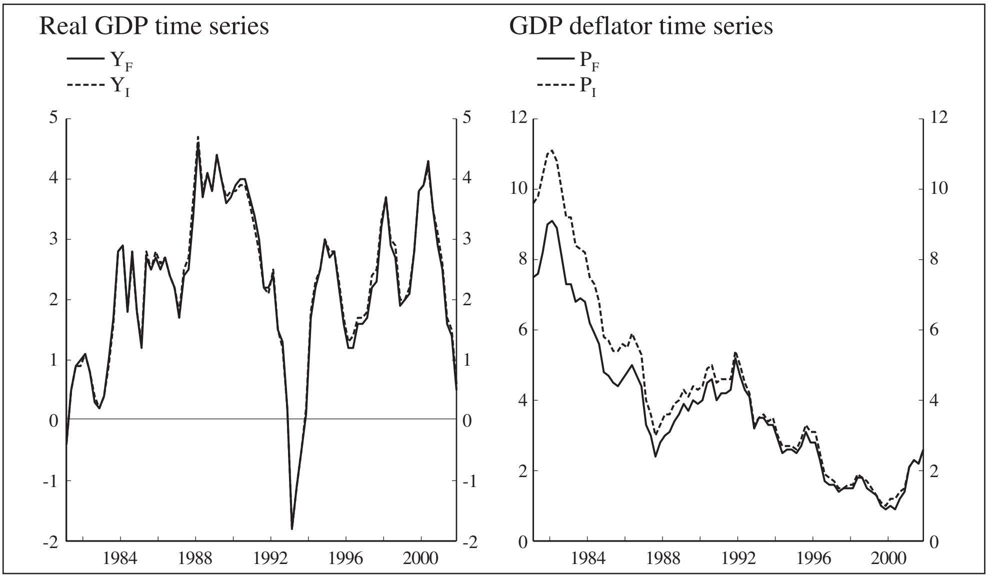
[8] The same argument could, of course, be made for the whole sample 1981-2001.

Figure 1: Euro area nominal M3
(in annual percentage changes)



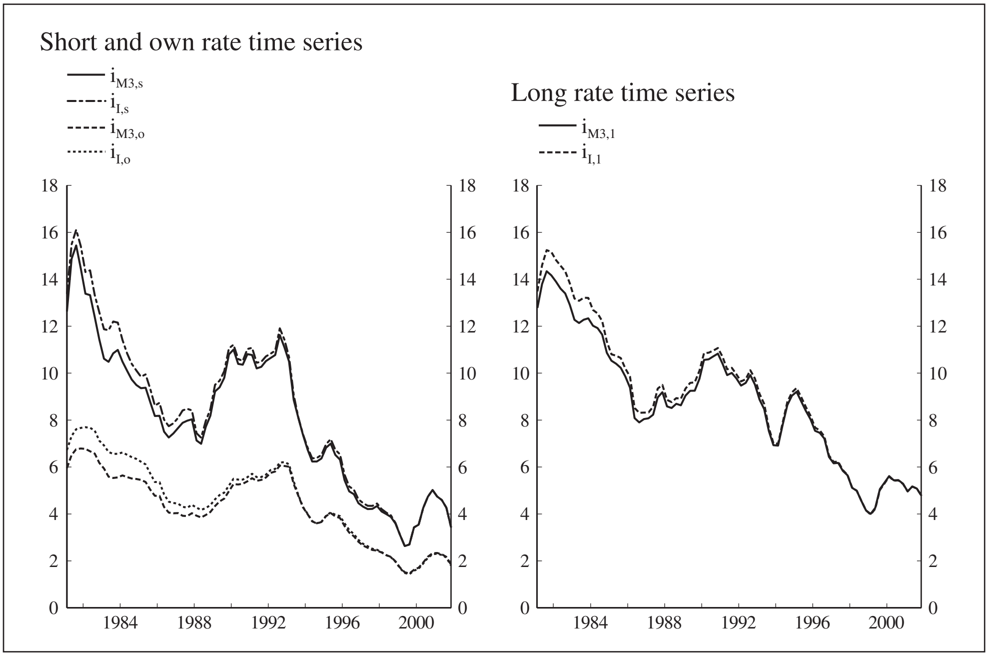
Notes: $M3_F$ denotes official euro area M3 aggregated according to the method of irrevocably fixed exchange rates, while $M3_I$ denotes euro area M3 aggregated according to the index method.

Figure 2: Euro area real GDP and the GDP deflator
(in annual percentage changes)



Notes: Y_F denotes euro area real GDP aggregated according to the method of irrevocably fixed exchange rates, while Y_I denotes euro area real GDP aggregated according to the index method. P_F denotes the euro area GDP deflator derived according to the method of irrevocably fixed exchange rates, while P_I denotes the euro area GDP deflator derived according to the index method.

Figure 3: Euro area short and long-term interest rates
(in percentages per annum)



Notes: $i_{M3,s}$ denotes the euro area three-month (short-term) market interest rate using time varying M3 weights, $i_{I,s}$ denotes the euro area three-month market interest rate using constant 2001 GDP weights. Similarly, $i_{z,o}$ for z = M3, I are the (average) own rates of return on M3. $i_{M3,l}$ denotes the euro area ten-year (long-term) government bond yield using time varying M3 weights, $i_{I,l}$ denotes the euro area ten-year government bond yield using constant 2001 GDP weights.

A similar pattern can be found in all nominal variables, i.e. the annual growth rate of nominal M3 (see Figure 1) and the various interest rates (see Figure 3).

2.1.2 Interest rates

Euro area interest rates are constructed as weighted averages of the national interest rate series.[9] Two alternative weighting schemes are also considered for interest rate variables in this paper. The main consideration in this respect is to use an aggregation method that is as consistent as possible with the method used for the scale variables.

A first (time-varying) weighting scheme uses the shares of the national contributions to euro area M3:

$$i_{M3,t} = \sum_c \frac{M_{c,t}}{M_{F,t}} i_{c,t}$$

[9] There is only one exception: since January 1999 the three-month EURIBOR rate is taken as the (average) euro area three-month market interest rate.

where $M_{c,t}$ is country c's national contribution to euro area M3 (converted into euro via the irrevocably fixed exchange rates), and $M_{F,t}$ is the measure of euro area M3.

A second (constant) weighting scheme relies on the shares of the countries' GDP in euro area GDP in 2001:

$$i_{I,t} = \sum_{c} w_{I,c} i_{c,t}$$

The quarterly data on interest rates are averages of monthly data. The use of the shares of the national contributions to M3 as a weighting scheme results (especially in the 80s) in somewhat lower nominal interest rates than the use of the constant 2001 GDP weights (see Figure 3). However, the general pattern of a downward trend in the 80s and the first half of the 90s, followed by a more stable development, remains.

2.2 The appropriate definition of the opportunity costs of holding money

The opportunity costs of holding money can be defined as the rate of return that economic agents forego by holding money instead of some other (financial or real) assets. From a conceptual point of view the opportunity costs should thus be calculated as the difference between the rate of return on the alternative assets and the own rate of return on M3.

For a very narrow monetary aggregate – like the monetary base or Ml – the choice of both rates of return is quite straightforward. The own rate of return on the monetary aggregate can be taken to be zero or at least fairly constant at a low level. The alternative rate of return is then usually approximated by a short-term market interest rate. This would then result in a long-run money demand equation of the form:

$$m1 = \beta_0 + \beta_y y - \beta_i i_s$$

where $m1$ denotes the log of real Ml, y the log of real GDP, and i_s the short-term market interest rate as a proxy for the opportunity costs of holding money.

However, when considering a broad monetary aggregate, like M3, the appropriate definition of the opportunity costs of holding money is less obvious. The own rate of return on M3 may no longer be well approximated by a constant, because a major part of M3 is remunerated at rates that are to a certain extent determined by the market interest rates. Ideally, one would therefore use an own rate of return on M3 that is a weighted average of the rates of return on the individual components of M3. Although there are some problems related to the unavailability of high quality data for some of these national interest rate series, a number of studies have attempted to construct such an average own rate of return on M3. For example, Cassard et al. (1994) used a "GDP-weighted average of the French and German own rate". Dedola et al. (2001) first calculated national own rates of return on M3 for all euro area countries and then computed a weighted average own rate of return on euro area M3, using the shares of the national contributions to M3 as weights. Due to data limitations, however, no distinction could be made between the different categories of deposits for some countries. Calza et al. (2001) constructed an own rate series for euro area M3 based on euro area interest rate series for all components of M3 from January 1990 onwards and extended this series backwards on the basis of national interest rate data for the five largest euro area countries. Most other studies either use the three-month market interest rate as the own rate of M3 or assume that the own rate is constant over time, implying that it should not be considered as a separate variable in the system. In this paper two new time series of the own rate of return on M3 are used. Unlike the series used in Calza et al. (2001) or Dedola et al. (2001), these new series are constructed on the basis of national interest rate series for *all* components of M3 and for *all* euro area countries from January 1980 onwards.[10] Only in this way can the robustness of the results of the money demand models with respect to the different aggregation methodologies be tested properly.

For the alternative rate of return, ideally one would like to include a whole range of longer-term financial assets (like bonds or equities) and real assets (possibly approximated by the inflation rate). However, the inclusion of too many interest rate variables in the system may complicate the analysis of how these various interest rates are related among one another and with money and income. It is therefore not surprising that the issue of the appropriate definition of the alternative rates of return has not been settled in the empirical literature on money demand.

The variables that are used most often are the short-term market interest rate, the long-term bond yield, and the inflation rate. The selection of the appropriate alternative rate of return is strongly related to the choice made for the own rate of return on M3. For example, Coenen and Vega (2001) assume that the own rate can be approximated by the short-term market interest rate and include the spread between the long-term and the short-term rates as the opportunity cost of holding money. Brand and Cassola (2000), however, state that:

> … the dynamics of the spread of the long-term interest rate against the own rate of M3 is almost fully captured by the dynamics of the long-term interest rate. This suggests that the long-term interest rate may be a better measure of opportunity costs than the market spread (long-term minus short-term market interest rates).

Their main argument for not including a variable capturing the average own rate of return on euro area M3 is that this reduces the complexity of the model. Calza et al. (2001), who did use an average own rate of return on M3, included both the spread between the long-term market interest rate and their own rate measure, and the spread between the short-term market interest rate and the own rate as possible opportunity cost variables. To reduce the complexity of the model, they opted for directly including the spreads instead of all three variables separately. From their empirical analysis they concluded, however, that the preferred money demand model only includes the spread between the short-term market interest rate and the own rate as the measure of the opportunity costs. Finally, Cassola and Morana (2002) find a stable money demand model that does not have an opportunity cost variable in the long-run money demand relation.

In this study we have opted for the inclusion of the average own rate of return on M3 as a separate variable in the system. In addition, we included the short-term market interest rate, the long-term bond yield, and the inflation rate as possible alternative rates

[10] For details on the construction of the own rate series, see Appendix A.

of return.[11] This also has the advantage of making several of the previous euro area M3 demand systems special cases of our system. However, we shall not perform any formal tests of encompassing in this paper since the data are not identical.[12]

3. The benchmark money demand system

In this section we shall present and discuss the statistical properties of our benchmark money demand system for the euro area. We focus on the determination of lag order, cointegration rank, and the estimation of cointegration relations in a vector error correction model. Based on this empirical model we shall then turn to the crucial issue of whether or not the parameters of the model are constant over time in Section 4. Alternative specifications and their implications on the parameter constancy issue are considered in Sections 5 and 6.[13]

The benchmark money demand model consists of the six variables: real M3, m_t, inflation measured by annualized quarterly changes of the GDP deflator, Δp_t, real GDP, y_t, the short-term market interest rate, $i_{s,t}$, the long-term market interest rate, $i_{l,t}$, and the own rate of return on M3, $i_{o,t}$. The interest rates are all measured in annual percentage rates (divided by 100) while the remaining variables are measured in natural logarithms of the seasonally adjusted data. The money stock, GDP, and the GDP deflator have been aggregated using the irrevocably fixed exchange rates, while M3 weights have been used for the aggregation of the interest rates.

Following the notation in Johansen (1996) we can express the vector error correction model as:

$$\Delta X_t = \Phi D_t + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \alpha\beta' X_{t-1} + \varepsilon_t \qquad t = 1,\ldots,T \tag{1}$$

where $X_t = (m_t, \Delta p_t, y_t, i_{s,t}, i_{l,t}, i_{o,t})$ and D_t is a deterministic vector. The cointegration rank, r, is given by the rank of $\alpha\beta'$. In addition, all roots to the system are either unity or greater than one and the number of unit roots is equal to $6 - r$, i.e. we restrict the system to be at most integrated of order 1. Finally, the residuals $\varepsilon_t \sim N(0, \Omega)$ and the initial values $(X_0, \ldots, X_{1-k})$ are assumed to be fixed. In all the systems studied in this paper we let $D_t = 1$.

As a complement to presenting inferences based on asymptotics we shall also conduct simple bootstrap simulations for all tests concerning rank determination, restrictions on

[11] The inclusion of the inflation rate in the system can be motivated on several grounds. First, it can be seen as the alternative rate of return on investment in real assets. Second, it allows us to test for the relevance of real interest rates in the system. Third, it allows for some degree of short-run price non-homogeneity in the money demand model. For a more detailed discussion on this issue, see, e.g., Coenen and Vega (2001).

[12] Several studies use, e.g., irrevocably fixed exchange rates aggregation for the scale variables and GDP weights for the interest rates, while we use M3 weights for the interest rates under that aggregation method for the scale variables.

[13] All computations, including simulations of the limiting distributions of the Nyblom tests (using a step length of 500 and 100,000 replications) as well as bootstraps, have been carried out in Structural VAR, version 0.19, which can be downloaded from http: //www.econometrics.texlips.org/. When possible cross-checking has been performed with CATS in RATS, Eviews, and PcFiml.

the cointegration space, as well as parameter constancy. The bootstrap procedure we employ belongs to a family of bootstraps known as parametric bootstrapping (see, e.g., Berkowitz and Kilian, 2000, and Horowitz, 2001). Specifically, we generate pseudo-samples $\Delta\tilde{X}_t(b)$, $b \in \{1,\ldots,B\}$, of the same length as the original data (T) by drawing standard normal errors, converting them to $\tilde{\varepsilon}_t(b)$ through $\hat{\Omega}^{1/2}$, the Choleski decomposition of the ML estimate of Ω under the null hypothesis, and using equation (1) with the original initial values, deterministic variables, and parameters evaluated at their estimated values under the null hypothesis. For simplicity we limit the number of pseudo-samples to 1000.[14]

As noted by, e.g., Horowitz (2001), at present there are no theoretical results on the ability of the bootstrap to provide asymptotic refinements for tests or confidence intervals when the data are integrated or cointegrated. The consistency of the bootstrap estimator of the distribution of the slope coefficient or Studentized slope coefficient in a simple AR(1) model has been studied by, e.g., Basawa, Mallik, McCormick, and Taylor (1991), while some more recent developments for a few specific cases are presented by Chang, Sickles, and Song (2001), Davidson (2001), Paparoditis and Politis (2001), and Inoue and Kilian (2002). The results of Monte Carlo experiments (see Li and Maddala, 1996,1997, and Gredenhoff and Jacobson, 2001) suggest that the differences between the true and the nominal rejection probabilities of tests of hypotheses about integrated and cointegrated data are smaller with bootstrap based than with asymptotic critical values.

3.1 Lag order and cointegration rank

Since the full sample only covers 87 observations and inference on lag order determination is based on classical asymptotic theory, one criterion we use is parsimony. In Table 1 we report a number of specification tests, covering serial correlation and the normality of the residuals, for models based on 2 lags ($k = 2$).

In Panel A we consider a model without imposing any unit root restrictions. When we test the null of $k = 2$ lags against 3 and 4 lags we find that the null cannot be rejected at conventional levels of marginal significance; in the case of a model of 1 lag against 2 lags, we find that the 1 lag model is strongly rejected. Furthermore, multivariate tests of serially uncorrelated residuals for the $k = 2$ model indicate that the null cannot be rejected against the alternative hypothesis of first order correlation and correlation at the 4th lag, respectively. Hence, 2 lags seem to be sufficient for describing the dynamics of the system.

Turning to the issue of normality we consider the multivariate Omnibus statistic, suggested by Doornik and Hansen (1994), which looks at the 3rd and 4th moments of normalized residuals. For the null hypothesis that these two moments are equal to those for a multivariate normal distribution we find that the p-value is roughly 5 percent when compared to its approximate asymptotic $\chi^2(12)$ distribution. Hence, whether or not normality of the residuals is supported by the data is for the unrestricted vector error correction model an open issue.

[14] Procedures for choosing the number of bootstrap replications are discussed by, e.g., Andrews and Buchinsky (2000) and Davidson and MacKinnon (2000a).

Table 1: Specification tests and asymptotic p-values for models with two lags

LM (36)	p-value	LM (72)	p-value	W (36)	p-value	LR (36)	p-value	LR (36)	p-value	E_6 (12)	p-value
2 vs. 3 lags		2 vs. 4 lags		1 vs. 2 lags		lag 1		lag 4			
(A) *Cointegration rank = 6*											
34.92	0.52	85.11	0.14	174.31	0.00	8.85	1.00	42.38	0.21	20.93	0.05
(B) *Cointegration rank = 2, unrestricted model* M_0											
33.47	0.59	72.07	0.48	254.84	0.00	8.48	1.00	50.82	0.05	14.92	0.25
(C) *Cointegration rank = 2, restricted model* M_6											
35.90	0.47	77.98	0.29	259.89	0.00	8.67	1.00	49.03	0.07	14.34	0.28
(D) *Cointegration rank = 2, restricted model* M_9											
35.89	0.47	77.57	0.31	249.00	0.00	8.03	1.00	48.65	0.08	15.07	0.24
(E) *Cointegration rank = 2, restricted model* M_{11}											
36.17	0.46	77.09	0.32	255.70	0.00	8.88	1.00	49.03	0.07	14.00	0.30
(F) *Cointegration rank = 2, restricted model* M_{12}											
35.77	0.48	78.36	0.28	259.46	0.00	8.20	1.00	48.94	0.07	14.86	0.25

Notes: $W(q)$, $LR(q)$ and $LM(q)$ are the Wald, the Likelihood Ratio, and the Lagrange Multiplier tests with q degrees of freedom. The 1st to the 3rd column give lag order tests for k against $k + h$ lags in the error correction model. The 4th and the 5th columns present test statistics and p-values for the null hypothesis of serially uncorrelated residuals against the alternatives of serial correlation at lag 1 and lag 4, respectively. $E_6(12)$ is the Omnibus test for normality, suggested by Doornik and Hansen (1994), which is approximately asymptotically χ^2 with 12 degrees of freedom.

We have also examined a number of additional specification tests. In particular, tests for ARCH of order 1 and of order 4 for each residual. With the exception of the residuals from the output equation, we do not find any strong signs of conditional heteroskedasticity. However, adding more lags to the model does not alleviate this potential source of misspecification. In what follows we will therefore consider the model with two lags.

The tests for the cointegration rank are given in Table 2. When the conventional trace tests, LR_{tr}, are compared with the relevant limiting distribution we find that the data suggest using 4 cointegration relations at the 10 percent level, 3 at the 5 percent level, and 2 at the 1 percent level.[15] However, several studies have concluded that the trace test tends to be over-sized in small samples (see, e.g., Jacobson, Jansson, Vredin, and Warne, 2001 and Toda, 1995). For that reason we report Bartlett corrected (mean corrected) trace tests, $LR^{\mathrm{c}}_{\mathrm{tr}}$, using the correction formulas presented in Johansen (2002b, Theorem 1).[16]

15 The p-values have been computed using the simulated distributions in MacKinnon, Haug, and Michelis (1999).

16 In particular, we have employed the approximations given in Corollary 2 of this article.

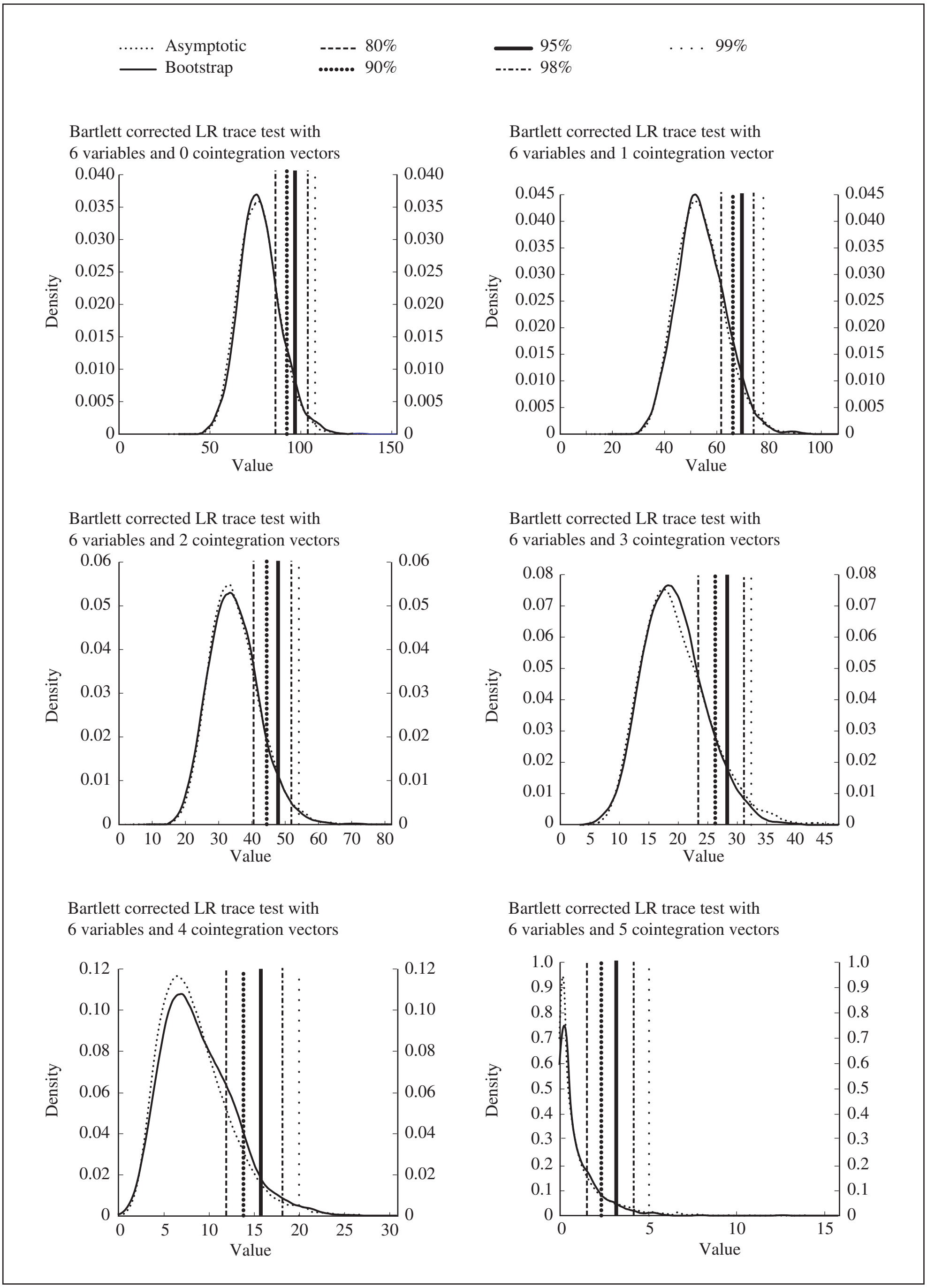
Table 2: Cointegration rank tests with asymptotic and bootstrapped p-values for models with 2 lags over the sample 1980:Q4-2001:Q4

Rank	Eigen-value	LR_{tr}	asymp. p-value	boot p-value	BF	LR^{c}_{tr}	asymp. p-value	boot p-value
0	0.47	140.46	0.00	0.00	1.176	119.48	0.00	0.00
1	0.34	86.92	0.00	0.02	1.178	73.81	0.02	0.02
2	0.24	50.85	0.03	0.11	1.183	42.98	0.13	0.12
3	0.23	27.00	0.10	0.26	1.225	22.03	0.30	0.28
4	0.04	4.33	0.88	0.94	1.147	3.77	0.92	0.94
5	0.00	0.35	0.56	0.60	1.508	0.23	0.63	0.62

As can be seen in Table 2 the correction factors differ somewhat for the possible choices of rank and the smallest correction factor is roughly 15 percent greater than unity. Hence, the direction of the correction and the magnitudes are consistent with our prior expectations. Applying these factors to the trace statistics and comparing the corrected statistics with the same asymptotic distributions as the uncorrected tests we find that the data suggest using 2 cointegration relations at the 10 percent (to the 2.5 percent) level of marginal significance and 1 relation at the 1 percent level. Moreover, the specification tests in Panel B of Table 1 indicate that the rank restrictions do not alter the whiteness properties of the residuals.

Turning to the bootstrapped p-values for the tests we find that the uncorrected and Bartlett corrected tests agree with essentially equal p-values. Moreover, the empirical p-values are almost equal to the p-values from the Bartlett corrected tests when the asymptotic distribution is used for inference. As an illustration we have plotted the empirical null distributions for the Bartlett corrected trace tests against the asymptotic distributions in Figure 4. It is quite surprising how well these distributions match for the current data. Based on all these results we conclude that a cointegration rank of 2 appears, at this stage, to be an appropriate choice.

Figure 4: Asymptotic and bootstrapped density functions for the Bartlett corrected trace tests along with 80, 90, 95, 98, and 99 percent quantiles from the empirical bootstrap distributions



3.2 The cointegration space

The next step in the analysis is to examine the cointegration space. In Table 3 we report *LR* tests of a few interesting hypotheses. The first three examine the null that various interest rate spreads are stationary. When comparing the test values to the asymptotic $\chi^2(4)$ distribution we find that they are all rejected at conventional levels of marginal significance. Moreover, when we test the hypotheses that the real long-term rate and inflation are stationary the conclusions are the same.

As in the trace test case, several studies have reported that the *LR* test of linear restrictions on the cointegration space is over-sized (see, e.g., Jacobson, Vredin, and Warne, 1997, and Gredenhoff and Jacobson, 2001). In fact, the deviation of, e.g., a bootstrapped empirical distribution from the χ^2 is often so large that the asymptotic distribution seems close to being a useless reference distribution for an uncorrected *LR* statistic. For the top five hypotheses in Table 3 we could apply the Bartlett correction factor derived in Johansen (2000, Corollary 5), while the Bartlett factor has not been derived for the hypotheses underlying the remaining seven models in the Table.[17] Alternatively, we can use bootstrapping.

Table 3: Tests of various hypotheses about the cointegration space for models with 2 lags and 2 cointegration relations

Model	$\beta_i' X_t$ is I(0)	β_{13}	β_{14}	β_{16}	*LR*	df	asymp. *p*-value	boot *BF*	boot *p*-value
M_1	$i_{s,t} - i_{l,t}$				16.33	4	0.00	2.35	0.12
M_2	$i_{l,t} - i_{o,t}$				26.11	4	0.00	3.50	0.05
M_3	$i_{s,t} - i_{o,t}$				21.60	4	0.00	3.12	0.11
M_4	$i_{l,t} - \Delta p_t$				21.81	4	0.00	2.80	0.06
M_5	Δp_t				23.79	4	0.00	3.25	0.08
M_6	$m_t + \beta_{13} y_t + \beta_{14} i_{s,t} + \beta_{16} i_{o,t}$	–1.38	0.81	–1.31	2.12	2	0.35	1.70	0.56
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								
M_7	$m_t + \beta_{13} y_t + \beta_{14} i_{s,t}$	–1.38	0.11	0	3.46	3	0.33	1.78	0.58
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								
M_8	$m_t + \beta_{13} y_t + \beta_{16} i_{o,t}$	–1.39	0	0.07	3.71	3	0.29	1.75	0.56
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								
M_9	$m_t + \beta_{13} y_t$	–1.40	0	0	3.75	4	0.44	1.73	0.70
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								
M_{10}	$m_t + \beta_{13} y_t + \beta_{14}(i_{s,t} - i_{o,t})$	–1.37	0.36	–0.36	2.96	3	0.40	2.74	0.66
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								
M_{11}	$m_t + \beta_{13} y_t + 0.8 i_{s,t} - 1.3 i_{o,t}$	–1.38	0.8	–1.3	2.12	4	0.71	1.71	0.87
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								
M_{12}	$m_t + \beta_{13} y_t + 0.4(i_{s,t} - i_{o,t})$	–1.37	0.4	–0.4	2.97	4	0.56	1.75	0.80
	$i_{s,t} + \beta_{22} \Delta p_t + \beta_{25} i_{l,t} + \beta_{26} i_{o,t}$								

[17] The analyses in Johansen (2002a and 2000) do not consider the types of linear restrictions on β that these hypotheses imply.

In Table 3 we report p-values of all tests from bootstrapped empirical distributions in the last (10th) column and bootstrap estimates of the Bartlett correction factors in the 9th column. The bootstrapped Bartlett factors are given by the average of the LR-tests from the bootstrap divided by the mean of the $\chi^2(q)$ distribution. The latter is equal to q, the number of restrictions. In addition, we provide plots of the densities of the asymptotic, the empirical bootstrap, and a Bartlett corrected empirical bootstrap for all 12 models in Figure 5. As can be seen from these plots Bartlett correction can potentially work well if the correction factors are not too big, i.e., for models M_6 to M_9, M_{11}, and M_{12}.

For the empirical p-values we find that models M_1 to M_5 all lie somewhere between 5 and 10 percent, suggesting that at least one of these models may be consistent with the data. At the same time the bootstrapped Bartlett factors are quite big, ranging from 2.35 to 3.50, indicating that Bartlett correction based on Johansen (2000) may not work well here. In view of the results in Omtzigt and Fachin (2002) it may also be the case that the bootstrap is over-sized. If so, then the p-values are too small also for the bootstrap. Henceforth, we let all the models M_1 to M_5 in Table 3 be special cases of the space spanned by one of the cointegration vectors.

In the 6th row of Table 3, model M_6, we report the results from testing the null that a linear combination of (i) real money, output, the short and the own rate, and (ii) the three interest rates and inflation are jointly stationary. With a test value of 2.12 we find that this null cannot be rejected at standard significance levels. Bartlett correction will not change this conclusion since, given an estimate of 1.70, we expect the correction factor to be greater than unity. The estimated parameters of these 2 relations and their *conditional* standard errors are given below.

$$\hat{\beta}' X_t = \begin{bmatrix} 1 & 0 & \underset{(0.02)}{-1.38} & \underset{(0.031)}{0.81} & 0 & \underset{(0.62)}{-1.31} \\ 0 & \underset{(0.06)}{-0.63} & 0 & 1 & \underset{(0.07)}{0.41} & \underset{(0.11)}{-1.96} \end{bmatrix} \begin{bmatrix} m_t \\ \Delta p_t \\ y_t \\ i_{s,t} \\ i_{l,t} \\ i_{o,t} \end{bmatrix} \tag{2}$$

The behavior of the system under these restrictions is summarized in Panel C of Table 1. Again we find that the restrictions do not appear to change the properties of the money demand system radically.

Examining the first cointegration relation, which resembles a long-run money demand relation, we find that the estimated coefficient on output is greater than unity and is of the same magnitude as earlier studies on euro area money demand have found (see, e.g., Brand and Cassola, 2000, Golinelli and Pastorello, 2002, and Calza et al., 2001).[18]

[18] See also Brand, Gerdesmeier, and Roffia (2002) for a review of the existing money demand models published by the ECB.

Figure 5: Asymptotic and bootstrapped density functions for the *LR* tests of restrictions on β in models M_1–M_{12} with estimated Bartlett corrected empirical distributions along with 80, 90, 95, 98, and 99 percent quantiles from the empirical bootstrap distributions

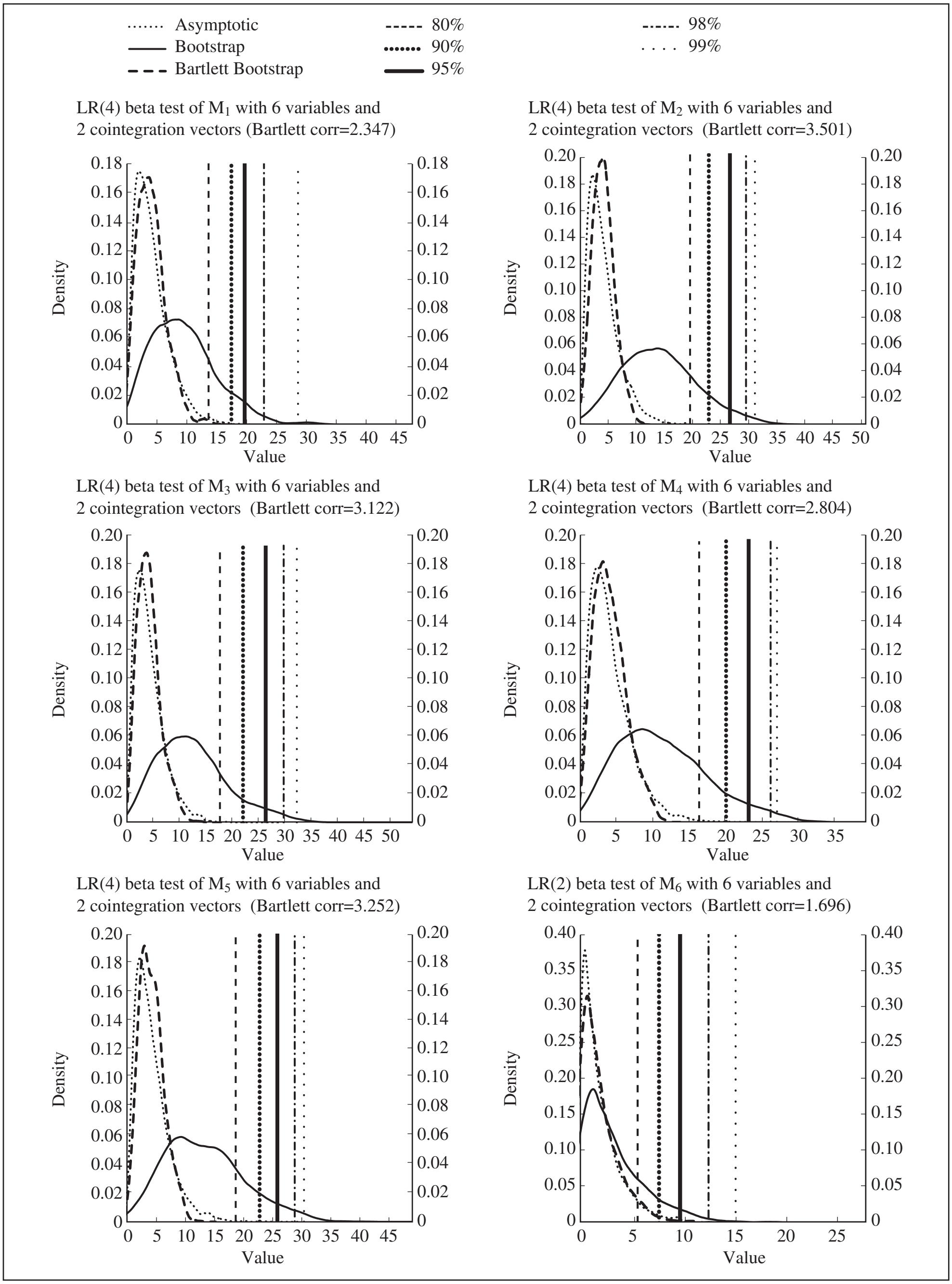
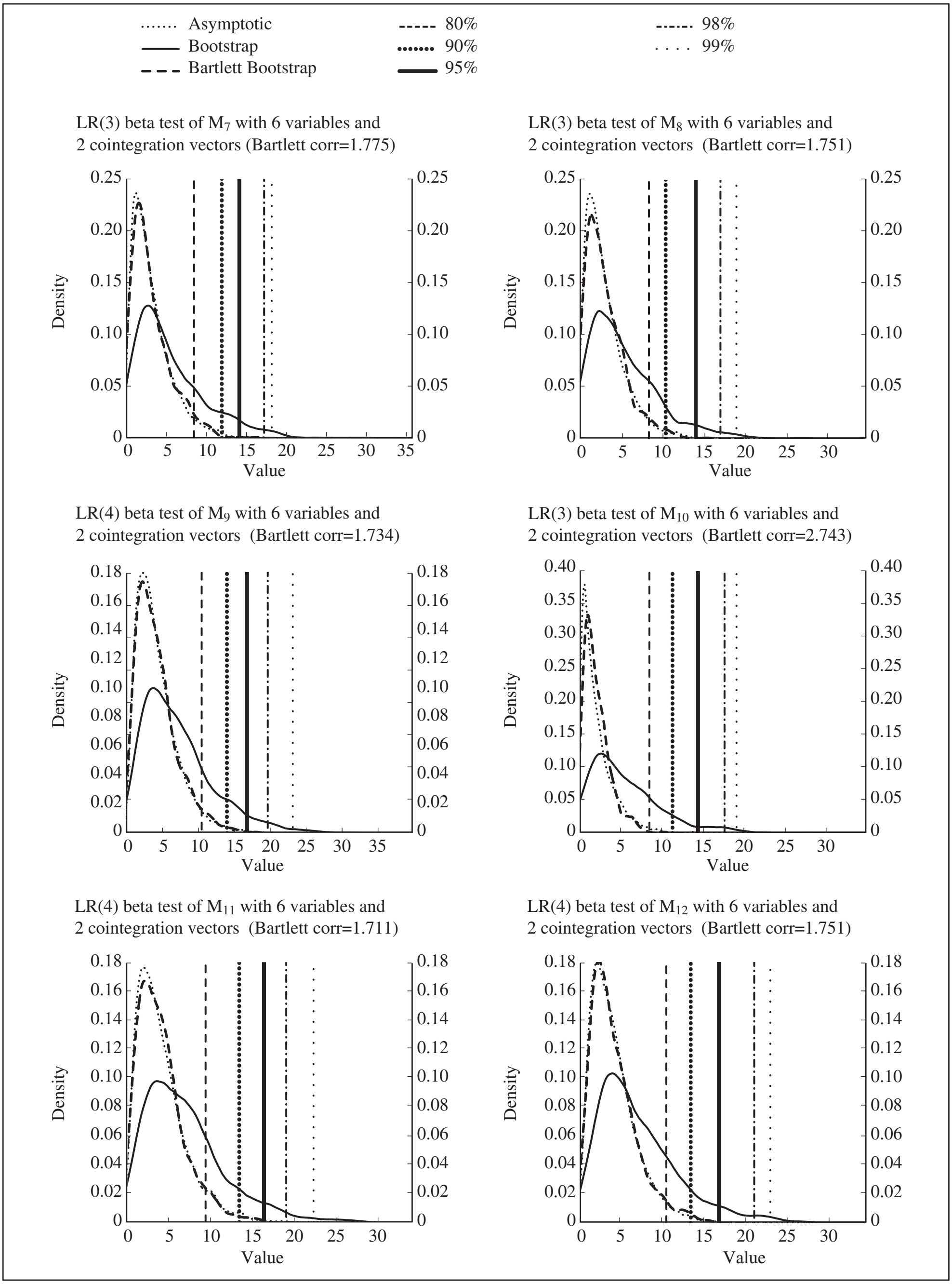


Figure 5 (cont.): Asymptotic and bootstrapped density functions for the *LR* tests of restrictions on β in models M_1–M_{12} with estimated Bartlett corrected empirical distributions along with 80, 90, 95, 98, and 99 percent quantiles from the empirical bootstrap distributions



Furthermore, the coefficients on the short rate and on the own rate have the correct signs when the former is interpreted as the alternative rate of return on holding money. If we were to compute a *t*-test for the null hypothesis that the coefficient on the short rate and the own rate, respectively, is zero, then both hypotheses would be soundly rejected at the 5 percent level when the Gaussian (or *t*) distribution is used as a reference distribution.

However, it is hazardous to make use of these conditional, or local, standard errors in this way. Instead, we can impose one additional restriction on the first cointegration relation and then reestimate the vector error correction model. In row 7 (model M_7) and 8 (model M_8) of Table 3, respectively, we give the test results from the joint hypotheses of the 2 (over-identifying) restrictions in model M_6 and the additional restriction that the coefficient on the own and on the short rate, respectively, is zero. The difference between the *LR* test in row 7 (8) and row 6, gives the appropriate *LR* test value of the hypothesis that β_{16} (β_{14}) is zero. Since the joint hypotheses both result in small numerical values for the *LR* test, we conclude that both these coefficients may be zero. In addition, in row 9 (model M_9) we report the *LR* test value of the hypothesis that all these 4 (over-identifying) restrictions on β are satisfied and again the null is not rejected. While this serves to illustrate the limited usefulness of the conditional standard errors for the identified β parameters, it also suggests that the semi-elasticities on the interest rates in the money demand relation are imprecisely estimated using classical ML. Moreover, the estimated coefficient on output changes only marginally when these additional restrictions are imposed on the first cointegration relation. Also, when we compare the estimated parameters of the second cointegration relation between models M_6 to M_{12}, the point estimates change very little (see Section 4 for discussions on M_9, M_{11}, and M_{12}).

As a final check on the first cointegration relation we have also tested the hypothesis that the spread between the short and the own rate enters this relation, i.e. model M_{10}. Again, neither the joint nor the conditional null hypothesis is rejected at conventional levels of marginal significance.

In Figure 6 we have graphed the values of the log-likelihood function when the income and interest rate parameters in long-run money demand take on certain values. All other parameters are reestimated in these experiments. The horizontal line shows the value of the log-likelihood function (at the 95 percent quantile of the $\chi^2(1)$ distribution) where the *LR* test signals rejection of the null that the parameter is equal to that value when compared to the case when it is estimated freely, i.e., the maximum point for the likelihood function. From Figure 6 it can thus be seen that based on this measure the income elasticity is well determined; the 95 percent “confidence interval” is between 1.30 and 1.45. The interest rate semi-elasticities, on the other hand, have very wide confidence bands, where the own rate semi-elasticity is between 3.7 and –1.2 with 95 percent confidence and the short rate semi-elasticity is between 0.7 and –2.2.

Figure 6: Log-likelihood values for β_{1j} (j = 3, 4, 6) in the 2 lag model M_6 with 2 cointegration relations

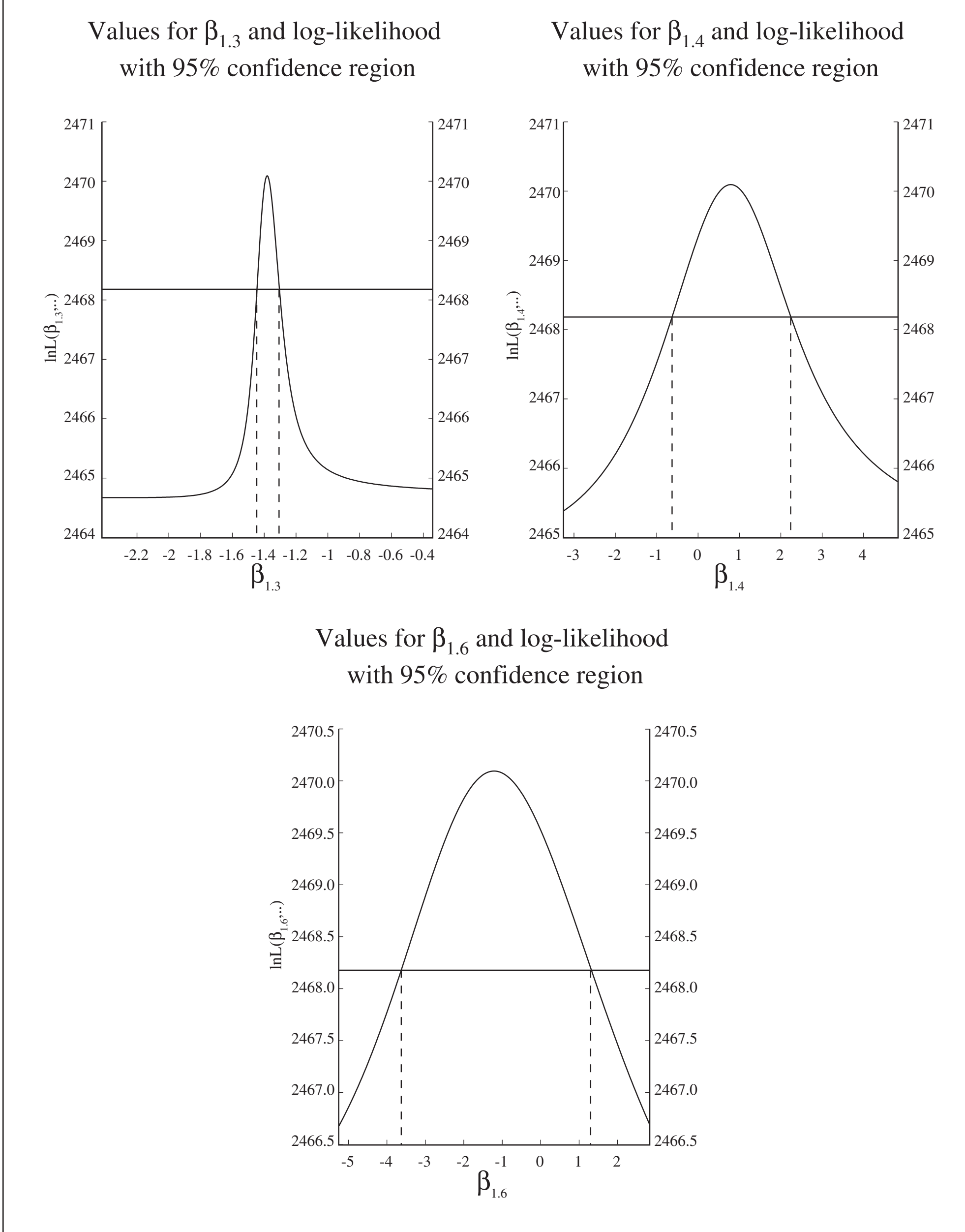
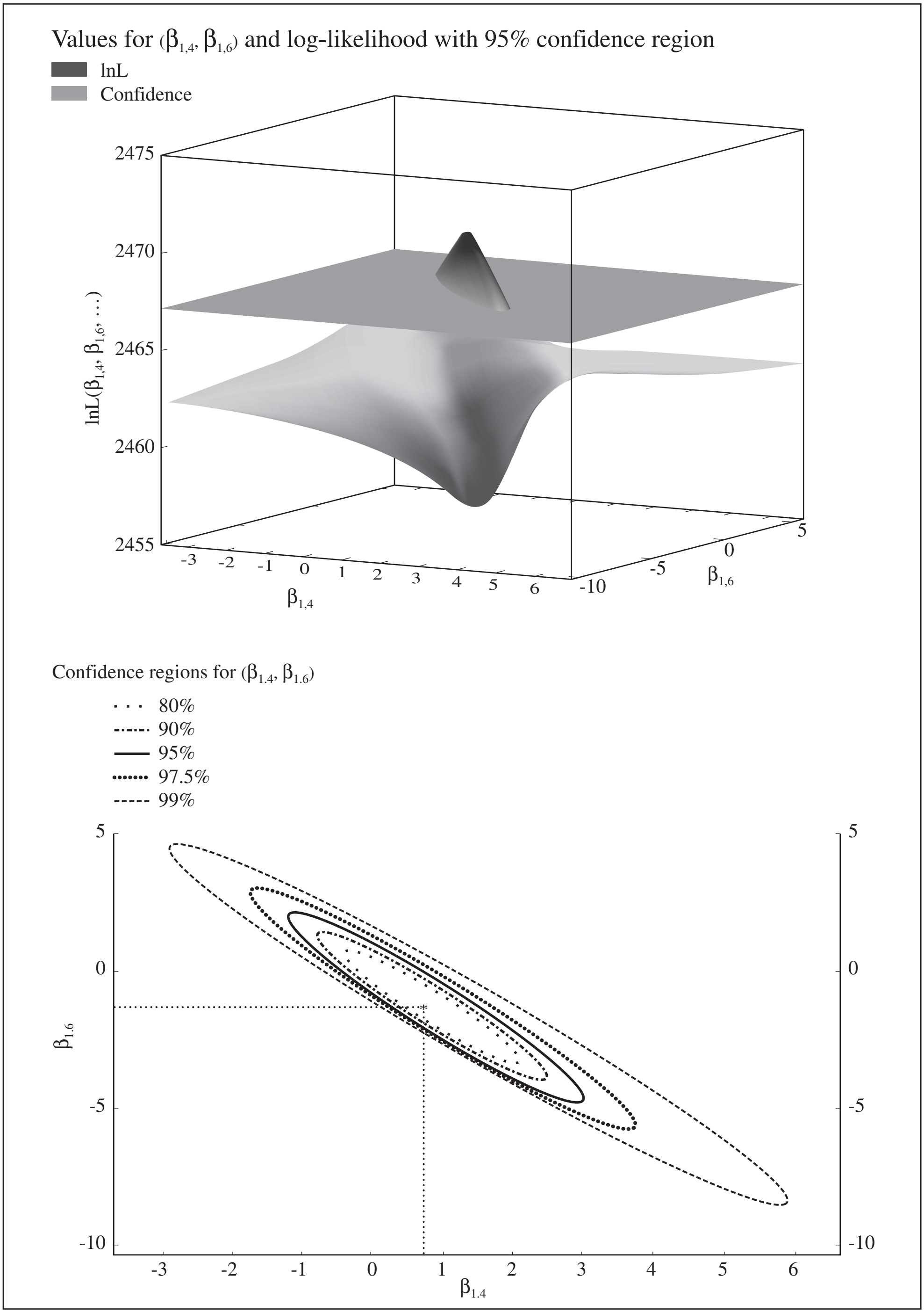


Figure 7: Log-likelihood surface for β_{14} and β_{16} in the 2 lag model M_6 with 2 cointegration relations and asymptotic confidence regions



To illustrate this issue further, the upper plot in Figure 7 displays the values of the log-likelihood function for fixed values of the short rate and the own rate semi-elasticities. The plane reflects the value of the log-likelihood when a joint *LR* test of (β_{14}, β_{16}) is exactly equal to the 95 percent critical value of the $\chi^2(2)$ distribution. The region above this plane reflects all combinations of pairs of values that these parameters can take on that are not rejected at the 5 percent level of marginal significance. In the lower plot we present confidence regions at the 80, 90, 95, 97.5, and 99 percent levels. That is, we have sliced the log-likelihood function from the upper graph at these levels of marginal significance. As can be seen from the latter graph, these regions are huge, especially in the own rate parameter direction, even at the 80 percent level. At the same time, the parameters seem to be negatively correlated.

The second cointegration relation relates the own rate to the short and the long-term market interest rates, i.e. a long-run equilibrium relation for the interest rates. In addition, inflation enters the relation with a coefficient almost equal to the coefficient on the long rate, but with the opposite sign. Potentially, one may interpret this as a long-run pricing relation for the own rate.

In the next section we shall study the parameter constancy properties of model M_0, where the cointegration space is unrestricted given a rank of 2, and some of its "siblings". In particular, we shall examine the constancy of the cointegration space as well as most of the remaining parameters.

4. Constancy analysis

In contrast to most previous studies of euro area money demand we shall apply formal tests to investigate the parameter constancy issue; the main exception is Fagan and Henry (1998) who use some of the tests suggested by Hansen (1992).[19] Typically, recursive estimates over a limited time period and ocular inspection of recursive Chow forecast, break-point, or predictive failure tests have been used to examine this problem. While such diagnostics may be useful for preliminary analyses, any inferences drawn from these exercises neglect a large fraction of the sample period and do not take into account that, e.g., the Chow test is a formal test only for a single point in time.

Ideally, one would like to have estimates of all parameters in the statistical model for each period in time and compare these with, e.g., the full sample estimates using a simple statistic with good power properties against a wide range of non-constancies. Until such a statistic exists, we may still consider using formal tests for parameter constancy which do compare estimated parameters across time, are relatively easy to compute, and take as much of the sample as possible into account. Moreover, there are test statistics satisfying these criteria whose limiting distributions are known and free from nuisance parameters.

In this section we shall examine the parameter constancy of three sets of parameters in equation (1). First we shall study the non-zero eigenvalues used in the cointegration rank analysis. The main tool here is the fluctuation test suggested by Hansen and Johansen (1999). Second, we examine the constancy of β using the Nyblom (1989) tests studied by Hansen and Johansen (1999). We also propose versions of these tests which are likely

[19] Coenen and Vega (2001) also apply some of Hansen's (1992) tests for parameter constancy, but only for the money equation. The relationship between these tests and some of those applied in this paper is discussed in Hansen and Johansen (1999).

to be more reliable. Third, we take a look at the constancy of the Φ, Γ_1, and α parameters using the fluctuation test due to Ploberger, Krämer, and Kontrus (1989), and finally we compare some of these results to a sample that begins in 1983:Q1. It may be noted that all the formal tests do *not* require trimming of the sample. For computational reasons, however, we will use about 30 percent of the sample as a base period and examine constancy over the remainder.

4.1 Preliminary considerations

When studying subsets of parameters, one issue to consider for the parameter constancy analysis is how to treat the remaining parameters. One approach is to fix the latter parameters at the full sample estimates, and the alternative is to update them along with the parameters of interest. Below we shall focus on the former approach, but at times also discuss the results when the latter approach is taken. In principle, the second approach should be preferred since fixing parameters that do indeed vary over time can lead to the wrong conclusion about those that are updated. However, given the short sample and given that the tests are based on asymptotic theory, the more parameters we update the more likely it is that the asymptotic distributions provide poor approximations of the unknown small sample distributions. We therefore extend the analyses with bootstrapped empirical distributions of all constancy tests.

4.2 The non-zero eigenvalues

The evidence from applying the Hansen and Johansen fluctuation tests to our data, when we condition on the full sample estimates of the parameters on the constant and the first lag, are given in Panel A of Table 4.

Table 4: Fluctuation tests of the constancy of the non-zero eigenvalues for the unrestricted model M_0 with 2 lags and 2 cointegration relations over the period 1987:Q2-2001:Q4

(A) Conditional on $\hat{\Phi}^{(T)}$ and $\hat{\Gamma}_1^{(T)}$			
Eigenvalue	$\sup_{t\in\mathbb{T}} \tau_{t\|T}(\lambda_i)$	asymptotic *p*-value	bootstrap *p*-value
1	2.67	0.00	0.00
2	1.18	0.13	0.33
	$\sup_{t\in\mathbb{T}} \tau_{t\|T}(\Sigma_{i=1}^{2} \log(\lambda_i/1-\lambda_i))$	asymptotic *p*-value	bootstrap *p*-value
	2.83	0.00	0.01
(B) Updating of $\hat{\Phi}^{(t)}$ and $\hat{\Gamma}_1^{(t)}$			
Eigenvalue	$\sup_{t\in\mathbb{T}} \tau_{t\|T}(\lambda_i)$	asymptotic *p*-value	bootstrap *p*-value
1	2.73	0.00	0.02
2	2.46	0.00	0.06
	$\sup_{t\in\mathbb{T}} \tau_{t\|T}(\Sigma_{i=1}^{2} \log(\lambda_i/1-\lambda_i))$	asymptotic *p*-value	bootstrap *p*-value
	3.70	0.00	0.11

Notes: The experiment period is given by $\mathbb{T} \equiv \{1987{:}Q2,..., 2001{:}Q4\}$. The fluctuation test converges weakly to a Brownian bridge; see Ploberger et al. (1989) for details.

As can be seen from the Table at least one of the two non-zero eigenvalues, λ_1 and λ_2, appears to be non-constant over the examination period, 1987:Q2-2001:Q4. In particular, the largest eigenvalue may be time varying. It should be emphasized here that the small sample properties of the fluctuation test when applied to non-zero eigenvalues are uncharted territory. Given what we know about, e.g., the *LR* test for linear restrictions on β and the trace test one may suspect that the fluctuation test is over-sized as well. Indeed, the bootstrapped *p*-values in the 4th column are always higher than the asymptotic, but at the 5 percent level do not change the results that λ_1 seems to be non-constant over the experimentation period. Still, the bootstrap is only based on 1000 replications, we only consider residuals drawn from a normal distribution, and do not make use of double or fast double bootstrap (see, e.g., Davidson and MacKinnon, 2000b). Hence the empirical distribution may not be very accurate, especially in the tails, and our results should therefore be interpreted with great care.

If we instead also update the Φ and the Γ_1 parameters over the 1987:Q2-2001:Q4 period, then as can be seen from Panel B of Table 4, all null hypotheses are firmly rejected when the reference distribution is the asymptotic. The empirical bootstrap distribution, however, gives a different picture, suggesting that the observed test statistics may not be so unlikely, especially the sum of the transformed eigenvalues.

To summarize, there are some indications that the non-zero eigenvalues may not be constant over the experimentation period. If one of these parameters is indeed time-varying, it may be due to either time-varying α or β parameters. Alternatively, the tests may indicate time-variation of these parameters when the selected cointegration rank is incorrect.[20] The fluctuation tests seem to be over-sized regardless of whether the Φ and the Γ_1 parameters are updated or not. To evaluate the small-sample properties of the fluctuation tests more thoroughly, however, is left for future research.

4.3 The cointegration space

To examine the constancy of the cointegration space we shall consider two types of Nyblom tests. The first (supremum) test is based on the maximum value of a weighted *LM*-type statistic over the experimentation period and the second (mean) test on the average of this statistic. In addition, the *LM*-type statistic is calculated using two different methods. The first method was suggested by Hansen and Johansen (1999) and involves a first order Taylor expansion of the score function, while the second method is new for the purpose of examining the constancy of β and it uses the scores directly.

[20] See, e.g., Quintos (1997, Theorem 4) for the behavior of a related fluctuation test when the cointegration rank is over and under-specified.

All Nyblom tests are computed for a model with Φ being unrestricted and $D_t = 1$. Using the notation from Hansen and Johansen (1999) this means that

$$c = \hat{\beta}^{(T)}, \quad c_{\perp} = \hat{\beta}_{\perp}^{(T)}$$

and the normalization matrix $\bar{c} = c(c'c)^{-1}$ such that $\hat{\beta}_c^{(t)} = \hat{\beta}^{(t)}(\bar{c}'\hat{\beta}^{(t)})^{-1}$ and $\hat{\alpha}_c^{(t)} = \hat{\alpha}^{(t)}\hat{\beta}^{(t)\prime}\bar{c}$. Moreover, defining

$$q^{(t)} = T\bar{c}'_{\perp}(\hat{\beta}_c^{(t)} - \hat{\beta}_c^{(T)})$$

$$V^{(T)} = \hat{\alpha}_c^{(T)\prime}\,\hat{\Omega}^{(T)^{-1}}\,\hat{\alpha}_c^{(T)}$$

$$M^{(t)} = T^{-1}c'_{\perp}S_{11}^{\tau(t)}c_{\perp}$$

Hansen and Johansen (1999) shows that a first order Taylor expansion of the score function in the Nyblom statistic for constant β yields the statistic

$$Q_T^{(t)}(HJ) = \left(\frac{t}{T}\right)^2 \mathrm{tr}\left[V^{(T)}\,q^{(t)\prime}\,M^{(t)}\,M^{(T)^{-1}}\,M^{(t)}\,q^{(t)}\right] \quad t = 1, \ldots, T \tag{3}$$

The matrices $S_{ij}^{\tau(t)} = (1/t)\,\Sigma_{s=1}^{t}\,R_{i,s}^{(\tau)}\,R_{j,s}^{(\tau)\prime}$ for $i, j \in \{0,1\}$. The time index $\tau = T$ when (Φ, Γ_1) are fixed at the full sample estimates, while $\tau = t$ when these parameters are updated. The residuals $R_{i,s}^{(\tau)} = Z_{i,s} - M_{i2}^{(\tau)}\,M_{22}^{(\tau)^{-1}}\,Z_{2,s}$, where $Z_{0,s} = \Delta X_s$, $Z_{1,s} = X_{s-1}$, $Z_{2,s} = (1, \Delta X_{s-1})$ and $M_{ij}^{(\tau)} = \Sigma_{s=1}^{\tau}\,Z_{i,s}\,Z'_{j,s}$.

The limiting distribution of $Q_T^{(t)}(HJ)$ is independent of which estimate of $S_{11}^{\tau(t)}$ is selected. Moreover, it can be shown that Theorem 4 in Hansen and Johansen (1999) is still valid, but with $J(s)$ and $S(s)$ given by:

$$J(s) = \int_0^s FF'du, \quad S(s) = \int_0^s F(dB_2)', \quad F(s) = \begin{bmatrix} B_1(s) - \int_0^1 B_1(u)du \\ s - (1/2) \end{bmatrix} \tag{4}$$

where B_1 and B_2 are independent standard Brownian motions of dimension $(n - r - 1)$ and r, respectively, and n is the number of endogenous variables.

Instead of using a first order Taylor expansion of the score function, we may consider using the score function directly. For that formulation we obtain the following version of the statistic:

$$Q_T^{(t)}(S) = \left(\frac{t}{T}\right)^2 \mathrm{tr}\left[V^{(T)}\,S^{(t)\prime}\,M^{(T)^{-1}}\,S^{(t)}\right] \quad t = 1, \ldots, T \tag{5}$$

where $S^{(t)} = c'_{\perp}[S_{01}^{\tau(t)} - \hat{\alpha}^{(T)}\hat{\beta}^{(T)\prime}S_{11}^{\tau(t)}]'\hat{\Omega}^{(T)^{-1}}\,\hat{\alpha}^{(T)}$. By construction, $\hat{\alpha}_c^{(T)} = \hat{\alpha}^{(T)}$ and $\hat{\beta}_c^{(T)} = \hat{\beta}^{(T)}$, thus simplifying these expressions further. It may be noted that $M^{(t)}q^{(t)}$ is a representation of the first order Taylor expansion of $S^{(t)}$ in the direction of the appropriately defined free parameters of β. The expression for $Q_T^{(t)}(S)$ in (5) is a weighted LM statistic, while $Q_T^{(t)}(HJ)$ in (3) is a first order approximation. The test statistic suggested by Nyblom (1989) corresponds to the average of $Q_T^{(t)}(S)$ (the mean statistic), but like in Hansen and Johansen (1999) we shall also consider its supremum.

Based on the arguments in the proof of Theorem 4 in Hansen and Johansen (1999) it can be shown that $Q_T^{(t)}(HJ)$ and $Q_T^{(t)}(S)$ are asymptotically equivalent.[21] In small samples, however, they differ since the remainder term from the first order Taylor expansion is non-zero for $t < T$. Moreover, this remainder term can be quite large if the log-likelihood function is flat in some direction of the unique parameters of the cointegration space. If that is the case, one may suspect that the statistic $Q_T^{(t)}(HJ)$ will not be well behaved. As we shall see below, this is indeed the case here.[22]

In Panel A of Table 5 we present the tests for the constancy of β when we condition on the full sample estimates of Φ and Γ_1. In row 1 we find the Nyblom supremum test, $\sup Q_T^{(t)}(HJ)$, and the Nyblom mean test, $\text{mean}\, Q_T^{(t)}(HJ)$, for the model M_0 with 2 unrestricted cointegration relations. It can be seen from this Table that the Hansen-Johansen version of the Nyblom tests generate extremely large values, while the score versions in row 2 behave less "suspect". For the latter version both the supremum and the mean tests are far below their asymptotic 95 percent critical values of 4.16 and 1.87, respectively. Turning to the statistics in Panel B where Φ and Γ_1 are updated we find similar results.

Furthermore, when we attempt to bootstrap the distributions for the Nyblom tests we find, not surprisingly, that the *HJ* versions do not have meaningful empirical distributions. Hence, we do not report any bootstrap *p*-values for these tests. For the *S* versions of the Nyblom tests the distributions are well behaved by comparison. When we condition on the full sample estimates of Φ and Γ_1 the empirical *p*-values are lower than the asymptotic, but not sufficiently low to suggest that the null of constancy should be rejected. Still, this indicates that the tests are under-sized in this situation. When we instead update Φ and Γ_1 the empirical *p*-values are quite close to the asymptotic. For the supremum test we find that it is slightly under-sized, while the mean test is somewhat over-sized.

Table 5: Nyblom tests for the constancy of β for the unrestricted model M_0 with 2 lags and 2 cointegration relations over the period 1987:Q2-2001:Q4

(A) Conditional on $\hat{\Phi}^{(T)}$ and $\hat{\Gamma}_1^{(T)}$						
i	$\sup_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. *p*-value	boot *p*-value	$\text{mean}_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. *p*-value	boot *p*-value
HJ	4240.36	0.00	–	95.17	0.00	–
S	2.86	0.30	0.15	1.05	0.41	0.32
(B) Updating of $\hat{\Phi}^{(t)}$ and $\hat{\Gamma}_1^{(t)}$						
i	$\sup_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. *p*-value	boot *p*-value	$\text{mean}_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. *p*-value	boot *p*-value
HJ	22315.63	0.00	–	457.85	0.00	–
S	3.45	0.14	0.13	1.50	0.14	0.18

21 See also the discussion on page 314-316 of Hansen and Johansen (1999) for, e.g., relations to statistics previously suggested in the literature on testing parameter constancy.

22 It may also be noted that $Q_T^{(t)}(S)$ can be computed faster than $Q_T^{(t)}(HJ)$ since updated estimates of the cointegration space are not required.

We have already noted in the previous section that for model M_6 the interest rate semi-elasticities are very imprecisely estimated since the log-likelihood function is flat over a large section of the parameter space in those 2 directions. This may explain why the *HJ* versions of the Nyblom tests have such extreme values. To investigate this further we have calculated the *HJ* version using the restrictions on β in models M_6 and M_9. When the full sample estimates of Φ and Γ_1 are used we find that the former model gives a supremum value of 304516.01 and a mean value of 5837.62, while the latter where $\beta_{14} = \beta_{16} = 0$ provides us with 2.55 and 1.13, respectively. Values similar to those for model M_9 are obtained under models M_{11} and M_{12}, while model M_{10}, where the spread parameter can vary freely, again yields extreme values. Since the log-likelihood function is also very flat in the direction of the spread parameter these numerical results suggest that the *HJ* versions may be "numerically unreliable". Further research on this issue is, however, necessary before any definite conclusion can be drawn.

To sum up, based on the suggested score version of the Nyblom tests we conclude tentatively that the cointegration space is constant for the irrevocably fixed exchange rate data. Moreover, the first order Taylor expansion version of the Nyblom tests provides numerically unreliable results. The reason for this unreliability seems to be that the log-likelihood function is flat over a large region of the cointegration space, represented by, e.g., the interest rate semi-elasticities of long-run money demand in model M_6. Finally, the constancy of β should be treated with caution since the tests rely on the constancy of all other parameters.

4.4 The short-run dynamics

The estimated cointegration relations for models M_6, M_9, M_{11} and M_{12} are depicted in Figure 8. The estimated β_{ij} parameters for M_9 and M_{11} are:

$$\hat{\beta}'_{M9} = \begin{bmatrix} 1 & 0 & \underset{(0.01)}{-1.40} & 0 & 0 & 0 \\ 0 & \underset{(0.07)}{-0.66} & 0 & 1 & \underset{(0.08)}{0.44} & \underset{(0.12)}{-1.98} \end{bmatrix}$$

$$\hat{\beta}'_{M11} = \begin{bmatrix} 1 & 0 & \underset{(0.01)}{-1.38} & 0.8 & 0 & -1.3 \\ 0 & \underset{(0.06)}{-0.63} & 0 & 1 & \underset{(0.07)}{0.41} & \underset{(0.11)}{-1.96} \end{bmatrix}$$

Given the small differences in most of the parameter estimates, it is perhaps not surprising that these relations are so similar for the two models. The first relation, "long-run money demand", primarily has a different mean for the models, while the second relation, which only involves the three interest rates and inflation, is virtually identical across models.[23]

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[23] The estimated cointegration matrix for the restricted spread model is given by:

$$\hat{\beta}'_{M12} = \begin{bmatrix} 1 & 0 & \underset{(0.01)}{-1.37} & 0.4 & 0 & -0.4 \\ 0 & \underset{(0.06)}{-0.66} & 0 & 1 & \underset{(0.08)}{0.42} & \underset{(0.11)}{-1.95} \end{bmatrix}$$

As can be seen in Figure 8 the cointegration relations formed using this β matrix are not very different from the series for the other models.

Figure 8: The estimated cointegration relations for models M_6, M_9, M_{11} and M_{12} over the period 1980:Q4-2001:Q4

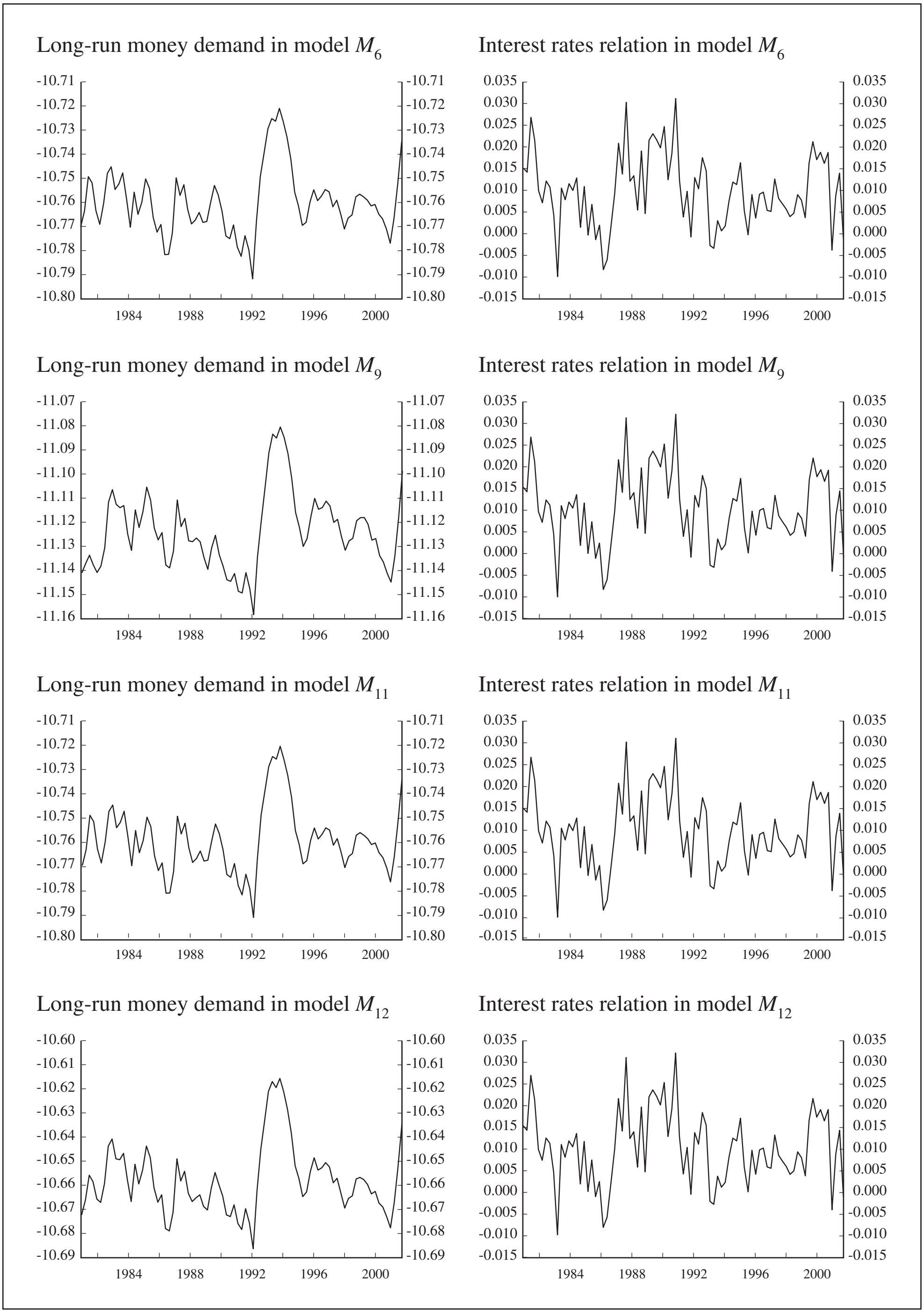

Table 6: Tests of linear restrictions on α for models M_9, M_{11} and M_{12} over the period 1980:Q4-2001:Q4

Equation	M_9		$M_{9.1}$ LR (8) = 9.70 [0.29]		$M_{9.2}$ LR (7) = 13.93 [0.05]	
m	–0.118 (0.034)	–0.088 (0.089)	–0.075 (0.025)	–0.075 (0.025)	–0.073 (0.027)	0
Δp	0.154 (0.076)	1.022 (0.201)	0	0.993 (0.172)	0	0.900 (0.168)
y	0.033 (0.042)	0.172 (0.110)	0	0	0	0
i_s	–0.132 (0.042)	–0.152 (0.112)	–0.128 (0.025)	–0.128 (0.025)	–0.121 (0.036)	0
i_l	–0.049 (0.033)	–0.040 (0.087)	0	0	0	0
i_o	–0.059 (0.012)	0.050 (0.031)	–0.055 (0.008)	0.055 (0.008)	–0.054 (0.011)	0.088 (0.018)
Equation	M_{11}		$M_{11.1}$ LR (8) = 5.78 [0.67]		$M_{11.2}$ LR (7) = 6.62 [0.47]	
m	–0.124 (0.037)	–0.034 (0.095)	–0.083 (0.026)	–0.083 (0.026)	–0.092 (0.028)	0
Δp	0.111 (0.086)	0.994 (0.216)	0	1.063 (0.178)	0	0.951 (0.173)
y	0.002 (0.046)	0.176 (0.116)	0	0	0	0
i_s	–0.176 (0.046)	–0.079 (0.115)	–0.154 (0.025)	–0.154 (0.025)	–0.169 (0.027)	0
i_l	–0.034 (0.036)	–0.021 (0.092)	0	0	0	0
i_o	–0.066 (0.013)	0.080 (0.033)	–0.059 (0.009)	0.059 (0.009)	–0.062 (0.011)	0.102 (0.020)
Equation	M_{12}		$M_{12.1}$ LR (8) = 6.51 [0.59]		$M_{12.2}$ LR (7) = 9.16 [0.24]	
m	–0.152 (0.034)	–0.059 (0.090)	–0.085 (0.024)	–0.085 (0.024)	–0.091 (0.027)	0
Δp	0.108 (0.079)	1.008 (0.208)	0	1.040 (0.173)	0	0.921 (0.169)
y	–0.003 (0.043)	0.174 (0.112)	0	0	0	0
i_s	–0.159 (0.042)	–0.116 (0.112)	–0.142 (0.025)	–0.142 (0.025)	–0.144 (0.035)	0
i_l	–0.046 (0.034)	–0.027 (0.089)	0	0	0	0
i_o	–0.061 (0.012)	0.065 (0.032)	–0.056 (0.009)	0.056 (0.009)	–0.056 (0.011)	0.096 (0.019)

The estimated α parameters for models M_9, M_{11} and M_{12} are presented in Table 6.[24] From the point estimates and the standard errors we find that long-run money demand enters the money, the short rate, and the own rate equations significantly at the 5 percent level in all models. Moreover, the signs of these parameters are all negative. Turning to the interest rate relation we find that it primarily matters for explaining the behavior in inflation, but also seems to be important for explaining the behavior of the own rate.

From Table 6 a number of possible restrictions on α emerge. Below, we shall consider two sets of restrictions. For both sets we let output and the long rate be weakly exogenous with respect to (α, β) and impose a zero restriction on the long-run money demand relation in the inflation equation.[25] For the first set of restrictions ($M_{s.1}$, where $s = 9,11,12$) we also let the $\alpha_{i1} = \alpha_{i2}$ in the money and the short-term rate equations, while the α parameters in the own rate equation are equal with opposite signs; a total of 8 restrictions. For the second set of restrictions ($M_{s.2}$, where $s = 9,11,12$) we let the α coefficients on the interest rate relation be equal to zero in the money and the short-term rate equations; adding up to 7 restrictions. The estimated parameters, standard errors, and *LR* tests of these restrictions are also reported in Table 6.

In all cases but $M_{9.2}$ we find that the restrictions cannot be rejected at conventional levels of marginal significance. Hence, there does not seem to be any information in the output and the long rate beyond the information contained in the other four equations about the two cointegration relations. Moreover, the *p*-values are higher and the test statistics are lower for the first set of restrictions, indicating that the data may be more "comfortable" with the equality restrictions than with the pure zero restrictions. Still, for the parameters which are allowed to be different from zero the differences are generally small when comparing across the two sets of restrictions.

The issue of whether or not to include the interest rate relation in the money equation cannot be resolved from the tests and the difference in point estimates is minor. The log-likelihood value is somewhat larger when the interest rate relation is included, as reflected through the lower test statistics for that case. Given the strong trends in real money and output it is perhaps not so surprising that it is difficult to obtain precise information about the relevance of the interest rates for long-run money demand. Yet, 5 of these 6 models do give a levels role for the interest rates to play in the money equation. Moreover, all these six models are consistent with the existence of something resembling a long-run "money supply" relation.[26]

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[24] Model M_6 (M_{10}) is not considered since it is basically identical to model M_{11} (M_{12}).

[25] The restriction that long-run money demand does not enter the inflation equation should *not* be interpreted as evidence that money does not matter for forecasting inflation, even if it were the case that all first difference terms in the inflation equation were equal to zero. The reason is, of course, that money seems to matter for forecasting the short rate and the own rate one period ahead, and these variables seem to be important for forecasting inflation one period ahead. Hence, it may very well be that money incorporates unique information for improving the forecasts of inflation, e.g., two periods ahead; see, e.g., Vega and Trecroci (2002) for a study of the information content in M3 for future inflation and Nicoletti-Altimari (2001).

[26] For money demand systems of narrow monetary aggregates, like Ml, the quantity of money is probably best thought of as being demand determined, i.e. the central bank supplies money as it is demanded by agents of the economy. For broad monetary aggregates, like M3, the picture may be somewhat different. An important component of M3 includes, e.g., savings and time deposits and these instruments typically yield a time-varying rate of return. While banks who supply access to such accounts may be expected to accept an increase (due to, e.g., portfolio shifts from equities) in such deposits, they are likely to react by lowering the rate of return on such accounts when increases are sufficiently big. A similar argument can be made for marketable instruments included in M3. Hence, from this perspective it can be argued that there is a supply side to M3.

Table 7: Linear combinations of the cointegration relations in the money, short rate, and the own rate equations for models $M_{9.s}$, $M_{11.s}$ and $M_{12.s}$

Equation	$M_{9.1}$	$M_{9.2}$
m	$m - 1.40y + i_s - 1.98i_o + 0.44i_l - 0.66\Delta p$	$m - 1.40y$
i_s	$m - 1.40y + i_s - 1.98i_o + 0.44i_l - 0.66\Delta p$	$m - 1.40y$
i_o	$m - 1.40y - i_s + 1.98i_o - 0.44i_l + 0.66\Delta p$	$m - 1.40y - 1.6i_s + 3.17i_o - 0.7i_l + 1.06\Delta p$
Equation	$M_{11.1}$	$M_{11.2}$
m	$m - 1.38y + 1.8i_s - 3.26i_o + 0.41i_l - 0.63\Delta p$	$m - 1.38y + 0.8i_s - 1.3i_o$
i_s	$m - 1.38y + 1.8i_s - 3.26i_o + 0.41i_l - 0.63\Delta p$	$m - 1.38y + 0.8i_s - 1.3i_o$
i_o	$m - 1.38y - 0.2i_s + 0.66i_o - 0.41i_l + 0.63\Delta p$	$m - 1.38y - 0.85i_s + 1.93i_o - 0.68i_l + 1.04\Delta p$
Equation	$M_{12.1}$	$M_{12.2}$
m	$m - 1.37y + 1.4i_s - 2.34i_o + 0.42i_l - 0.66\Delta p$	$m - 1.37y + 0.4(i_s - i_o)$
i_s	$m - 1.37y + 1.4i_s - 2.34i_o + 0.42i_l - 0.66\Delta p$	$m - 1.37y + 0.4(i_s - i_o)$
i_o	$m - 1.37y - 0.6i_s + 1.54i_o - 0.42i_l + 0.66\Delta p$	$m - 1.37y - 1.3i_s + 2.9i_o - 0.71i_l + 1.12\Delta p$

In Table 7 we have formed linear combinations of the two cointegration relations for models M_9, M_{11} and M_{12}, respectively, under the two sets of α restrictions for three of the equations. We find that only in the case of model $M_{9.2}$ do the interest rates not enter the money equation in levels. And this is precisely the model where the α restrictions may be rejected at the 5 percent level. For the other models, the signs of the short rate and the own rate are consistent with the interpretation of the linear combination being a long-run money demand relation. Notice that the long rate and inflation are also included in those linear combinations.

For the short rate equation we find that a linear combination, consistent with a long-run money demand relation, enters in all six models. In the own rate equation, however, the signs of all coefficients on the interest rates and inflation have been reversed. This is consistent with the interpretation of a long-run money supply relation being important for explaining the changes in the own rate.

At this point it is worthwhile to emphasize that whenever there are two or more cointegration relations in the system, we are faced with an economic identification problem concerning the long-run relations. While cointegration analysis may help us identify stationary linear combinations of potentially non-stationary time series, it generally cannot clarify what these cointegration relations mean economically. The reason is, of course, that any linear combination of two or more cointegration relations is also a cointegration relation. Hence, exactly which linear combination of our two statistically identified relations (if any) is the economically identified long-run money demand relation cannot be determined by the data.

Table 8: Ploberger-Krämer-Kontrus fluctuation tests for the constancy of Φ, Γ_1, α for models with 2 lags and 2 cointegration relations over the period 1987:Q2-2001:Q4

Equation	M_9	asymp. p-value	boot p-value	M_{11}	asymp. p-value	boot p-value	M_{12}	asymp. p-value	boot p-value
m	1.59	0.11	0.49	2.00	0.01	0.22	1.83	0.02	0.29
Δp	1.76	0.04	0.34	1.63	0.08	0.44	1.62	0.09	0.43
y	2.19	0.00	0.14	2.23	0.00	0.13	2.23	0.00	0.13
i_s	2.03	0.00	0.18	1.56	0.13	0.51	1.85	0.02	0.26
i_l	1.84	0.02	0.30	1.32	0.43	0.76	1.47	0.22	0.61
i_o	1.77	0.03	0.32	1.25	0.57	0.81	1.41	0.28	0.65

In Table 8 we report fluctuation tests (cf. Ploberger et al., 1989) for the constancy of the (unrestricted) Φ, Γ_1, and α parameters in the six equations. There are signs of non-constancy in several of the equations when we rely on the asymptotics for a reference distribution. Generally, models M_{11} and M_{12} display fewer signs of non-constancy than does model M_9. However, at the 5 percent level the parameters in the money equation are non-constant for models M_{11} and M_{12}, but not for M_9.

Still, these results are based on the asymptotic distribution and it may not be a good approximation of the unknown small sample distribution. Consequently we have also bootstrapped these fluctuation tests and the p-values from the empirical distributions are also given in Table 8. This time all p-values are greater than 10 percent and always greater than the p-values based on the asymptotic distribution. Hence, it seems as if these fluctuation tests are quite severely over-sized. Moreover, the empirical p-values suggest that the parameters in the individual equations are constant over the experimentation period.

4.5 Excluding data prior to 1983

As a robustness check we will re-examine the six variable model when we exclude the first three years of data. While the choice of sub-sample is always to some extent arbitrary, it makes sense to exclude the first years of our sample since the countries making up the euro area were most likely less integrated, especially the financial markets, in the early 80s than at some other point of our sample.

In Table 9 we report the cointegration rank tests for the sample 1983:Q3-2001:Q4 for a model with two lags.[27] Compared with the full sample, we now find that the uncorrected trace tests suggest using a cointegration rank of 2 at the 5 percent level, while the corrected trace tests indicate that we should choose only one cointegration relation even at the 10 percent level. Since the bootstrapped empirical distributions yield p-values comparable with those from the Bartlett corrected test using the asymptotic distribution we will proceed the analysis here with one cointegration relation.

[27] The first two quarters of 1983 are used as initial values.

Table 9: Cointegration rank tests with asymptotic and bootstrapped p-values for model with 2 lags over the sample 1983:Q3-2001:Q4

Rank	Eigen-value	LR_{tr}	asymp. p-value	boot p-value	BF	LR^c_{tr}	asymp. p-value	boot p-value
0	0.43	118.90	0.00	0.03	1.191	99.82	0.02	0.02
1	0.35	76.57	0.01	0.14	1.207	63.42	0.14	0.14
2	0.22	44.67	0.10	0.32	1.189	37.56	0.32	0.34
3	0.19	25.48	0.14	0.32	1.354	18.81	0.51	0.42
4	0.12	9.70	0.30	0.45	1.144	8.49	0.42	0.42
5	0.00	0.07	0.78	0.84	1.383	0.05	0.82	0.87

For the model with cointegration rank equal to one we find that the S version of the Nyblom supremum test is 1.52 while the mean test is 0.51; yielding asymptotic (bootstrap) p-values of 57 (57) percent and 54 (63) percent, respectively, when Φ and Γ_1 are updated.[28] Hence, without restricting β further we may conclude that the cointegration relation:

$$\hat{\beta}' = \begin{bmatrix} 1 & \underset{(0.67)}{3.90} & \underset{(0.06)}{-1.32} & \underset{(1.11)}{-5.88} & \underset{(0.67)}{-3.03} & \underset{(2.25)}{13.07} \end{bmatrix}$$

indeed seems to be constant over the sample in question.

If we restrict the parameters of β according to the long-run money demand relation in model M_6 we obtain:

$$\bar{\beta}' = \begin{bmatrix} 1 & 0 & \underset{(0.02)}{-1.37} & \underset{(0.50)}{0.43} & 0 & \underset{(0.98)}{-0.48} \end{bmatrix}$$

The LR test value is 13.15 with a p-value equal to 0 when compared with the $\chi^2(2)$ distribution. However, if we were to compute a Bartlett corrected LR test for this case we would need a correction factor of 2.20 to obtain a test value equal to the 95 percent critical value from the asymptotic distribution. The p-value from the bootstrapped distribution of the test statistic is 7 percent, while the bootstrap estimate of the Bartlett factor is 2.57, thus suggesting that the null hypothesis may be consistent with the data. Moreover, the point estimates suggest that the spread between the short-term rate and the own rate appears in the money demand relation. Again, however, the interest rate semi-elasticities are imprecisely estimated with huge confidence bands.

Turning to the Ploberger et al. (1989) fluctuation tests for the non-cointegration parameters in the individual equations, inference based on the asymptotic distribution suggests that the parameters in the output, short-term and long-term rates as well as the money equation need not be constant when the cointegration space is unrestricted. However, the bootstrapped distributions again suggest that these tests are over-sized in small samples and the empirical p-values are always greater than 10 percent. When we impose the cointegration vector above the results from the fluctuation

[28] When these parameters are fixed at their full sample estimates we obtain a supremum value of 1.45 and a mean value of 0.50. This corresponds to bootstrapped (asymptotic) p-values of 42 (61) and 53 (55) percent.

tests are broadly in line with those from the unrestricted β case. Hence, when we condition on one cointegration relation it seems that the parameters of the model are constant over the experimentation period. Moreover, when testing restrictions on α we find that output and the long-term rate seem to be weakly exogenous for the cointegration space since the *LR* test is equal to 0.12 when we impose the long-run money demand relation above.

In summary, shortening the sample to begin in 1983:Q1 leads to a reduction in the preferred cointegration rank. Still, the main conclusions from the full sample analysis survive. That is, there is strong evidence in the data of constant parameters for the cointegration relation, and the interest rate semi-elasticities are difficult to estimate precisely. Moreover, the Φ, Γ_1, and α parameters appear to be constant over the experimentation period.

5. An alternative aggregation method

In this section we shall reexamine the six variable model using an alternative aggregation method. Namely, when money, prices, output, and all interest rates have been aggregated using the 2001 GDP weights at PPP exchange rates. Moreover, the sample begins in 1981:Q3 due to data limitations.

For the irrevocably fixed exchange rate aggregated data we found that two lags were sufficient for capturing the serial correlation in the data. The GDP weights aggregated data is also consistent with this choice of lag order. Turning to the selection of cointegration rank, however, the issue is now somewhat trickier. The *LR* trace tests along with the Bartlett corrected tests are presented in Table 10. For the uncorrected tests we now find that 4 cointegration relations are supported by the data at the 20 percent (to the 5 percent) level while 3 are supported at the 1 percent level. When we use the corrected tests for rank selection we prefer 3 at the 20 percent (to the 5 percent) level and 2 at the 1 percent level. Moreover, when inference is based on bootstrapped empirical distributions we find that they confirm the evidence for the Bartlett corrected trace tests using the asymptotic distributions. In what follows we shall therefore examine the case of 2 and 3 cointegration relations separately and thereafter compare the main results.

Table 10: Cointegration rank tests with asymptotic and bootstrapped *p*-values for model with 2 lags using the 2001 GDP weights at PPP exchange rates aggregated data over the sample 1982:Q1-2001:Q4

Rank	Eigen-value	LR_{tr}	asymp. *p*-value	boot *p*-value	*BF*	LR^{c}_{tr}	asymp. *p*-value	boot *p*-value
0	0.42	134.08	0.00	0.00	1.175	114.11	0.00	0.00
1	0.34	91.12	0.00	0.02	1.185	76.89	0.01	0.02
2	0.28	58.22	0.00	0.02	1.190	48.94	0.04	0.03
3	0.23	31.58	0.03	0.10	1.342	23.53	0.22	0.16
4	0.12	10.69	0.23	0.42	1.177	9.08	0.36	0.40
5	0.00	0.06	0.80	0.84	1.310	0.05	0.82	0.85

Table 11: Nyblom tests for the constancy of β for models with 2 lags using the 2001 GDP weights at PPP exchange rates aggregated data over the period 1988:Q2-2001:Q4

(A) Conditional on $\hat{\Phi}^{(T)}$ and $\hat{\Gamma}_1^{(T)}$							
r	i	$\sup_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. p-value	boot p-value	$\text{mean}_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. p-value	boot p-value
2	HJ	1082.46	0.00	–	357.53	0.00	–
	S	3.89	0.08	0.01	1.41	0.17	0.10
3	HJ	987.31	0.00	–	87.72	0.00	–
	S	3.23	0.30	0.06	1.15	0.53	0.27
(B) Updating of $\hat{\Phi}^{(t)}$ and $\hat{\Gamma}_1^{(t)}$							
r	i	$\sup_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. p-value	boot p-value	$\text{mean}_{t\in\mathbb{T}} Q_T^{(t)}(i)$	asymp. p-value	boot p-value
2	HJ	3854.80	0.00	–	568.66	0.00	–
	S	4.09	0.06	0.04	1.94	0.04	0.04
3	HJ	36425.92	0.00	–	802.27	0.00	–
	S	4.24	0.09	0.04	1.90	0.11	0.07

Before we turn to these issues, note that the Nyblom supremum tests in Table 11 indicate possible non-constancy of the cointegration space under the empirical distributions for the score versions with p-values generally between 1 and 10 percent. The mean tests are somewhat more in line with the constancy hypotheses. When inference is based on the asymptotic distribution the score versions suggest that the null of constancy cannot be rejected at the 5 percent level for any one of these tests. As noted above, the Taylor expansion version of the scores yield extreme values for the tests that are most likely unreliable.

5.1 Two cointegration relations

To save space we shall focus on one set of restricted cointegration relations which is supported by the data. The estimated parameters are given by:

$$\hat{\beta}'_{M_{2,1}^{\text{GDP}}} = \begin{bmatrix} 1 & 0 & \underset{(0.02)}{-1.25} & 1 & 0 & -1 \\ 0 & \underset{(0.03)}{-0.62} & 0 & 1 & 1 & \underset{(0.03)}{-2.62} \end{bmatrix}$$

The LR test of the 6 (over-identifying) restrictions imposed on the cointegration vectors is 4.83, with a p-value of 57 percent according to the $\chi^2(6)$ distribution. One aspect that deserves some comment is the coefficient on output in the first cointegration relation. If we interpret this parameter as the income elasticity of long-run money demand, then the point estimate is lower here than what we found for the irrevocably fixed exchange rates data. Given what has been found in previous studies of euro area money demand, this result is not surprising (see, e.g., Brand et al., 2002).

Since the constancy of the unrestricted cointegration space may be questioned we have also calculated Nyblom tests for the restricted β above. The test statistic is based on *LM* statistics as in equation (5). For the restricted β case the score function is given by the first derivative of the log-likelihood function in the direction of the free parameters of β. The second derivatives are calculated in the same direction and all parameters are evaluated at their full sample estimates for each t over the experimentation period. As in the case of (5) the *LM* statistic is weighted by $(t/T)^2$. The asymptotic distributions of the supremum and mean statistics for these sequences are unknown but will most likely have critical values that are smaller than those from the limiting distribution of the statistics based on (5), i.e., when the cointegration space is unrestricted. When Φ and Γ_1 are fixed at their full sample estimates, the values for the supremum and mean statistics are here 0.56 and 0.12, respectively, with bootstrapped p-values equal to 0.60 and 0.73. Hence, it seems that the restricted β is not non-constant over the experimentation period.

Like in the case of the irrevocably fixed exchange rates data, we have also considered two sets of restrictions on α for the GDP weights data. The first set involves 8 restrictions and the second 7 restrictions and they are similar to those used in models $M_{9.s}$, $M_{11.s}$ and $M_{12.s}$.[29] Denoting the models by $M_{2,1.1}^{\text{GDP}}$ and $M_{2,1.2}^{\text{GDP}}$, respectively, we obtain the following restricted α parameters:

$$\hat{\alpha}_{M_{2,1.1}^{\text{GDP}}} = \begin{bmatrix} \underset{(0.020)}{-0.084} & \underset{(0.020)}{-0.084} \\ 0 & \underset{(0.141)}{0.732} \\ 0 & 0 \\ \underset{(0.025)}{-0.135} & 0 \\ 0 & 0 \\ \underset{(0.008)}{-0.039} & \underset{(0.008)}{0.039} \end{bmatrix}$$

$$\hat{\alpha}_{M_{2,1.2}^{\text{GDP}}} = \begin{bmatrix} \underset{(0.023)}{-0.095} & 0 \\ 0 & \underset{(0.134)}{0.591} \\ 0 & 0 \\ \underset{(0.027)}{-0.107} & 0 \\ 0 & 0 \\ \underset{(0.009)}{-0.028} & \underset{(0.014)}{0.065} \end{bmatrix}$$

The *LR* tests for these two models are 13.12 and 9.22, respectively, with p-values equal to 11 and 24 percent. Hence, at the 5 percent level we cannot reject either of these

[29] In fact, the only difference is found in the short rate equation, where the coefficient on the interest rates relation is set to 0 for the GDP weights data, and equal to the coefficient on the long-run money demand relation for the irrevocably fixed exchange rates data.

models conditional on the selected cointegration relations. Furthermore, when we examine the parameter constancy properties of the model with an unrestricted α, the results (cf. Table 12) are broadly in line with those obtained in Section 4.4 (cf. Table 8). Hence, it seems as if the non-cointegration parameters are constant over the experimentation period for the case of two cointegration relations.

Table 12: Ploberger-Krämer-Kontrus fluctuation tests for the constancy of Φ, Γ_1, α for models with 2 lags using the 2001 GDP weights at PPP exchange rates aggregated data over the period 1988:Q2-2001:Q4

		$r = 2$			$r = 3$	
Equation	$M^{GDP}_{2,1}$	asymp. p-value	boot p-value	$M^{GDP}_{3,1}$	asymp. p-value	boot p-value
m	1.44	0.25	0.66	1.82	0.03	0.49
Δp	0.95	0.97	0.98	1.63	0.09	0.61
y	1.69	0.06	0.41	2.18	0.00	0.26
i_s	1.94	0.01	0.25	2.02	0.01	0.30
i_l	1.64	0.08	0.49	1.56	0.14	0.69
i_o	1.71	0.05	0.41	1.88	0.02	0.42

5.2 Three cointegration relations

If we instead select three cointegration relations, a set of interesting restrictions on the cointegration space emerges. In particular, the following restricted estimate of β yields a LR statistic of 2.51 which, when compared to the $\chi^2(6)$ distribution, has a p-value of 87 percent:

$$\hat{\beta}'_{M^{GDP}_{3,1}} = \begin{bmatrix} 1 & 0 & \underset{(0.005)}{-1.26} & 1 & 0 & -1 \\ 0 & \underset{(0.03)}{-0.77} & 0 & 1 & \underset{(0.03)}{1.77} & \underset{(0.06)}{-3.54} \\ 1 & 0 & \underset{(0.005)}{-1.30} & 1 & -1 & 0 \end{bmatrix}$$

The first two cointegration vectors resemble those found in the two vector case above. The third cointegration relation is, however, at first sight a bit more perplexing. It is almost identical to the first with the exception that the long rate enters the relation instead of the own rate. Potentially, one may be inclined to interpret this as a long-run money demand relation, but the question is then how to interpret the first relation. Still, if we take the linear combination of the first relation minus the third we obtain a long-run relation between output and the spread between the long rate and the own rate. Hence, the third relation is perhaps best interpreted as a linear combination between long-run money demand and aggregate demand.

Concerning the constancy of the restricted β we have computed the same type of Nyblom statistics as those discussed in Section 5.1. We now find that the supremum and mean statistics are equal to 1.30 and 0.46, respectively, when Φ and Γ_1 are fixed at their full sample estimates. Comparing these with bootstrapped empirical distributions we find that the p-values are equal to 15 and 18 percent, thus suggesting that the cointegration space may indeed be constant over time.

Moving on to the fluctuation tests for the Φ, Γ_1, and a parameters, however, there are indications especially in the output and the short-term rate equations (cf. Table 12) that some of these parameters may not be constant. However, these tendencies are probably due to the fluctuation tests being over-sized and the bootstrapped p-values are always greater than 25 percent. Hence, the empirical evidence suggests that model $M_{3,1}^{\text{GDP}}$ is not subject to parameter non-constancy.

Already from the unrestricted α parameters (not reported) an interesting pattern of possible restrictions emerges. In the spirit of the restrictions for the two cointegration relations case and for the irrevocably fixed exchange rates data, we shall discuss the following two models:

$$\hat{\alpha}_{M_{3,1.1}^{\text{GDP}}} = \begin{bmatrix} \underset{(0.017)}{-0.067} & \underset{(0.017)}{-0.067} & 0 \\ \underset{(0.206)}{-1.146} & \underset{(0.132)}{0.930} & \underset{(0.206)}{1.146} \\ 0 & 0 & 0 \\ 0 & 0 & \underset{(0.024)}{-1.139} \\ 0 & 0 & 0 \\ 0 & \underset{(0.006)}{0.038} & \underset{(0.006)}{-0.038} \end{bmatrix}$$

$$\hat{\alpha}_{M_{3,1.2}^{\text{GDP}}} = \begin{bmatrix} \underset{(0.022)}{-0.075} & 0 & 0 \\ \underset{(0.207)}{-1.138} & \underset{(0.131)}{0.828} & \underset{(0.207)}{1.138} \\ 0 & 0 & 0 \\ 0 & 0 & \underset{(0.027)}{-0.135} \\ 0 & 0 & 0 \\ 0 & \underset{(0.009)}{0.040} & \underset{(0.009)}{-0.036} \end{bmatrix}$$

The α matrices are subject to 13 and 12 restrictions, respectively. The *LR* tests are in these cases 15.27 and 18.05, respectively, with p-values equal to 29 and 11 percent. Hence, data seems to be quite comfortable with either set of restrictions. As before, the only differences between these two models are found in the money and the own rate equations. For model $M_{3,1.1}^{\text{GDP}}$ we let the coefficient on the interest rate relation be equal to the coefficient on the money demand relation, while for model $M_{3,1.2}^{\text{GDP}}$ the coefficient on the interest rate relation is set to 0 in the money equation. Notice that these two sets of restrictions are not very different from those used in the two cointegration relations case above. The main difference can, in fact, be found in the inflation equation. In the three cointegration relations case the long-run money relations enter, while long-run money demand did not enter when we examined two cointegration relations. However, the fact that the first and the third relations enter with equal coefficients with opposite signs, means that it is the difference between these two relations that matters for inflation, i.e. the aggregate demand relation. Since the coefficient on output is so small relative to the interest rate coefficients, an approximation of that difference is the spread between the long rate and the own rate.

5.3 Comparing the results from the two aggregation methods

In Table 13 we list linear combinations of the cointegration relations that appear in the money, short rate, and the own rate equations. For all four models we find that changes in real money react to something that looks like a long-run money demand relation; we have a positive income elasticity, a negative semi-elasticity on the short rate, a positive semi-elasticity on the own rate, and a negative (positive) or zero semi-elasticity on the long-term rate (inflation). This is basically the same picture we obtained for the irrevocably fixed exchange rates aggregated data (see Table 7). Moreover, the change in the short rate also reacts to something resembling a long-run money demand relation and an aggregate demand relation. Finally, the first difference of the own rate depends on what may be a money supply relation. Again, this is consistent with what we found for the irrevocably fixed exchange rates aggregated data.

Still, it is worth emphasizing that the two aggregation methods share a fundamental identification problem. It has been suggested by Davidson (1998) that the principle of irreducible cointegration relations be applied to such cases, i.e. that a set of non-stationary variables is irreducibly cointegrated if these variables are cointegrated, but the exclusion of any of the variables leaves a set that is not cointegrated. According to Davidson's ideas, structural economic interpretations can only be made for irreducible cointegration relations. However, the principle is based on statistics (mathematics), not economics, and therefore neglects the possibility that, for instance, an economically

Table 13: Linear combinations of the cointegration relations in the money, short rate, and the own rate equations for models $M^{\text{GDP}}_{r,1.s}$, $r = 2, 3$ and $s = 1, 2$

Equation	$M^{\text{GDP}}_{2,1.1}$	$M^{\text{GDP}}_{2,1.2}$
m	$m - 1.25y + 2i_s - 3.62i_o + i_l - 0.62\Delta p$	$m - 1.25y + i_s - i_o$
i_s	$m - 1.25y + i_s - i_o$	$m - 1.25y + i_s - i_o$
i_o	$m - 1.25y + 1.62i_s - i_l + 0.62\Delta p$	$m - 1.25y + 4.76i_o - 1.32i_s - 2.32i_l + 1.44\Delta p$
Equation	$M^{\text{GDP}}_{3,1.1}$	$M^{\text{GDP}}_{3,1.2}$
m	$m - 1.26y + 2i_s - 4.54i_o + 1.77i_l - 0.77\Delta p$	$m - 1.26y + i_s - i_o$
i_s	$m - 1.30y + i_s - i_l$	$m - 1.30y + i_s - i_l$
i_o	$m - 1.30y + 3.54i_o - 2.77i_l + 0.77\Delta p$	$m - 1.30y + 3.93i_o - 0.11i_s - 2.96i_l + 0.85\Delta p$

interpretable transformation of the cointegration space is just as irreducible as a transformation of the space which is not economically meaningful.[30]

Given the strong trending behavior of real money and income, it is perhaps not so surprising that it is difficult to obtain precise information about the relevance of the interest rates for long-run money demand. Moreover, for the purpose of forecasting the level of real money it is unlikely that the exact values for the interest rate semi-elasticities in money demand matter. The income elasticity in the irrevocably fixed exchange rate data is, as a point estimate, somewhat larger than the estimates of the same parameter in the GDP weights data. But the difference is by no means huge and it is difficult to assess the uncertainty of the point estimates using asymptotic results.

We have computed bootstrapped 95 percent confidence intervals for the income elasticity in three models; M_6 for the irrevocably fixed exchange rate data and $M_{2,1}^{\mathrm{GDP}}$ and $M_{3,1}^{\mathrm{GDP}}$ for the GDP weights data. For M_6 we find that this interval is given by [1.26,1.52] while $M_{2,1}^{\mathrm{GDP}}$ gives us [1.20,1.29] and $M_{3,1}^{\mathrm{GDP}}$ yields [1.21,1.29]. Since these intervals are overlapping the income elasticities for the two aggregation methods may not be different. However, as noted by, e.g., Horowitz (2001) one should keep in mind that bootstrapping is best suited for (asymptotically) pivotal statistics, i.e., a statistic whose (limiting) distribution is free from nuisance parameters, and hence these confidence intervals may not be very accurate. It would be interesting to study the parameter uncertainty issue using Bayesian methods (see, e.g., Villani, 2001), but this is left for future work.

6. The importance of asset markets

The usefulness of analyzing money demand systems in monetary policy analyses depends on our ability to separate changes in its behavior that are due to income from changes that come about from other factors, since these may generate shifts in the income velocity of money (see, e.g., Dow and Elmendorf, 1998). For example, euro area households and firms increased their equity holdings significantly in the late 1990s, even though they may have reduced them somewhat afterwards.[31] We may then expect that in the last few years the behavior of, e.g., M3 has been affected by the stock market.[32]

Friedman (1988) put forth the hypothesis that stock price developments affect money demand in a direction that depends on whether the substitution effect or the wealth effect prevails. While the substitution effect predicts a fall in the demand for money when stock

[30] It should be pointed out that Davidson (1998) does not claim that all irreducible cointegration relations are structural in an economic (Cowles Commission) sense. For example, if we replace the third cointegration relation in Section 5.2 by the aggregate demand relation (the first minus the third), the first two relations are structural according to Davidson (1998, Theorem 5), while aggregate demand need not be structural since it does not contain a variable which does not appear in another cointegration relation. On the other hand, if we replace the first cointegration relation with the first minus the third (aggregate demand) and keep the third, then the second and the third cointegration relations are structural according to Davidson (1998, Theorem 5), while the first need not be. Hence, the principle may lead to increased confusion rather than increased understanding about what is meant by structural relations or structural parameters. The case of verifying "generic" identification is beautifully treated by Johansen (1995, Theorem 3), while economic interpretations of cointegration relations are still best handled by referring to economic theory.

[31] See, e.g., the box on "Financial investment of the non-financial sectors in the euro area up to the third quarter of 2002" in ECB (2003).

[32] See, for example, Cassola and Morana (2002) and Kontolemis (2002) for related studies.

prices rise, the wealth effect would lead to a higher demand for liquidity. Along these lines and under the assumption that stock market variables may help capture the store of value and portfolio reallocation motives behind the demand for M3, we first allow for a measure of euro area real stock prices as an additional endogenous variable. Second, a proxy for euro area stock market volatility is added to the system as a stationary weakly exogenous variable. Stock market volatility can be seen as a measure of the risk investors face when holding stock market portfolios. It often appears to move counter-cyclically and tends to exhibit spikes during recessions, financial crises, structural change, and periods of uncertainty (see, e.g., Campbell, Lettau, Malkiel, and Xu, 2001). Under such conditions expectations of firms' future earnings may well worsen and investors may be inclined to reallocate their portfolios in favour of instruments that are included in M3. This suggests that the effects of stock market volatility on money demand may primarily be a short-term phenomenon. Moreover, if we view volatility as a stationary random variable it cannot affect the long-run money demand relation.[33] Below we shall first examine the effects of real stock prices and then turn to the volatility issue.

6.1 Adding real stock prices to the statistical model

The stock price index for the euro area that we use in this paper is taken from Datastream. The quarterly observations are constructed as averages of the daily data. The currency basis for this index is in euro and to construct a real stock market price index we have taken the natural logarithm of the index minus the natural logarithm of the GDP deflator series. The resulting real stock market index is displayed on the left hand side in Figure 9. The remaining six variables are taken from the irrevocably fixed exchange rate data.

The cointegration rank results are presented in Table 14. We have chosen to use 2 lags in the VAR model, i.e. $k = 2$ in equation (1). With real stock prices added to the vector of endogenous variables, we find that the uncorrected trace tests suggest that we should select 2 cointegration relations at the 1 percent level, 3 relations at the 5 percent level, and 4 at the 10 percent level. In contrast, the corrected tests indicate that 1 cointegration relation is suitable at the 1 percent level, 2 relations at the 5 percent level and 3 at the 10 percent level. Thus, while the selection of an appropriate cointegration rank has become somewhat more problematic for the seven variable model than for the six variable model, below we shall discuss the case of two cointegration relations. This facilitates comparisons to the six variable model, but is also the preferred number of such relations when we follow the results for the Bartlett corrected *LR* trace tests at the 5 percent level as well as for the bootstrapped empirical distributions of the uncorrected and Bartlett corrected trace tests.

[33] In contrast, volatility may matter for all non-stationary endogenous variables in the long run for the same reason that some shock can have permanent effects on such variables; see, e.g., Jacobson, Vredin, and Warne (1998) for an LR test of such effects.

Figure 9: Quarterly averages of the daily stock market price index deflated by the GDP deflator (left) and the weekly stock market volatility (right)

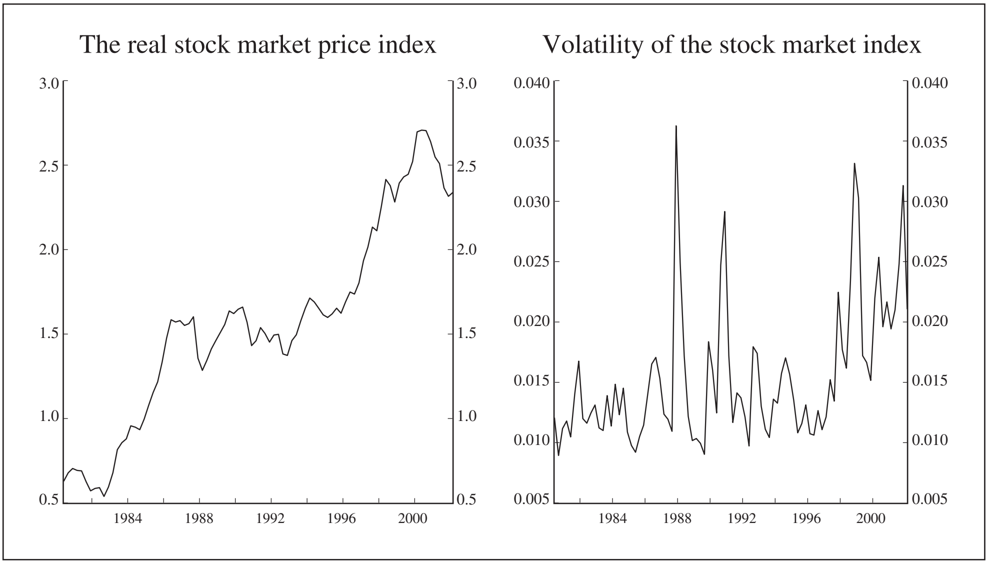

Table 14: Cointegration rank tests with asymptotic and bootstrapped p-values for models with 2 lags and including the real stock price index over the sample 1980:Q4-2001:Q4

Rank	Eigen-value	LR_{tr}	asymp. p-value	boot p-value	BF	LR^{c}_{tr}	asymp. p-value	boot p-value
0	0.48	174.51	0.00	0.00	1.196	145.91	0.00	0.00
1	0.37	119.37	0.00	0.02	1.204	99.16	0.03	0.03
2	0.33	80.23	0.01	0.07	1.204	66.61	0.09	0.08
3	0.24	46.66	0.06	0.26	1.215	38.39	0.28	0.27
4	0.20	23.81	0.21	0.47	1.186	20.07	0.42	0.49
5	0.05	4.76	0.83	0.94	1.259	3.78	0.92	0.94
6	0.00	0.15	0.69	0.77	1.486	0.10	0.75	0.78

Conditional on this choice of cointegration rank, it turns out that the results for the seven variable model are similar to those for the six variable model. In particular, the hypothesis that the real stock market variable can be excluded from the cointegration space cannot be rejected at conventional levels of marginal significance. When we impose exactly the same restrictions on β as in equation (2), i.e. model M_6, we obtain the following:

$$\hat{\beta}' X_t = \begin{bmatrix} 1 & 0 & \underset{(0.03)}{-1.39} & \underset{(0.30)}{0.62} & 0 & \underset{(0.65)}{-1.04} & \underset{(0.011)}{0.001} \\ 0 & \underset{(0.05)}{-0.62} & 0 & 1 & \underset{(0.09)}{0.28} & \underset{(0.10)}{-1.92} & \underset{(0.003)}{-0.004} \end{bmatrix} \begin{bmatrix} m_t \\ \Delta p_t \\ y_t \\ i_{s,t} \\ i_{l,t} \\ i_{o,t} \\ p_t^s \end{bmatrix} \quad (6)$$

where p_t^s is the real stock price index. Hence, the estimated coefficients on the real stock market price index in these cointegration relations are approximately zero.[34]

In the six variable model we settled for three alternative sets of restrictions on β, namely models M_9, M_{11} and M_{12}. Given the lack of importance of the real stock price in the present case, it is not surprising that the same type of restrictions emerge here as well. Moreover, the estimated β parameters are only marginally affected. For example, what would correspond to model M_9 yields a *LR* test value of 3.45, which when compared with the $\chi^2(6)$ distribution has a p-value of 75 percent.

The parameter constancy results for unrestricted β are somewhat more troublesome than for the six variable model. Based on the score version and fixing Φ and Γ_1 at their full sample estimates, the supremum test is 3.78 while the mean test is 1.91. If we compare these with the limiting distributions we obtain p-values of 16 and 8 percent, respectively. The bootstraps again suggest that the tests are under-sized and the empirical p-values are 5 percent for both tests. If we instead update Φ and Γ_1, the supremum test is 4.46 while the mean test is 2.39. From both the asymptotic and the bootstrapped empirical distributions these values correspond to roughly 6 and 3 percent respectively.

Turning to restricted cointegration spaces, the situation is similar to the unrestricted space. For example, the model with the M_6 restrictions, i.e., the restrictions on $\hat{\beta}$ in equation (6) plus two zero restrictions on p_t^s, provides us with a supremum (mean) test of 2.43 (1.29). When these Nyblom statistics for restricted β are bootstrapped, the empirical p-values are 10 and 6 percent, respectively. Hence, introducing real stock prices to the system seems to provide somewhat stronger evidence of parameter non-constancy for the cointegration space. Regarding the constancy of the Φ, Γ_1, and α parameters we obtain similar results to those for the six variable system, i.e., we cannot reject constancy of these parameters in any equation when inference is based on bootstrapping.

The α parameters also obey the same sets of restrictions as in the six variable models. Moreover, in the real stock price equation we find that the hypothesis of the sum of the α parameters being equal to 0 is supported by the data, i.e. the same type of restriction as

[34] The *LR* test for the 2 restrictions on β in equation (6) is 1.48, with a p-value of 48 percent. Conditional on these cointegration relations we also find that the *LR* statistic of two zero restrictions on the coefficients on the real stock price index is 0.52, with a p-value of 77 percent.

in the own rate equation. If we test the hypothesis that the real stock price index is weakly exogenous for (α, β), however, the Wald test strongly rejects the null. Hence, real stock prices seem to contain unique information about the cointegration relations. Still, neither the estimated β nor the estimated α parameters in the other equations are much affected by the inclusion of the real stock price index.

From all these results it seems natural to ask: Do real stock prices really matter? If we examine the Granger non-causality tests (cf. Table 15, where we report the results when β has been restricted as in model M_9) it can be seen that real stock prices primarily contain unique information for predicting the next period change in the short-term rate. In addition, they may be useful for predicting changes in real money, in inflation, in the long rate, and in the own rate.[35] Hence, from a forecasting perspective it makes sense to include real stock prices in the data set. Let us therefore consider the case when the impact of stock markets on money demand is represented by stock market volatility.

Table 15: Granger non-causality tests for the 2 lag model with real stock prices and with 2 restricted cointegration relations

Hypothesis	W	p-value	F	p-value
$p^s \nRightarrow m$	4.22	0.04	3.73	0.06
$p^s \nRightarrow \Delta p$	4.09	0.04	3.61	0.06
$p^s \nRightarrow y$	0.55	0.46	0.48	0.49
$p^s \nRightarrow i_s$	10.52	0.00	9.28	0.00
$p^s \nRightarrow i_l$	3.99	0.04	3.52	0.06
$p^s \nRightarrow i_o$	4.46	0.03	3.94	0.05

6.2 Does volatility matter?

While it seems plausible that stock market volatility can be influenced by the behavior of at least some of the variables in the six variable model, we shall only consider the case when volatility is weakly exogenous for the parameters of interest. The time series observations on the volatility variable are displayed in Figure 9. It is interesting to note that measured volatility has been fairly stable until 1998, with a few peaks in the late 80s and early 90s. From 1998, however, it seems to drift upward. In what follows we shall assume that the volatility series is stationary since it seems plausible given its behavior and, moreover, the underlying estimation procedure relies on such an assumption.[36]

When weakly exogenous stationary variables are added to the VEC model in equation (1), it has been shown by Rahbek and Mosconi (1999) that the trace test for the cointegration rank depends on nuisance parameters.[37] The solution suggested by Rahbek

[35] The real stock price index is, in fact, the only variable in the seven variable model which seems to Granger cause the long rate.

[36] The volatility series is the conditional standard deviation of an estimated leverage GARCH model for weekly data. The leverage term (an interactive dummy variable for negative stock price changes) is significant and positive, meaning that volatility tends to be higher when stock prices decline.

[37] The nuisance parameters are characterized as canonical correlations between the common trends, which include the accumulated stationary weakly exogenous variables, and the accumulated residuals.

and Mosconi is to accumulate the stationary regressors and allow these variables to enter the cointegration relations. Once the rank has been determined, it is possible to estimate the cointegration space under the restrictions that the accumulated stationary variables have zero coefficients.

The limiting distribution of the cointegration rank test in the case with I(1) weakly exogenous variables has been treated by Harbo, Johansen, Nielsen, and Rahbek (1998). One important result in their article is that a model with an unrestricted constant and a zero restriction on a linear trend leads to a nuisance parameter in the limiting distribution. If we relax the restriction on the linear trend such that its coefficients span the same space as α,[38] then the nuisance parameter drops out.[39]

From this discussion it follows that a natural model to consider when volatility is viewed as a stationary weakly exogenous variable is the following:

$$\Delta X_t = \Phi_0 + \alpha\Phi_1 t + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \alpha\beta' X_{t-1} + \alpha\beta'_v \sum_{i=1}^{t-1} v_i + \sum_{i=0}^{k-1} \psi_i v_{t-i} + \varepsilon_t \qquad t = 1,\ldots, T \tag{7}$$

where v_t is the volatility measure. Once the rank has been determined, we can restrict Φ_1 and β_v to be zero, and then conduct the analysis of the influence of the stationary volatility variable in the restricted VEC model.

The cointegration rank tests, along with the 80, 90, 95, and 97.5 percent quantiles for the trace test are presented in Table 16.[40] If we base our inference on the *LR* trace tests, then at the 5 percent level we would pick 3 cointegration relations, and 4 cointegration relations at the 20 percent level. We have already discussed, in Section 3.1, that the trace test is typically over-sized in small samples. To minimize this size distortion problem we would like to Bartlett correct the trace tests for the model in equation (7) as well. Since this problem has, to our knowledge, not been addressed in the literature yet, we will instead make an approximation based on the correction factors found above. The smallest correction factors we obtained for the six variable model was 1.15 and the biggest around 1.5. Typically, the correction factors took on values around 1.15 to 1.2. In Table 16 we therefore list the values of the trace test when they are divided by 1.15 and 1.2; denoted by $LR_{\mathrm{tr}}^{1.15}$ and $LR_{\mathrm{tr}}^{1.2}$, respectively. When we assume that the Bartlett correction factor is 1.15 for all ranks, the corrected trace tests suggest 3 cointegration relations at the 5 percent level, and 2 relations at the 2.5 percent level. For the case when we correct all the trace tests with 1.2, we instead obtain the results that there are 2 cointegration relations at the 5 percent level and 3 at the 10 percent level.

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38 That is, there are no quadratic trends in the levels of the endogenous variables.

39 The nuisance parameter essentially includes $\alpha_\perp$ and the coefficient on the highest order deterministic variable. If this product is zero, then the nuisance parameter is also zero. For the model where the linear trend is restricted to the cointegration space, i.e. a linear trend is the highest order deterministic variable, it follows that its coefficient spans the column space of α and is therefore orthogonal to $\alpha_\perp$. If the coefficient on the linear trend in the VEC model is restricted to zero, but the coefficient on the constant is unrestricted, then there is no guarantee that the nuisance parameter is zero. This follows from the fact that the constant is now the highest order deterministic variable, and its coefficient need not be orthogonal to $\alpha_\perp$. If it were, then again the limiting distribution of the cointegration rank test would be free of nuisance parameters.

40 The critical values are taken from Harbo et al. (1998, Table 2).

Table 16: Cointegration rank tests with asymptotic critical values and bootstrapped p-values for 2 lags models with volatility as a weekly exogenous variable over the sample 1980:Q4-2001:Q4

Rank	Eigen-value	LR_{tr}	$LR_{tr}^{1.15}$	$LR_{tr}^{1.2}$	Q_{80}	Q_{90}	Q_{95}	$Q_{97.5}$	bootstrap p-value
0	0.54	205.18	178.42	170.98	116.0	123.0	127.0	132.0	0.00
1	0.48	138.26	120.23	115.22	88.1	93.5	98.0	102.0	0.01
2	0.33	83.38	72.50	69.48	63.0	67.9	71.7	75.2	0.11
3	0.27	49.28	42.85	41.07	41.9	45.9	49.6	52.4	0.24
4	0.16	22.78	19.81	18.98	24.7	27.8	30.5	33.3	0.52
5	0.09	7.70	6.70	6.42	11.0	13.2	15.2	17.4	0.57

We have also bootstrapped the distributions for the uncorrected trace test for the models represented by equation (7), i.e., for the null hypotheses $r = 0,1,..., 5$. To construct pseudo-data we condition on the observed time series for volatility. As can be seen from Table 16 the empirical p-values agree best with asymptotic inference based on a Bartlett correction factor of 1.20. All in all this leads us to conclude that a choice of two cointegration relations is supported by the data.

Given two lags and two cointegration relations we next restrict the coefficients on the linear trend, i.e. Φ_1 in equation (7), to be zero. A LR test of these two restrictions yields a value of 28.28 and is thus strongly rejected by the data. Nevertheless, we exclude the linear trend from the model. Conditional on these choices we can now test if the volatility variable can be excluded from the model. Such a test involves 14 restrictions on the parameter space and the LR statistic is equal to 16.63. When compared with the $\chi^2(14)$ distribution we find that the asymptotic p-value of the test is roughly 28 percent. If we instead consider an alternative hypothesis where $\beta_v = 0$ and test the null that $\Psi_0 = \Psi_1 = 0$, the LR test is equal to 10.82, corresponding to an asymptotic p-value of 54 percent. Hence, the data does not object to the volatility variable being dropped from the model altogether.

7. Summary and conclusions

The main purpose of this paper is to study if the demand for euro area M3 is subject to parameter non-constancies. In contrast to most previous studies of euro area money demand, we apply formal tests rather than informal diagnostics. In addition to having the correct size (at least asymptotically), the tests do not require trimming of the sample, thus making it feasible to examine the constancy issue using as much information as possible. As a complement we have also performed small scale bootstrap simulations of the constancy tests, as well as some other statistics of interest, as a means for obtaining better small sample approximations of the unknown distributions.

The constancy analysis is divided into three sub-sets of parameters. First, we look at the non-zero eigenvalues from the cointegration analysis. As shown by Hansen and Johansen (1999), these eigenvalues are asymptotically Gaussian, meaning that we can use the fluctuation test (of Ploberger et al., 1989) to investigate if these parameters are constant over the experimentation period or not. Should these parameters be non-constant, the cointegration space, the coefficients on the cointegration relations or the covariance matrix for the residuals must vary over time. Second, we test for the constancy of the cointegration space using the Nyblom (1989) statistics studied by Hansen and Johansen (1999). Finally, conditional on the cointegration relations, we apply the Ploberger et al. fluctuation tests directly to the parameters of the individual equations of the vector error correction model.

In addition, the paper addresses a number of issues concerning euro area money demand, specifically the need for a consistent aggregation methodology for scale variables and interest rates and the measurement of the own rate of return on M3. The primary aggregation method used in this paper is based on the irrevocably fixed exchange rates for the scale variables and M3 weights for the interest rates. Hence, we are not using a consistent aggregation technique for scale variables and interest rates. For this reason (as well as for others), we also study data aggregated using the 2001 GDP weights measured at PPP exchange rates for all variables, thus enabling us to compare the results from the primary euro area dataset with those obtained with a method using a consistent aggregation scheme for scale variables and interest rates. The own rate of return on M3 is constructed as a weighted average of national interest rate series for all components of M3 and for all euro area countries.

First and foremost, there is strong evidence favouring the hypothesis that there is a stable long-run relationship between real money and real GDP. The estimated coefficient on real GDP is in all cases greater than unity and is thus consistent with the findings of previous euro area money demand studies (see Brand et al., 2002). Moreover, the point estimate is somewhat larger for the irrevocably fixed exchange rate data (roughly 1.4) than for the GDP weights data (about 1.25). This difference is, however, not large and 95 percent confidence bands, constructed from bootstraps, overlap. Thus, the income elasticity estimates from the two data sets need not be different.

The Nyblom statistics suggested by Hansen and Johansen (1999) yield extreme values whenever the cointegration space is unrestricted. As an alternative we suggested Nyblom statistics which do not rely on a first order Taylor expansion of the score vector (as Hansen and Johansen do), but instead use the score directly. Such statistics are thus functions of the *LM* statistic, whereas the Hansen and Johansen versions are functions of an approximate *LM* statistic. When the constancy tests for the unrestricted cointegration space are calculated using the score form they no longer yield extreme values. Moreover, the empirical evidence based on both asymptotics and bootstraps generally suggests that the cointegration space is not subject to non-constancy.

Second, the interest rate semi-elasticities of long-run money demand are imprecisely estimated using classical maximum likelihood. This has also been pointed out by Fagan and Henry (1998) and Dedola et al. (2001)[41] and it would be interesting to discover the extent to which this depends on the use of a classical rather than a Bayesian estimator.[42] For the primary dataset, these elasticities can range from at least –2.2 to 0.7 (with 95 percent asymptotic confidence) for the short-term rate and from –1.2 to 3.7 for the own rate. Standard *LR* tests of such hypotheses result in high *p*-values and, not surprisingly, the long-run relations are virtually unaffected.

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41 For example, Dedola et al. (2001) note that national differences in interest rate elasticity may explain the difficulty of accurately estimating the euro area elasticity.

42 This issue, as well as that of the uncertainty of income elasticity, are left for future research.

Third, once the coefficient matrix of the cointegration relations in the vector error correction system is fixed, the remaining parameters of the money demand system are typically also found to be constant when inference relies on empirical bootstrapped distributions. It has been suggested by Kontolemis (2002) that the stock market index should be included in the money demand system for the non-cointegration coefficients to be constant over time. Unlike Kontolemis, we include the own rate in the system and do not find that the non-cointegration parameters are non-constant. If we drop the own rate from e.g. the primary dataset, we find that one of the cointegration relations "disappears".[43] Parameter constancy in other respects is, however, preserved. Whereas our methodology is based on formal tests applied to recursively estimated parameters for a large proportion of the sample, Kontolemis uses informal, period-by-period Chow tests for the short sub-sample 1999-2001. Hence, the non-constancy conclusion by Kontolemis may very well be the result of not taking the overall significance level for the (correlated) Chow tests into account.

Once we add a measure of real euro area stock prices as an endogenous variable to our basic six-variable system, we find that stock prices do not matter for the selection of the cointegration rank or for the estimated parameters of the cointegration space. It is only when we test if stock prices are Granger non-causal for any of the six other variables that we find a role for stock prices in the money demand system. In particular, real stock prices seem to help predict the next period's change in the short-term interest rate, but may also be useful for predicting the other interest rates as well as real money and inflation changes.

As a second check on the relevance of stock market developments for the stability of the money demand system, we included the estimated volatility for the euro area stock price index as a weakly exogenous stationary regressor. In this case, the coefficients on volatility are not significantly different from zero. One explanation for this result is that the signal contained in our stock market volatility measure about the effects of financial crises, structural change and increased uncertainty (e.g. during the second half of 2001) may be too weak in the selected sample. The effects of stock market variables on money demand are important issues that warrant further research.

Finally, when we shorten the sample by excluding the early years 1980-1982, there is evidence of only one cointegration relation. Nevertheless, the main conclusions regarding the stability of the parameters in the long-run money demand equation and the difficulty in precisely estimating the interest rate semi-elasticities remain true for this sample. Additionally, inference based on bootstrapping suggests that the non-cointegration parameters of the system are not subject to non-constancy.

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[43] The results have not been reported in the paper, but are available on request.

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Appendix A: The construction of the own rate of return on euro area M3

The own rate of return on euro area M3 used in this paper is constructed as a weighted average of the national own rates of return on M3, where the latter are calculated as a weighted average of the rates of return on the different instruments included in M3. More formally,

$$\begin{aligned} i_0 &= \sum_c w_c i_c \\ &= \sum_c w_c \left(\sum_k w_{c,k} i_{k,c} \right) \\ &= \sum_c w_c \left(\sum_k \frac{M_{c,k}}{M_c} i_{k,c} \right) \end{aligned} \tag{A.1}$$

where i_o denotes the own rate of return on euro area M3, w_c the weight of country c in the euro area interest rate, i_c the national own rate of return on M3 for country c, $w_{c,k}$ the share of instrument k in M3 for country c (M_c), $M_{c,k}$ instrument k included in M3 for country c, and $i_{k,c}$ the rate of return on instrument k in country c.

The instruments included in M3 have been grouped as follows: currency in circulation (*cc*); overnight deposits (*od*); deposits redeemable at notice up to three months or short-term savings deposits (*sd*); deposits with an agreed maturity of up to two years or short-term time deposits (*td*); and marketable instruments (*mi*). The rate of return on currency in circulation is assumed to be zero. For the rates of return on the various categories of deposits use has been made of retail bank deposit rates. Finally, it is assumed that the rate of return on marketable instruments can be approximated by the three-month market interest rate (i_s).

For each country, an own rate of return on M3 is then calculated according to the following equation:

$$i_c = \frac{\mathrm{M}_{\mathrm{cc},c}}{\mathrm{M}_c} \cdot 0 + \frac{\mathrm{M}_{\mathrm{od},c}}{\mathrm{M}_c} \cdot i_{\mathrm{od},c} + \frac{\mathrm{M}_{\mathrm{sd},c}}{\mathrm{M}_c} \cdot i_{\mathrm{sd},c} + \frac{\mathrm{M}_{\mathrm{td},c}}{\mathrm{M}_c} \cdot i_{\mathrm{td},c} + \frac{\mathrm{M}_{\mathrm{mi},c}}{\mathrm{M}_c} \cdot i_{s,c} \tag{A.2}$$

Data for the national interest rate series are taken from various sources, namely, ECB, BIS, IMF, and OECD (see Table A.l.). In most cases data from several sources had to be combined to obtain a series for the period from January 1980 onwards. Quarterly data refer to averages of monthly data.

To transform the national interest rate series into a national own rate of return on M3 they are weighted by the share of each instrument in M3, according to equation (A.2). To this end, series for the 'notional stocks' of each of the instruments included in M3 were constructed. A time series of notional stocks corrects the series of outstanding amounts for reclassification, foreign exchange revaluations, and other revaluations to give a better

[44] For a detailed discussion of the statistical procedure, see the box on "The derivation and the use of flow data in monetary statistics", in ECB (2001).

indication of the actual transactions that have taken place.[44] When there are major differences between the changes in the end-of-month stocks and the changes in the notional stocks, using the latter results in much smoother series for the own rates of return.

Finally, to combine the national own rates of return on M3 into a series for the own rate of return on euro area M3, two different weighting schemes have been used, in line with the procedure for the other interest rate variables (see Section 2.1.2).

Table A.1: National monthly interest rate series used in the construction of the own rate of return on euro area M3

Country	Overnight deposits	Time deposits	Savings deposits	Short-term market interest rates
Belgium	80:1-89:12 CP in 90:1	80:1-89:12 NRIR	80:1-89:12 BIS (savings book deposits – HPHA.BE.91)	80:1-98:12 BIS (treasury certificate, 3-month – HEPA.BE.01)
	90:1-01:12 CP	90:1-01:12 CP	90:1-01:12 CP	99:1-01:12 3-month EURIBOR
Germany	80:1-89:12 CP in 90:1	80:1-01:12 CP	80:1-01:12 Weighted average of BIS (savings deposits at 3 months notice – HPHA.DE.02) and CP (higher yielding time deposits)	80:1-98:12 BIS (money market rate, 3-month – HEEA.DE.02)
	90:1-01:12 CP			99:1-01:12 3-month EURIBOR
Spain	80:1-01:12 CP	80:1-01:12 NRIR (deposits with agreed maturity between 1-2 years)	80:1-89:12 BIS (savings deposits – HPHA.ES.01)	80:1-98:12 BIS (monthly market rate, 3-month – HEEA.ES.02)
		90:1-01:12 CP	90:1-01:12 CP	99:1-01:12 3-month EURIBOR
France	80:1-01:12 zero	80:1-01:12 CP	80:1-89:12 BIS (savings deposits – HPHA.FR.01)	80:1-98:12 BIS (money market) rate, 3-month – HEEA.FR.92)
			90:1-01:12 CP	99:1-01:12 3-month EURIBOR
Greece	01:1-01:12 CP	01:1-01:12 CP	01:1-01:12 CP	01:1-01:12 3-month EURIBOR
Ireland	80:1-01:12 zero	80:1-01:12 same as short-term market rate	80:1-01:12 CP	80:1-98:12 BIS (money market rate, 3-month – HEEA.IE.02)
				99:1-01:12 3-month EURIBOR
Italy	80:1-86:7 BIS (bank deposits – HPHA.IT.98)	80:1-89:12 BIS (demand deposits – HPBA.IT.96)	80:1-84:6 BIS (bank deposits – HPHA.IT.98)	80:1-90:1 BIS (treasury bills, 3-month – HEPA.IT.02)
	86:8-89:1 BIS (savings deposits – HPHA.IT.96)	90:1-01:12 CP	84:7-94:12 BIS (average current/ savings deposits – HPHA.IT.96)	90:2-98:12 BIS (money market rate, 3 month – HEEA.IT.02)
	89:2-01:12 CP		95:1-01:12	99:1-01:12 3-month EURIBOR
Luxembourg	80:1-94:2 CP in 94:3	80:1-94:2 regression using OECD annual series	80:1-01:12 same as time deposits	80:1-98:12 OECD annual series of short-term interest rates
	94:3-01:12 CP	94:3-01:12 CP		99:1-01:12 3-month EURIBOR
Netherlands	80:1-01:12 CP	80:1-89:12 NRIR (time deposits with a fixed term of 2 years)	80:1-01:12 BIS (ordinary savings deposits – HPHA.NL.01)	80:1-98:12 BIS (money market rate, 3-month – HEEA.NL.92)
		90:1-01:12 CP		99:1-01:12 3-month EURIBOR
Portugal	80:1-89:12 CP in 90:1	80:1-89:12 IMF 60L (minimum time deposits rate)	80:1-01:12 same as time deposits	80:1-89:1 OECD annual series of short-term interest rates
	90:1-01:12 CP	90:1-01:12 CP		89:2-98:12 BIS (money market rate, 3-month – HEEA.PT.32)
				99:1-01:12 3-month EURIBOR
Austria	80:1-95:3 CP in 95:4	80:1-95:3 German CP series of time deposits	80:1-93:12 BIS (savings deposits – HPHA.AT.92)	80:1-98:12 BIS (money market rate, 3-month – HEEA.AT.92)
	95:4-01:12 CP	95:4-01:12 CP	94:1-00:10 IMF60L(deposit rate)	99:1-01:12 3-month EURIBOR
			00:11-01:12 CP time deposits	
Finland	80:1-01:12 CP	80:1-90:4 BIS (bank deposits at 24 months notice – HPHA.FI.93)	80:1-90:12 BIS (bank deposits at 24 months notice – HPHA.FI.93)	80:1-86:12 OECD annual series of short-term interest rates
		90:5-01:12 CP	91:1-01:12 CP	87:1-98:12 BIS (money market rate, 3-month – HEEA.FI.92)
				99:1-01:12 3-month EURIBOR

Notes: CP rates are the national components of the aggregated euro area retail interest rate; NRIR are national retail interest rates. Both sets of variables are taken from the ECB database.

11

Forecasting real GDP: What role for narrow money?

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1. Introduction

Is money a good indicator of future real economic developments? And if yes, what are the theoretical justifications and what is the concrete mechanism behind the connection? These questions are among the most hotly debated in monetary economics. The present paper tries to shed some light on these issues for the euro area. In particular, it concentrates on the forecast performance of M1 for real GDP.

There are plenty of empirical papers dealing with this question for the US (see e.g. Hamilton and Kim, 2002, Amato and Swanson, 2001, Vilasuso, 2000, Swanson, 1998, Estrella and Mishkin, 1997, Feldstein and Stock, 1997, Friedman and Kuttner, 1992). The general conclusion is that M1 is not very useful in predicting future GDP growth[1] Compared with these studies, evidence on this with respect to euro area countries is scarce. For **Germany**, Kirchgässner and Savioz (2001) show that for four-quarter ahead forecasts of real GDP growth real M1 clearly outperforms forecasts based on interest rate spreads. This indicator role for M1 is also apparent in Sauer and Scheide (1995), who present evidence that there is a causal relationship from M1 to real economic activity measured by real domestic spending. Moreover, Fritsche and Kouzine (2002), find that M1 is one of the best leading indicators for business cycle turning points, measured by the index of industrial production, within a Markov switching model.[2] On the other hand, in the paper by Estrella and Mishkin (1997), the one-quarter growth of M1 is not significant in an equation forecasting the annualised growth rate of GDP four to eight quarters ahead. In Plosser and Rouwenhorst (1994), past and future monetary growth only helps to predict future growth in industrial production for relatively long forecasting horizons (five years). Furthermore, they show that the term spread is a significant predictor of future M1 growth. And finally, Seitz (1998), who looks at the best leading indicators for the growth of GDP from the 1960s until the 1990s, shows that monetary aggregates do not play a significant role within a wide range of variables.

For **France**, Sauer and Scheide (1995), reveal a causal relationship between real M1 and real domestic spending within a cointegration framework whereas, in Estrella and Mishkin 1997, monetary aggregates are not helpful in predicting GDP irrespective of the chosen forecasting horizon. For **Italy**, Sauer and Scheide (1995), interpret evidence of a common trend in M1 and real economic activity as a special case of a causal role between the two variables. Furthermore, the interest rate spread does not contain any additional information on future output developments. Comparing the information content of the term spread and M1 for real GDP in Italy, Estrella and Mishkin (1997),

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[1] Exceptions are Swanson (1998), Vilasuso (2000) and Nelson (2002a). The first works with a special model selection procedure while the second uses detrended M1 growth that incorporates trend breaks. Nelson's paper is discussed in detail in section 2. Moreover, Leeper and Zha (2001), using a VAR analysis, conclude that the exclusion of money from this class of models is not empirically innocuous as the interpretation of the historical policy behaviour changes substantially once money is reintroduced. This result is confirmed by Favara and Giordani (2002), who examine the role played by shocks to the LM equation in shaping the dynamic behaviour of output, inflation and interest rates. A distinctive feature of their VAR analysis is that both the variables included in the system and the identifying restrictions used to isolate shocks to the LM equation are suggested by the class of models that assign a marginal role to monetary aggregates. They also find that all the variables they considered are not block-exogenous with respect to money. While Hamilton and Kim (2002) find that M1 is significant in explaining output growth in the U.S., this finding is not robust to all extensions of the information set.

[2] This is not true, however, when they use a probit model.

reveal a slight puzzle in that the spread only becomes significant once M1 is added to the relation, although the monetary aggregate itself is mostly insignificant and has the wrong sign. Altissimo et al. (2002), use two approaches to analyse the relation between surprises in GDP and innovations in monetary variables. The first requires filtering the new information contained in monetary variables by mapping surprises into estimates of the structural disturbances impinging on the variables of interest and then starting a new forecasting round of the model; the second looks directly at the correlations among surprises. The monetary variables taken into account are M2 and the currency component of M1. Within the first approach neither M2 nor currency contribute to reducing the forecast uncertainty on GDP. In contrast, the second approach reveals that there is information in the two monetary aggregates for forecasting real GDP.

Finally, Canova and de Nicoló (2002), assess the importance of different monetary disturbances as sources of cyclical movements for the G-7 from 1973 to 1995. For that purpose they use a VAR model with industrial production as a proxy for real activity, real M1, the term spread and inflation. The major result of their paper is that the combined contribution of these monetary disturbances for real economic fluctuations is large in Germany and Italy. In Germany, there is a single monetary shock which explains the major part of output variability. In contrast, in France, monetary disturbances hardly contribute to output fluctuations. These conclusions are robust to the choice of sample period and to the inclusion of further variables, especially stock returns and short- and long-term nominal interest rates. The peculiarity with Canova and de Nicoló's approach is that monetary disturbances are an amalgam of many different factors, not just M1.

Overall, the results concerning the information content of M1 for real activity in general and real GDP in particular in euro area countries are not conclusive. Furthermore, up to now, there were only a few euro area countries under investigation.[3]

This study differs from the aforementioned ones in several respects. First, the role of narrow money for output has so far not been studied for the whole euro area. There are several papers dealing with the situation in individual euro area countries (see the discussion above) but the results may differ for the euro area as a whole. Second, we distinguish between different forecasting horizons ranging from one quarter to two years. Usually, only one such horizon is evaluated.[4] Third, in assessing the role of M1 for output we perform an ex-post and an ex-ante analysis. And fourth, we compare the forecasting ability of different optimal VARs because the time series properties of the data and the results from preliminary model analysis are ambiguous.

The paper is structured as follows. The next section presents an overview of theoretical arguments why money might be useful for forecasting real GDP, effects of monetary policy apart. The third section contains the empirical analysis. In this part, we first present some preliminary evidence that M1 might be useful for forecasting GDP by drawing on a recent study by Hamilton and Kim (2002). In a second step, we derive our

[3] There are also papers which try to construct composite leading business cycle indicators in which different measures of money enter, see e.g. Berk and Bikker (1995), for an analysis for, inter alia, several EU countries.

[4] Exceptions are Swanson (1998), for the US and Estrella and Mishkin (1997), as well as Plosser and Rouwenhorst (1994), in multi-country studies. Bagshaw (1985), compares the predictive performance of M1 relative to a univariate model of GNP and finds no significant differences. Furthermore, he stresses that the merits of M1 in helping to forecast output depends more on the forecasting period considered than on the forecast steps or the frequency over which M1 is measured (monthly versus quarterly).

univariate benchmark model against which we judge several VAR models in terms of their ability to predict GDP out of sample. The last chapter summarises and draws some tentative conclusions.

2. Why does money help forecast GDP – some theoretical arguments

In most modern macro models, short-term interest rates rather than monetary quantities capture the monetary policy stance. Monetary policy rules, for example, are typically specified in terms of a money market interest rate.[5] This raises the question of how money in general (and in particular M1, which is the aggregate we focus on) might be useful in explaining and predicting business fluctuations over and above the influence of interest rates. In what follows, we present some of these arguments emphasised in the literature.

2.1. The traditional real balance effect

Probably the first theoretical considerations about this relation originate from Pigou (1943) and Patinkin (1965). What has become known as the famous Pigou- or the real-balance effect, describes wealth effects created by a change in the stock of real money. Patinkin (1965), p. 20, defines the real balance effect as "an increase in the quantity of money, other things being held constant, [that] influences the demand for a commodity just like any other increase in wealth". There has been a long debate as to whether or not money should be treated as a part of wealth. Gurley and Shaw (1960), tried to clarify this discussion by introducing the distinction between outside and inside money.[6] Outside money is a part of government debt (including the central bank), while it is an asset of the private sector. An example is currency in circulation. Inside money constitutes debt of private agents as well as an asset held by them. This is true, for example, for overnight deposits. Ignoring distributional effects and the efficiency increasing effects of money compared to a barter economy, wealth effects would, if at all, only apply to outside money[7]. This would imply that we should not pay attention to monetary aggregates per se, but to its breakdown into inside and outside money. The latter is normally only a small part of total monetary aggregates; for example, in 2001, currency was only about 15 % of euro area M1 and only 2 % of total financial assets of the non-financial sector. It seems doubtful that such a small aggregate can have a significant impact on the economy. The judgement would be different, however, if both inside and outside money mattered.

[5] In the volume by Taylor (1999), all the papers presented use such a formulation.

[6] Whether these wealth effects are only a transitory phenomenon or are also relevant in the long run is crucially dependent on the assumptions of money being the only financial asset or not and on the time horizon considered for individual decisions. If bonds co-exist with money and agents have an infinite horizon the wealth effects may even be existent in the long run, see Handa (2000, p. 492).

[7] Furthermore, one has to recognise that households fail to take into account the impact that a future creation of excess money may have on the economy.

2.2. Money in modern macro models

In all existing economies, private parties hold transaction balances despite the fact that they yield a lower return than other very short-term riskless assets. This indicates that there must be advantages from holding money which have so far not been considered in our discussion. The advantages relate to the assumption that money holdings facilitate transactions and lower transaction costs.[8] This idea has been incorporated in money-in-the-utility-function models (see e.g. Woodford, 2003, ch. 2), shopping time models (see e.g. Bakhshi et al., 2002) or cash-in-advance models with population growth (Ireland, 2002).[9] Within the first class of models, originating from Sidrauski (1967), the household maximises the expected value of the discounted sum of per-period contributions to utility u of the form

$$E_0\left[\sum_{t=0}^{\infty} \beta^t u(c_t, m_t)\right] \tag{1}$$

where $0 < \beta < 1$ is the discount factor, E is the expectation operator and the per-period utility u depends positively on consumption c and real balances $m = M/P$, subject to its intertemporal budget constraint, possibly incorporating a borrowing limit (Woodford, 2003, ch. 2). The way money affects the consumption path crucially depends on the assumption made about u_{cm}.

If $u(\,.\,)$ is additively separable between its arguments c and m, the marginal utility of consumption would be independent of real balances, just as in the case of a cashless economy. This implies that aggregate demand and the expectational IS curve would be unaffected by real money balances. There would be no real balance effect despite the fact that money enters the utility function. One alternative way of justifying the neglect of real balance effects on the marginal utility of consumption is Woodford's (2003, ch. 2.3.4), case of a "cashless limiting economy". In this model the marginal utility of additional real balances becomes quite large as household real balances fall to zero, so that it is possible in equilibrium to have a non-trivial interest-rate differential between monetary and non-monetary assets. Yet, at the same time, the transactions that money is used for are sufficiently unimportant so that variations in the level of real balances have only a negligible effect on the marginal utility of consumption. The idea is that in such an economy money is used for transactions of only a very few kinds, though it is essential for those. As a result, positive real balances are demanded even in the case of a substantial interest-rate differential (and hence, a substantial opportunity cost of holding

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[8] For King (2002), even the proof of a significant role for money for real developments has to be based on the two observations that money reduces transactions costs and that transactions costs are important in determining asset prices. The frictions which money helps to overcome in financial markets have to be related to its role in providing liquidity services.

[9] Croushore (1993), shows that the first two models are functionally equivalent. Holman (1998), postulates that money-in-the utility-function models allow for transactions as well as precautionary and store-of-value motives for holding money. McCallum (2000) presents a reduced form shorthand of all these analyses by introducing a transactions cost function, which reflects the transaction-facilitating properties of money, in the per-period budget constraint.

money); but equilibrium real balances are very small relative to national income. Consider an economy in which a fraction α of goods may only be purchased with cash and make the parameter α arbitrarily small. This means that whereas the elasticity of u_m with respect to real consumption (ε_c) is positive[10]

$$\varepsilon_c = \frac{c \cdot u_{mc}}{u_m} > 0 \tag{2}$$

the elasticity of u_c with respect to real balances (ε_m)

$$\varepsilon_m = \frac{m \cdot u_{cm}}{u_c} \tag{3}$$

which is essential for a real balance effect to be operative, is infinitesimally small. Woodford (1998), shows that if monetary policy may be characterised by an interest rate rule which specifies the short-term nominal interest rate as a function of the price level, there is no further need to consider the role of money in such an economy.

In the cashless-limit environment as well as in the consumption-money-separability environment money is redundant, as real money balances are demand determined given the endogenously determined interest rates and output. The usual LM equation in such a framework serves the sole purpose of determining the quantity of money the central bank needs to supply to clear the money market. The cashless-limiting-economy assumption, however, seems questionable as e.g. currency certainly provides valuable services to consumers. These may stem from its anonymity or from the fact that exchanges conducted with money can be done "without knowledge of individual histories" (see Wallace, 2000). Against this background, McCallum (2000, 2001 and 2002) strongly argues that there is also no compelling theoretical basis for the assumption of separability of u (see also Woodford, 2003, ch. 2.3.4). Thus, a direct money effect would arise if real balances enter the representative agent's utility function, which in turn is not additively separable in consumption and real balances, but has a positive cross-derivative, i.e. $u_{cm} > 0$.[11]

This would result in an (expectational) IS function depending on the real rate of interest, expected future output, government expenditures as well as real balances.

2.3. Money as a proxy for a whole range of relative prices of assets

Friedman and Schwartz (1963), Meltzer (2001), and Nelson (2002a and 2002b) evaluate the important role of money for real activity and prices from a more general perspective.

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[10] Assuming separability would imply that the elasticity ε_c is negligible.

[11] The empirical analysis for the US in Koenig (1990), strongly suggests $u_{cm} > 0$. Taking the effects of real balances, measured by M1, into account, there is little evidence that other variables like anticipated or lagged changes in income, stock prices, government purchases or any other variable that might influence uc or serve as a measure of liquidity, have a direct impact on consumption or its timing. In Koenig's study the effect of real balances on consumption is quite strong: a 10 percent increase in real M1 results in a three percent increase in spending on non-durables and services. This kind of non-separability has already been considered by Sidrauski (1967). Ireland (2002), however, derives a real balance effect in an infinite-horizon optimising model which does not require non-separability in utility.

In particular, they argue that money cannot be ignored because it proxies the effects of many other asset prices on aggregate demand. If changes in money lead to changes in private sector portfolios and changes in yields of financial and real assets, this in turn also influences real spending decisions. The usefulness of this channel and the portfolio balance effect that arises depends on the assets being imperfect substitutes. A special advantage of this kind of model is that it tries to identify separate effects of real money on aggregate demand which are not captured by a short-term real interest rate.

What are the theoretical rationalisations for a direct money term in aggregate demand functions? Meltzer (2001), Friedman and Schwartz (1982), and Brunner and Meltzer (1993), state that money demand is not only dependent on one interest rate but a function of many different asset yields and wealth including human and non-human wealth. Therefore, money plays a special role for real developments in that it proxies the effects of these different yields and wealth effects which are relevant for economic activity.[12] In Meltzer's view, the gap between desired and actual real balances is a measure of the relative price adjustment necessary to restore the new full equilibrium. And, as he argues, a measure of the real money stock serves as a good summary statistic of the various changes in yields and wealth. The relevant yields include the whole term structure of interest rates, the yield on shares, the exchange rate, yields on housing etc.

A model which tries to fully capture the role of money therefore has to incorporate multiple assets which are imperfect substitutes for each other. If the yields influencing money demand and the yields influencing aggregate demand are correlated, real balances will be a good indicator of real developments in that they summarise all the relevant aspects.

Recent applications of this general idea may be found in Nelson (2002a and 2002b). Nelson (2002a) derives this effect within an intertemporal general equilibrium model with Calvo price setting, where money becomes important in explaining output, once portfolio adjustment costs are present. In Nelson (2002b), this is the case in an environment where current private sector shocks are not observable to the monetary authority. In such a world, looking at money is information-efficient and aids inflation stabilisation if current period nominal money growth can be observed.[13]

The special role of money may be yet more important when nominal interest rates are close to zero. Meltzer (2001), argues that a monetary expansion can stimulate the economy even in this case as nominal securities are not the only substitute for money. If, at some point, households and firms become satiated with money balances at the current level of income, any attempt to increase the money supply leads them to adjust their portfolios to limit their money holdings. These portfolio changes lead to changes in relative yields on financial and real assets and hence on real spending. The essential question then is whether there exists such a satiation point (see King, 2002).[14]

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[12] The results of Coenen et al. (2001) within a New-Keynesian passive-money-type approach can be interpreted in the light of this argument. In their model money is a helpful summary statistic for uncertain real output as money demand depends on output.

[13] In the same spirit, Tödter (2002) presents a model in which money is a summary statistic for a whole range of shocks hitting the economy.

[14] The dependence of the IS relation on money may also be rationalised within the credit channel framework as credit is the main balance sheet counterpart to money (see Bernanke and Blinder, 1988). However, at times when money and credit exhibit disparate movements, it seems worthwhile to treat both separately.

3. Empirical analysis

In the following, we first present some single-equation evidence in the spirit of Hamilton and Kim (2002) that money may be useful in forecasting real GDP growth in the euro area. This part also enables us to compare evidence from the euro area and the US. The next section develops a univariate benchmark model against which we assess the forecast performance of a battery of VARs.

3.1. Some preliminary evidence

Hamilton and Kim (2002), establish the importance of the yield spread for forecasting real output growth in the United States for the period 1953:Q2 to 1998:Q2. They use the following equation:

$$\Delta y_t^h = \alpha_0 + \alpha_1 (il - is)_t + \alpha_2 x_t + \varepsilon_t \tag{4}$$

where Δy_t^h is $\frac{400}{h}(\ln Y_{t+h} - \ln Y_t)$ the annualised real GDP growth over the next h quarters and x_t is a vector of alternative explanatory variables (e.g. M1) besides the term spread (il - is). Their general conclusion is that the term spread is especially useful in predicting real GDP growth up to two years ahead.

In what follows we estimate one specific test regression for the euro area. It reads as

$$\Delta y_t^h = \alpha_0 + \alpha_1 spread_t + \alpha_2 \Delta_4 \, m1r + \alpha_3 x_t \tag{5}$$

where $m1r$ is seasonally adjusted real M1 (h = 1,...,8). Our GDP measure (y) refers to seasonally adjusted GDP (see Figures 1 and 2 below).[15] As regards the spread, we do not only assess the performance of the long-term (the yield on 10-years government bonds) minus the short-term rate (the 3-month money market rate) (il-is), but also the difference

[15] Historical data for the euro area over the period 1980 Q1-1998 Q4 are constructed on the basis of national series converted into euro using the irrevocably fixed exchange rates of 31 December 1998. For a discussion of the merits and a presentation of various aggregation methods for historical euro area data, see Brand, Gerdesmeier, Roffia (2002, pp. 28-29), and, in particular, Beyer, Doornik and Hendry (2000 and 2001). The quarterly growth rates calculated from the euro-area-11 GDP series have been used to extend the euro-area-12 GDP observations from 2000 Q4 back to 1980 Q1. (Greek data have been converted on the basis of the irrevocable fixed exchange rate determined on 19 June 2000 for Greece). For more detailed information on the compilation of these data and, in particular, the underlying national data, see Brand, Gerdesmeier and Roffia (2002, Annex D.2, pp. 56-58) and Gerdesmeier and Roffia (2003). The monetary data have been aggregated in line with the method used in Brand, Gerdesmeier and Roffia (2002, Annex D.1, p.56). Euro-11 (euro-12 from January 2001) ten-year government bond yields are weighted averages of long-term interest rates using national shares in M3 as weights (Source for national series: Datastream and BIS) based on national 10-year government bond yield or closest substitutes. 3-month money market interest rates have been constructed in the same manner (Source: BIS), and linked to EURIBOR (from Reuters) as from 1999 onwards. The world-wide stock price index has been taken from Datastream. Source for the oil price index, the EUR/US-$ exchange rate, and German interest rates: BIS. These data are available from the authors upon request. Furthermore, the own rate of M1 has been constructed on the basis of Stracca (2001), the nominal and real effective exchange rate measures on the basis of Maeso-Fernandez, Osbat and Schnatz (2001), the HICP data on the basis of Gerdesmeier and Roffia (2003), the composite lending rate on the basis of Calza, Manrique, and Sousa (2003), and the Divisia aggregate on the basis of Stracca (2001).

between a composite lending rate and the money market rate (*clr-is*), the difference between the capital market rate and the own rate of M1 ($il\text{-}i_{m1}$), the difference between the money market rate and the own rate of M1 ($is\text{-}i_{m1}$) as well as the difference between the German yield on bonds and the German money market rate (*il_ger-is_ger*).[16] Nominal interest rates have been divided by 400. *Ex-post* real interest rates are calculated on the basis of nominal interest rates and annual changes in the GDP deflator (*pgdp*) (or the HICP) (divided by 4). In one case, M1 is substituted by a Divisia aggregate (*divr*). Finally, x_t are additional variables like stock prices (stock) (a worldwide stock price index highly correlated with the Euro Stoxx which could not be used as, it only exists since the end of the 80s), oil prices in US-Dollars (oilp) and in euros (oilp€), the bilateral US-$/€euro exchange rate (*e*) as well as the multilateral effective nominal (*eeffn*) and real (*eeffr*) exchange rates of the euro. All data, except interest rates, are in logarithms. Our sample runs from 1980:Q1 to 2001:Q4.

[16] The inclusion of the German spread may be rationalised by the fact that within the former (asymmetric) European Exchange Rate Mechanism the Bundesbank pursued an independent monetary policy aimed at price stability while the other ERM countries tried to maintain a stable exchange rate vis-à-vis the Deutsche Mark (De Grauwe (2000, ch. 5), Wellink and Knot (1996)). If Uncovered Interest Parity holds, it seems natural to consider the German spread.

Figure 1: Real M1 and GDP: Log Levels

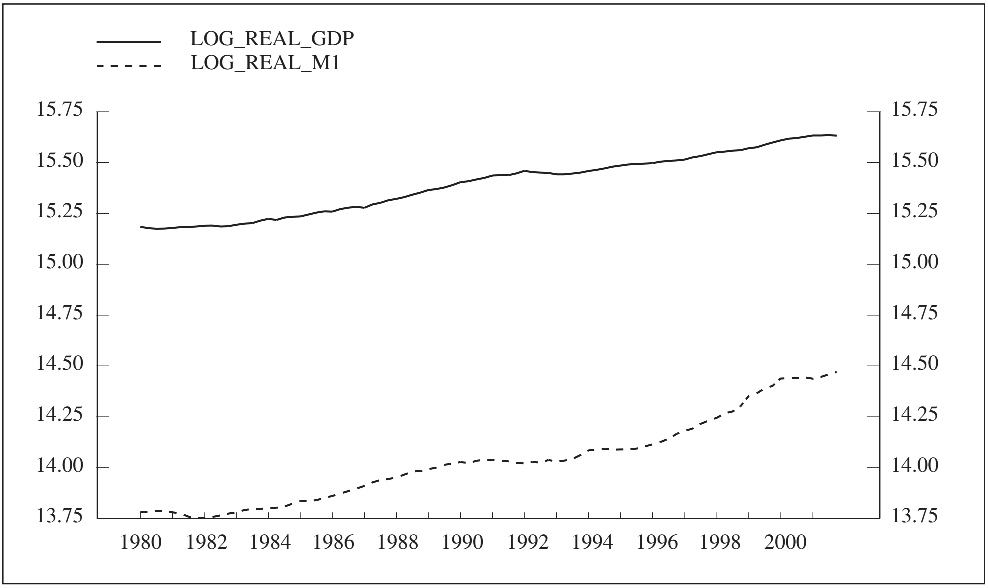

Figure 2: Real M1 and GDP: Changes on a Year Earlier

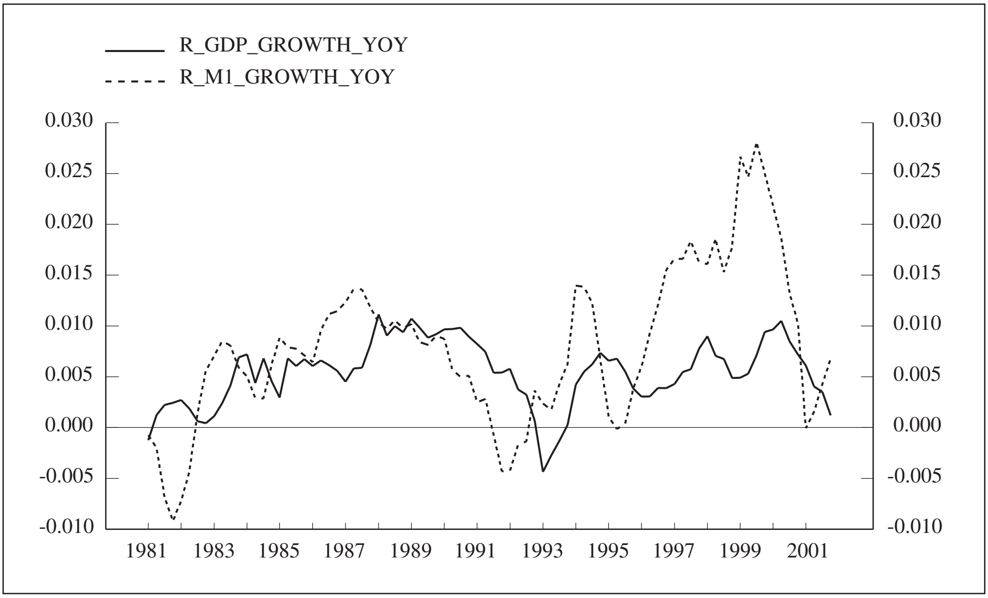

Table 1 shows the coefficient estimates of equations (4) or (5), the (Newey-West-corrected) *t*-ratios and the adjusted R^2 of the equations. Each model block includes results for the forecast horizons $h = 1, \ldots, 8$. For model 1, which only takes into account the term spread, the estimated coefficients are not significant at the 5 percent test level for all $h = 1, \ldots, 8$. This is in contrast to the results of Hamilton and Kim (2002) for the US.[17] Adding the growth rates of real M1 to the test equations does not alter the results for the spread (model 2). However, the estimated coefficients of M1 are significant at the 1 percent test level for all $h = 1, \ldots, 8$. The adjusted R^2 are considerably higher than those of the first model block.[18] The spread between the capital market rate and the own rate of M1 (model 3) is more important for $h = 1$ to 4. The real capital market rate based on the HICP (model 5) affects the growth rate of output significantly, whereas the real money market rate has no significant influence (model 6). All these approaches have one feature in common: in all cases the growth rate of M1 remains significant. This is also true if the regression equations only include M1 (model 4). This evidence does not change if the equations additionally contain other variables like the annual change of the world stock prices, of oil prices, of the US-$/€ exchange rate, of the nominal or real effective exchange rates or of other interest rate variables. These other variables do not help to forecast output in the short term ($h = 1$ to 4). In the longer run ($h = 4$ to 8) some variables have significant coefficients, especially, the nominal effective exchange rate and the oil prices in euro. These results are also available upon request. It is also worth noting that the results for the change of the real Divisia aggregate (model 7) point in the same direction as the M1 change.

In sum, this exercise gives preliminary evidence of the importance of M1 for future output developments in the euro area. However, the forecast performance is not systematically evaluated relative to a benchmark. Moreover, the analysis is only carried out within a single equation approach. These issues are addressed in the following sections.

[17] Evidence about the information content of various financial spread measures with respect to a large number of EU countries has been found in Davis and Fagan (1997). Their results are not supportive for the hypothesis that financial spreads can be used comprehensively and indiscriminately as indicators of future output growth and inflation. In the few cases where Granger-causality has been detected, the forecast performance proved to be disappointing, and, furthermore, their forecasting equations appeared to be unstable.

[18] On the other hand, the German interest rate spread helps to forecast changes in output over time for horizons h = 6 to 8, whereas the difference between the money market rate and the own rate of return of M1 (between a composite lending rate and the money market rate) does so for the horizon h = 2, 3 (h = 1). These results are available from the authors upon request.

Table 1: Coefficient estimates of equations (7) and (8) for future real GDP (Hamilton/Kim approach)

Model	Variables	Forecast horizon h							
		1	2	3	4	5	6	7	8
1	il-is	.462	.471	.451	.402	.362	.323	.293	.273
		(1.638)	(1.783)	(1.813)	(1.693)	(1.636)	(1.614)	(1.625)	(1.658)
	adj. R^2	.050	.093	.115	.108	.097	.087	.083	.082
2	il-is	.118	.098	.077	.050	.043	.052	.058	.064
		(.425)	(.414)	(.374)	(.270)	(.260)	(.358)	(.443)	(.534)
	$\Delta_4$log(m1r)	.260	.280	.279	.263	.239	.205	.178	.157
		(4.401)	(5.454)	(5.663)	(5.085)	(4.406)	(3.632)	(3.120)	(2.750)
	adj. R^2	.165	.320	.418	.427	.391	.331	.293	.266
3	il-i_{m1}	.296	.283	.261	.208	.165	.097	.028	-.007
		(2.770)	(3.292)	(2.920)	(2.074)	(1.449)	(.752)	(.243)	(.063)
	$\Delta_4$log(m1r)	.403	.414	.401	.360	.319	.258	.200	.165
		(5.569)	(6.126)	(5.535)	(4.446)	(3.554)	(2.549)	(1.977)	(1.668)
	adj. R^2	.202	.376	.479	.471	.419	.339	.291	.262
4	$\Delta_4$rlog(m1r)	.280	.297	.292	.271	.246	.214	.187	.168
		(5.038)	(5.575)	(5.510)	(4.876)	(4.25)	(3.544)	(3.072)	(2.771)
	adj. R^2	.172	.325	.422	.433	.397	.337	.299	.272
5	$il_{real(HICP)}$	.441	.436	.437	.408	.421	.417	.377	.346
		(3.327)	(3.987)	(4.160)	(3.395)	(2.925)	(2.342)	(1.992)	(1.845)
	$\Delta_4$log(m1r)	.363	.376	.361	.330	.310	.282	.246	.223
		(6.431)	(7.474)	(6.902)	(5.451)	(4.561)	(3.657)	(3.163)	(3.036)
	adj. R^2	.215	.398	.500	.492	.458	.391	.332	.273
6	$is_{real(HICP)}$	.211	.217	.223	.219	.221	.195	.153	.125
		(1.038)	(1.217)	(1.367)	(1.453)	(1.521)	(1.394)	(1.159)	(.983)
	$\Delta_4$log(m1r)	.359	.374	.361	.331	.308	.268	.225	.200
		(5.814)	(7.502)	(7.484)	(6.107)	(5.038)	(3.992)	(3.341)	(2.972)
	adj. R^2	.178	.340	.430	.430	.395	.321	.265	.236
7	il-is	.219	.200	.177	.148	.134	.132	.132	.134
		(.835)	(.894)	(.918)	(.858)	(.870)	(.972)	(1.054)	(1.144)
	$\Delta_4$log(divr)	.478	.531	.534	.495	.447	.380	.321	.275
		(4.761)	(6.108)	(6.276)	(5.494)	(4.645)	(3.729)	(3.100)	(2.669)
	adj. R^2	.183	.372	.494	.496	.449	.373	.318	.276

Notes: In parentheses are the Newey and West (1987) heteroskedasticity and autocorrelation consistent t-values. Column h is based on estimation for 1981:Q1to 2001:Q4-h, except for the regressions involving real interest rates, which start in 1982:Q1. The estimates of the intercept term are not shown.

3.2. The benchmark model

To assess the forecast performance of different models a benchmark is necessary. In finding this model, a univariate autoregressive specification of quarterly real GDP growth is considered for the period 1982:Q1 to 2001:Q4. Starting with a lag length of eight, insignificant coefficients are successively set to zero. This exercise results in the following equation:

$$\Delta_1 y_t = \underset{(3.31)}{0.0033} + \underset{(1.78)}{0.198}\Delta_1 y_{t-1} + \underset{(1.77)}{0.198}\Delta_1 y_{t-3} \tag{6}$$

t-statistics in parenthesis; adj. R^2: .060, DW: 2.047, S.E: .0049, Portmanteau $\chi^2(16)$: 14.642 (.551), normality-χ^2 (2): .671 (.715), serial correlation χ^2 (4): .489 (.744), ARCH(1): 3.878 (.053), functional form χ^2 (2): .801 (.453), predictive failure (χ^2 (12)): .657 (.903).

where Portmanteau χ^2 (16) is the Ljung Box test of autocorrelation for the first 16 lags, normality-χ^2 (2) is the Jarque-Bera test for normality based on skewness and kurtosis of residuals, serial correlation χ^2 (4) is the Lagrange Multiplier test of residual serial correlation for the first four lags, ARCH is the autoregressive conditional heteroskedasticity test, where one lag is considered, functional form χ^2 (2) is Ramsey's RESET test where two terms are taken into account and the test of adequacy of predictions is a Chow-test for the last 12 quarters (1999:Q1 to 2001:4). It is apparent that the diagnostic statistics are not significant at the 5 % test level. However the adj. R^2 is unacceptably small. Therefore, a specification in annual growth rates is considered. Once more, insignificant coefficients are set to zero. The preferred model for the whole sample is:

$$\Delta_4 y_t = \underset{(2.78)}{0.0036} + \underset{(16.22)}{1.051}\Delta_4 y_{t-1} - \underset{(3.58)}{0.534}\Delta_4 y_{t-4} + \underset{(2.70)}{0.325}\Delta_4 y_{t-5} \tag{7}$$

t-statistics in parenthesis; adj. R^2: .805, DW: 1.982, S.E: .0055, Portmanteau χ^2 (16): 8.832 (.940), normality-χ^2 (2): 4.870 (.088), serial correlation χ^2 (4): .115 (.977), ARCH(1): 2.005 (.161), functional form χ^2 (2): 2.560 (.084), predictive failure (χ^2 (12)): .662 (.781).

The diagnostic statistics are also not significant at the 5 % test level and thus give no hint to any misspecification of equation (7). In comparison to the former equation, the adj. R^2 is considerably higher. Therefore equation (7) is our benchmark model. The intercept in (7) – together with the autoregressive coefficients – is consistent with a trend real GDP growth of 2 - 2.5 % over the period under consideration.

3.3. Different VARs

We assess the predictive content of M1 relative to other different classes of VARs, including (unrestricted) VARs in terms of the level and of the time difference of the data, cointegrated VARs, or VEC models, and Bayesian VARs (based on the Minnesota prior). For model selection, we do not pre-test the time series properties of individual variables. The preferred model specification is rather selected on the basis of its forecasting performance.[19] According to Sims, Stock, and Watson (1991), the existence of unit roots does not create problems for the estimation of VARs in terms of the level of the variables. Furthermore, due to the low power of univariate unit root tests, an appropriate approximation of the time series properties of the data may be better achieved in the context of multivariate cointegration tests on the respective VAR. If forecasting is the main topic of interest, Clements and Hendry (1998) have shown that VARs in differences may do a good job. Finally, in the context of Bayesian VARs, the Minnesota prior ensures that to the extent that random walk components are important, they are preserved in the model selection.

3.3.1. VAR and VEC models

In what follows, we use different VARs to assess the predictive content of M1. We start with unrestricted VARs since these are good empirical representations of economic time series as long as enough lags are included (Canova (1995))

$$X_t = \Gamma + A_1 X_{t-1} + \dots + A_o X_{t-o} \tag{8}$$

where X_t is the vector of endogenous variables, Γ the matrix of deterministic terms, especially the intercept term and a linear deterministic trend, A_1 to A_o are the symmetric coefficient matrices and o the selected lag order of the VAR. If the variables are not stationary but cointegrated, the VAR is reparameterised as a vector error correction (VEC) model. The rank of the long run matrix is equal to the number of independent cointegrating relationships. If the variables are not cointegrated, the VEC becomes a VAR in first differences.

The selection of the lag order o is based on the information criteria of Akaike (AIC) and Schwarz (SC) (see Lütkepohl (1993)). Ng and Perron (2001), analyse the AIC and SC and show that it is necessary to hold the effective sample size fixed across models to be compared. In the present study, a maximum lag order of 7 is considered and the test period is 1982:Q1 to 2001:Q4. Corresponding to the benchmark model, the values of the criteria are additionally determined for VARs with lags 1 and 4 as well as 1 and 5. We select the lag specification at which a criterion obtains its minimum. For the chosen specification the existence of (no-) autocorrelation is tested by a Lagrange-Multiplier test for autocorrelation of 1 to 8. Moreover, the cointegration hypothesis is checked using Johansen's trace test (Johansen (1995, 2000); Johansen and Juselius (1990)) on the assumption that the intercept term is unrestricted.

[19] Selection of an empirical model by its forecast performance may be a good way to select a forecasting model, but it is not so to select a model for evaluating economic theory or a policy model (see e.g Clements and Hendry (1998)).

3.3.2. A Bayesian VAR

From a Bayesian perspective VARs have been tailored too much towards fitting historical data eventually leading to an overfitting problem. While, in principle, Bayesian VARs (BVARs) comprise as many coefficients as unrestricted VARs, the influence of the data on them is reduced by a statistical procedure to revise prior beliefs in light of the empirical evidence (see, e.g. Todd (1984)).

As the construction of a complete normal prior on a VAR is intractable due to the number of coefficients, the Minnesota prior (Doan, Litterman and Sims (1984)) uses a general prior involving only a few hyperparameters. It has the characteristic feature that the priors on deterministic components are flat, the priors on lags of endogenous variables are independent normal and the means of prior distributions of all coefficients are zero with the exception of the first lag of the dependent variable in each equation which has a prior mean of one. Longer lags have smaller variances around their prior means than shorter lags. Therefore, cross-lag variances have the same relative sizes as the coefficients of own lags. Thus, the prior initially incorporates the assumption that individual time series predominantly evolve like random walks.

3.4. Results from the VAR models

In the multivariate analysis different three-dimensional and four-dimensional variable sets are investigated. Table 2 below shows the variable sets under consideration.

All three-dimensional processes include the real output and a monetary aggregate (in most cases *m1r*). In addition, an interest rate measure is taken into account. Moreover, the four-dimensional processes contain one of the six other variables like oil prices or exchange rates. The combinations from Table 2 yield 34 different processes which, in combination with the four model classes, produced 135 models. To save space only the results of selected models and processes are presented. The others are available from the authors upon request.

Table 2: Different variable sets for the three- and four-dimensional processes

Three-dimensional processes contain the variables:			
First	Second	Third	
y	m1r	il-is, il, is, il_ger-is_ger, il_ger, is_ger, clr-is, is-i_{m1}, il-i_{m1}, $il_{real(PGDP)}$, $il_{real(HICP)}$, $is_{real(PGDP)}$, $is_{real(HICP)}$	
	divr	il-is, il, is	
Four-dimensional processes contain the variables:			
First	Second	Third	Fourth
y	m1r	il-is is il	stock, oilp, oilp€, e, effn, effr

The choices of the lag order selection procedures within unrestricted VARs in levels are provided in Table 3. Using AIC, the lags 1 and 4 or 1 and 5 are selected (column 2, no lags in-between). Nevertheless, the LM-test indicates that the null of no autocorrelation is often rejected at the 5 percent test level for the fifth autocorrelation (column 3). The SC in most cases chooses a lag order of 1 (column 4). For this specification, the null of no autocorrelation is rejected in more cases (column 5). In the context of VEC models, the cointegrating properties are tested for the specifications selected by AIC (column 2 with the test results in column 6) and SC (test results in column 8). If both criteria select the same lag order the specification is given in Table 3. In some cases, the null of no cointegration is rejected for the AIC specification. As the test gives no evidence for a cointegrating rank of two, this implies that no stationary process is considered. (The LM-test of no autocorrelation presents evidence that the specification of one cointegration rank reduces the probability to reject the null of no cointegration (column 7 compared to column 3).) For the SC specification the null of no cointegration is mostly rejected (column 8). This specification implies autocorrelation in the estimated residuals (column 9). Therefore, the preferred VEC models are selected by the AIC.[20]

As the results of these lag order selection tests are not unambiguous, we decided to estimate VARs in levels, VARs in time differences and cointegrated VARS, or VECMs. This procedure should be interpreted as a kind of robustness check of the forecasting results. As we are interested in the forecasting performance of M1 for real activity, we always keep *m1r* and *y* in the models considered.

[20] Mills (1999), p. 36, shows that although theoretically the SC has advantages over the AIC, it would seem that the latter selects the preferred model on more general grounds.

In the context of BVARs, the lag-selection is not as crucial as in unrestricted VARs which build on "hard-shape" exclusion restrictions cutting off the lag length at a certain point. Therefore, the prior builds on an initial lag length which is rather generous (in our case 5 lags with quarterly data). This approach has been maintained for all BVARs presented. The prior is usually tightened with the lag length by choosing a certain decay where we choose a harmonic decay with coefficient 2. This specification gives some improvement over models without lag decays. The BVARs have been set up in terms of levels, including a drift term and with asymmetric priors. These priors reflect the belief that real M1 and the yield spread are more important in affecting GDP than the other way around, and that real M1 is relatively more important in determining GDP than the yield spread. Conversely the remaining relative weights have been set close to zero in the weighting matrix.

Table 3: Lag order estimates of VAR in levels, cointegration tests and rejections of the LM-autocorrelation test

Process with variables	AIC lag order	LM-test	SC lag order	LM-test	Cointegration rank AIC	LM-test for r=1	Cointegration rank SC	LM-test for $r\geq1$
Y, mlr, il-is	1, 5	3	1	1,2	0	1,2	0	1,2,3,4,5
Y, m1r, il	2	-	1	1,5	1	-	1	1
Y, m1r, is	1,5	5	1	1,2,5	1	-	1	1,2
Y, m1r, il_ger-is_ger	1,5	5	1,5	5	0	-	o=1, 1	1,2,3,4,5
Y, m1r, clr-is	1,5	-	1	2	0	2	1	1,2,5
Y, m1r, is-i_{m1}	1,5	5	1	1,2	0	-	1	1,2
Y, m1r, il-i_{m1}	2	-	1	1,5	1	-	1	1,5
Y, m1r, $il_{real(PGDP)}$	1,4	-	1	1,4,5	0	1	1	1,2,4,5
Y, m1r, $il_{real(HICP)}$	1,4	5	1	1,2,5	0	2,3	1	1,2,3,4,5
Y, m1r, $is_{real(PGDP)}$	1,5	5	1	5	0	5	1	1,3,5
Y, m1r, $is_{real(HICP)}$	1,4	1	1	2,3,5	0	1,3	0	1,3
Y, divr, il-is	1, 5	1	1	1	1	-	1	1,2,3
Y, m1r, il-is, stock	1, 5	1,5	1	1,2,5	1	-	1	1,2,5
Y, m1r, il-is, oilp	1	1,5	1	1,5	o=2, 1	5	1	5
Y, m1r, il-is, oilp€	1	1,5	1	1,5	o=2, 0	5	1	5
Y, m1r, il-is, e	1,5	1,2,3	1	1,5	0	1,2	0	1,2
Y, m1r, il-is, eeffn	1,5	1,2,3	1	1,5	1	2,3	1	1,2
Y, m1r, il-is, eeffr	1,5	2,3	1	1,2,3	0	1,2,8	1	1,2,3

Notes: AIC: Akaike information criterion, LM-test: Rejection of the Lagrange-Multiplier test of autocorrelation for lag order i, where i = 1,2,…,8. The cells of the respective column contain the lag orders o, where the null hypothesis of no autocorrelation at this lag is rejected at the 5 percent significance level. SC: Schwarz-criterion, Cointegration rank AIC: Cointegration rank test of Johansen, where the lag order of the corresponding unrestricted VAR is determined by the AIC. If the AIC (SC) lag order estimates are identical to the SC (AIC) lag order estimates, the lag order is augmented by one (is set to unity). Cointegration rank SC: Cointegration rank test of Johansen, where the lag order of the corresponding unrestricted VAR is determined by the SC. Test period is 1982:Q1 to 2001:Q4 and 1983:Q1 to 2001:Q4 for the test regressions involving real interest rates.

The out-of-sample forecasts are computed with a recursive regression method.[21] A recursive estimation of the system yields a series of out-of-sample forecasts for the different forecasting horizons h=1,…,8. The starting coefficients are computed over the period 1980:Q1 to 1993:Q4. Using these coefficients, the first forecasts are determined. The forecast errors are the differences between the forecast of y and the historical values of y. In a next step, the sample is extended by one quarter and the system is re-estimated to calculate the forecasts again. This procedure is continued until the end of the sample. It is conducted for the benchmark model (10) and the different VAR models.

The accuracy of forecasts can be judged by various statistics about the forecast errors. In this study the root mean square forecast errors (RMSFE) are used. To assess the relative predictive accuracy of two forecasting models, the Diebold Mariano test is selected, which has an asymptotic normal distribution (see Diebold and Mariano (1995)).[22] The longest interval for all forecasts is from 1994:Q1 to 2001:Q4, hence the maximum length of the forecast period is 32. The values of the RMSFE for real output of the benchmark model are given in the first row of Table 4. In general, they increase with the forecasting horizon. The results of the other approaches are all given relative to this benchmark (RMSFE of the alternative model divided by RMSFE of the benchmark model). Values greater than one indicate that the alternative model is worse than the benchmark model.

Considering VARs in levels with or without a deterministic trend all models are worse than the benchmark (not shown, but available upon request). Very often the differences are even significant at the 5 or 1 percent level. Up to forecast horizon 3 the second-best model after the benchmark model is the one with the additional variable (*clr-is*), for the horizons 4 to 6 the model with *is* and *oilp* and for the two longest horizons 7 and 8 the model with the Divisia aggregate and *il*. It is worth noting that the differences are slightly smaller if VARs in levels without a deterministic trend are estimated. However, in any case this alternative does not dominate the benchmark either. The results of the cointegrated VARs, or VEC models, point in the same direction (not shown, but available upon request). Often the results are better than the results of the VARs in levels. Nevertheless, only for h=1 some variants of this model class outperform the benchmark. But the difference is in no case statistically significant at conventional significance levels.

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[21] A comparison of out-of-sample and in-sample tests of predictability may be found in Inoue and Kilian (2002).

[22] See the appendix for a description of the test.

Table 4: Root mean square forecast errors for VARs in first differences in relation to the root mean square forecast error of the benchmark equation

Model/Process with variables	Specification	Forecast horizon *h*							
	O	1	2	3	4	5	6	7	8
Benchmark	1,4,5	.0040	.0062	.0082	.0097	.0112	.0126	.0124	.0124
y, m1r, il-is	1	0.829#	0.837+	0.790*	0.781*	0.734*	0.750*	0.841+	0.844#
y,m1r,il	1	0.787+	0.796+	0.731*	0.751*	0.720*	0.743*	0.848+	0.836#
y,m1r,is	1	0.813#	0.826+	0.776*	0.778*	0.733*	0.752*	0.846+	0.841#
y,m1r,il_ger-is_ger	1	0.823#	0.829+	0.782*	0.776*	0.734*	0.753 *	0.848+	0.853
y,m1r,clr-is	1	0.815#	0.838#	0.783*	0.784*	0.729*	0.746*	0.833+	0.824#
y,m1r,is-i_{m1}	1	0.807+	0.821+	0.772*	0.777*	0.732*	0.751*	0.845+	0.839#
y,m1r,il-i_{m1}	1	**0.778+**	**0.780+**	**0.704***	**0.732***	**0.709***	**0.738***	0.852#	0.841#
y,divr, il-is	1	0.836#	0.843#	0.820+	0.837*	0.796*	0.798*	0.864+	0.876
y,m1r,$il_{real(PGDP)}$	1	0.815+	0.832+	0.806+	0.808+	0.761*	0.760*	0.815*	0.792*
y,m1,$il_{real(HICP)}$	1	0.831#	0.832+	0.795*	0.790*	0.743*	0.748*	**0.810***	**0.786+**
y,m1,$is_{real(PGDP)}$	1	0.813+	0.823+	0.796*	0.804+	0.762*	0.766*	0.822+	0.803+
y,m1r,$is_{real(HICP)}$	1	0.831#	0.831+	0.791*	0.787*	0.743*	0.750*	0.813*	0.792+
y, m1r,il-is,stock	1	0.828#	0.854#	0.828+	0.818*	0.775*	0.780*	0.849+	0.809*
y,m1r,il-is,oilp	1	0.809+	0.821+	0.783*	0.786*	0.739*	0.750*	0.825+	0.804+
y,m1r,il-is,oilp€	1	0.844#	0.868	0.820+	0.806+	0.748*	0.753*	0.820+	0.796+
y,m1r,il-is,e	1	0.889	0.903	0.871#	0.828#	0.754+	0.757+	0.838+	0.836#
y,m1r,il-is,eeffn	1	0.875	0.911	0.888	0.851#	0.775+	0.766+	0.829+	0.805+
y,m1r,il-is,eeffr	1	0.871	0.904	0.878#	0.845#	0.773+	0.766*	0.831+	0.806+

Notes: The column "Specification" includes the lag order (o) of the VAR in first differences. The cells contain the root mean square forecast error of the process divided by the root mean square forecast error of the benchmark model. #,+,* denote significance at the 10, 5, 1 percent level, respectively. Normal distributed statistic using the critical values 1.64486; 1.95997; 2.55758. The bold values give the lowest RMSFE for this forecast horizon for all approaches.

The results obtained on the basis of the BVAR models also show that it was not possible to outperform the univariate benchmark model using a BVAR (not presented, but available upon request). This result is in line with recent findings in Canova (2002). Except for one-step-ahead forecasts, BVARs are able to outperform the respective non-Bayesian VARs in levels over all horizons. The best performing model is the one containing the Divisia aggregate. Second to these models are BVARs containing real interest rate measures in addition to M1.

The situation is completely different with respect to difference VARs. Table 4 shows the results of selected VAR models with only variables in first difference (and no long-run relations), where a lag order of one is selected.[23] It is apparent that all models are better than the benchmark model for the whole range of forecast horizons. The reduction in the RMSFE is 20 to nearly 30 percent. The best model includes the variables y, $m1r$ and $(il–i_{m1})$ for the horizon h = 1 to 6 (see the bold figures in Table 4). For h = 7 and 8, the best model is y, $m1r$ and $il_{real(HICP)}$. Having in mind that the differences between the benchmark model and the alternative model are not significant if they are less than 10 percent this implies that the choice of the variables has only a small effect. It seems that it is more important to choose the “right” general class of VAR models.[24]

4. Summary and conclusions

The purpose of this paper was to assess the forecast performance of narrow M1 for real activity, measured by the growth rate of real GDP, in the euro area. After a brief review of the empirical literature, we recall a number of theoretical arguments why money might be useful for real developments beyond the effects of monetary policy captured by a short-term interest rate.

Using a single equation methodology recently proposed by Hamilton and Kim (2002), we find that M1 has important indicator properties with respect to real output, even after controlling for other variables. In contrast to findings for the U.S., the evidence in the euro area seems to suggest that – over the sample period under investigation (i.e. 1981-2001) – M1 outperforms the yield spread in terms of its predictive content for cyclical movements in GDP. These properties are confirmed also when looking at a broader information set comprising non-monetary indicator variables. Hence, the findings appear to be quite robust when extending the information set to other relevant variables.

Comparing the out-of-sample forecasting performance of different classes of VAR models with a univariate benchmark model 1 to 8 quarters out, only VARs in first differences are able to outperform the univariate benchmark model and yield significantly better forecasting results at all forecast horizons. This may be due to the fact that the evidence for the existence of cointegration relationships is not unambiguous and that most level variables seem to contain a unit root. As we are only interested in short-term forecasting, economic theory would also suggest that the dynamic part is the

[23] In most cases, where the AIC chooses a lag order of 1 and 4 or 1 and 5 for the level approach, a lag specification of 1 and 4 or 1 and 5 for the VARs in first differences does not yield better results than those presented.

[24] A single equation approach with D4y, D4yt-1, D4m1r and one or more of the variables taken into account in the Tables 3 to 6 would not be able to outperform the benchmark model with dynamic forecasts irrespective of the forecast horizon considered.

essential one. Moreover, as Clements and Hendry (1998, ch. 6 and 7) show, vector autoregressions in first differences are better able to capture structural breaks during the forecast period than VECMs or VARs in levels, even if they are mis-specified. In their view, the use of growth-rate data is one possibility to make forecasts more robust to shifts (and measurement errors) in the levels of variables. Sometimes it is simply the case that one-off innovations affect the levels, but do not persist, so that rates of growth are not affected.

The best models for the shorter horizons (up to six quarters) is the one which - besides real M1 and real GDP growth – includes the spread between the yield on government bonds and the own rate of return of M1. For the two longest horizons (7-8 quarters), the best model additionally takes into account the real long-term interest rate.

One interesting field of future research would be to elaborate in more detail on the theoretical justifications on the indicator properties of M1 for real activity. Empirically, one could analyse which of the components of M1, i.e. currency and overnight deposits, are responsible for the results. Moreover, it may also be interesting to examine the model performance at forecast horizons longer than 2 years or use other metrics as the root mean squared error, e.g. the direction of change or the general forecast-error second moment matrix (see Clements and Hendry, 1998, ch. 3.6). And finally, as the primary goal of the monetary policy of the ECB is to maintain price stability, it is of overriding importance to assess how changes in demand conditions indicated by movements in M1 affect price developments.[25]

[25] Leading indicator properties of M1 for prices have also been analysed in Nicoletti-Altimari (2001).

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Appendix 1: List of variables and symbols

ß	discount factor
c	real private consumption expenditure
clr	composite lending rate
divr	real divisia aggregate
$\Delta_{1(4)}$	logarithmic first (fourth) difference
e	US-$/€ exchange rate
eeffn	nominal effective exchange rate of the €
eeffr	real effective exchange rate of the €
E	expectations operator
ε	elasticity
h	forecast horizon
HICP	Harmonised Index of Consumer Prices
i	interest rate
is	short-term interest rate
il	long-term interest rate
i_m	own rate of interest of money
i_{ger}	interest rate in Germany
i_{real}	real interest rate
m	real money balances
m1r	real M1 calculated with the GDP deflator
oilp	oil prices (in $)
oilp€	oil prices (in €)
pgdp	GDP deflator
stock	world stock prices
u	per-period utility
y	real income, real GDP

Appendix 2: The Diebold-Mariano test

The accuracy of forecasts can be assessed by various statistics about the forecast errors. In this study, the root mean square forecast errors are selected. To check the relative predictive accurarcy of two forecasting models, different test statatistics are suggested and analysed by Diebold and Mariano (1995). Their preferred test statistic is

$$\hat{d}_F = F^{-1/2} \frac{\sum_{t=T+1}^{S-h} (\hat{e}^2_{0,t+h} - \hat{e}^2_{1,t+h})}{\hat{\sigma}_F}$$

where T denotes the length of the estimation period, F is the length of the forecast period, hence $S=T+F$, $h \geq 1$ is the forecast horizon, $\hat{e}^2_{0,t+h}$ and $\hat{e}^2_{1,t+h}$ are the squared forecast errors of the benchmark model and the alternative model, respectively, using consistent estimators, and

$$\hat{\sigma}_F = \frac{1}{F}\sum_{t=T+1}^{S-h}(\hat{e}^2_{0,t+h} - \hat{e}^2_{1,t+h})^2 + \frac{2}{F}\sum_{j=1}^{l_F} \omega_j \sum_{t=T+1+j}^{S-h}(\hat{e}^2_{0,t+h} - \hat{e}^2_{1,t+h})(\hat{e}^2_{0,t+h+j} - \hat{e}^2_{1,t+h+j}),$$

where $\omega_j = 1 - \frac{j}{l_F + 1}$, $l_F = o(F^{1/4})$. The parameter ω_j is the Bartlett weight and l_F

is the truncation parameter depending on the converging rate of F. For $F = 32$ we choose $l_F = 2$. The test statistic is denoted the Diebold-Mariano (dm) test. The null of equal predictive ability is

$$H_0 : E\,(\mathrm{e}^2_{0,t+h} - e^2_{1,t+h}) = 0$$

while the alternative is

$$H_1 : E\,(\mathrm{e}^2_{0,t+h} - e^2_{1,t+h}) \neq 0$$

Under the null hypothesis, this statistic has an asymptotic standard normal distribution. Harvey, Leybourne and Newbold (1997 and 1998) analyse the test statistic using an extensive Monte Carlo design, and find that the test has good size and fairly good power properties.

Annex A

ECB Press Release: The ECB's monetary policy strategy

8 May 2003

After more than four years of conducting monetary policy for the euro area, the Governing Council of the ECB has undertaken a thorough evaluation of the ECB's monetary policy strategy.

This strategy, which was announced on 13 October 1998, consists of three main elements: a quantitative definition of price stability, a prominent role for money in the assessment of risks to price stability, and a broadly based assessment of the outlook for price developments.

More than four years of implementation have worked satisfactorily. Nevertheless, the Governing Council deemed it useful to evaluate the strategy in the light of this experience, taking into account the public debate and a series of studies undertaken by staff of the Eurosystem.

"Price stability is defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%. Price stability is to be maintained over the medium term." Today, the Governing Council confirmed this definition (which it announced in 1998). At the same time, the Governing Council agreed that in the pursuit of price stability it will aim to maintain inflation rates close to 2% over the medium term. This clarification underlines the ECB's commitment to provide a sufficient safety margin to guard against the risks of deflation. It also addresses the issue of the possible presence of a measurement bias in the HICP and the implications of inflation differentials within the euro area.

The Governing Council confirmed that its monetary policy decisions will continue to be based on a comprehensive analysis of the risks to price stability. Over time, analysis under both pillars of the monetary policy strategy has been deepened and extended. This practice will be continued. However, the Governing Council wishes to clarify communication on the cross-checking of information in coming to its unified overall judgement on the risks to price stability.

To this end, the introductory statement of the President will henceforth follow a new structure. It will start with the **economic analysis** to identify short to medium-term risks to price stability. As in the past, this will include an analysis of shocks hitting the euro area economy and projections of key macroeconomic variables.

The **monetary analysis** will then follow to assess medium to long-term trends in inflation in view of the close relationship between money and prices over extended horizons. As in the past, monetary analysis will take into account developments in a wide range of monetary indicators including M3, its components and counterparts, notably credit, and various measures of excess liquidity.

This new structure of the introductory statement will better illustrate that these two perspectives offer complementary analytical frameworks to support the Governing Council's overall assessment of risks to price stability. In this respect, the monetary analysis mainly serves as a means of cross-checking, from a medium to long-term perspective, the short to medium-term indications coming from economic analysis.

To underscore the longer-term nature of the reference value for monetary growth as a benchmark for the assessment of monetary developments, the Governing Council also decided to no longer conduct a review of the reference value on an annual basis. However, it will continue to assess the underlying conditions and assumptions.

The ECB will today publish on its website a number of background studies prepared by its staff which, together with papers published earlier, served as input into the Governing Council's reflections on the ECB's monetary policy strategy.

Annex B

Further references to relevant papers already published by the ECB

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