EUROPEAN CENTRAL BANK

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ENERGY MARKETS AND THE EURO AREA MACROECONOMY

JUNE 2010

Structural Issues Report

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STRUCTURAL ISSUES REPORT

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ABBREVIATIONS

COUNTRIES

BE	Belgium
DE	Germany
IE	Ireland
GR	Greece
ES	Spain
FR	France
IT	Italy
CY	Cyprus
LU	Luxembourg
MT	Malta
NL	Netherlands
AT	Austria
PT	Portugal
SI	Slovenia
SK	Slovakia
FI	Finland
UK	United Kingdom
JP	Japan
CH	Switzerland
US	United States

OTHERS

CO2	carbon dioxide
CO2-e	carbon dioxide equivalent
DSGE	dynamic stochastic general equilibrium
ECB	European Central Bank
EIA	Energy Information Administration
EMU	Economic and Monetary Union
ESCB	European System of Central Banks
ETS	Emission Trading Scheme
EU	European Union
EUR	euro
GDP	gross domestic product
GJ	gigajoule
GHG	greenhouse gas
HICP	Harmonised Index of Consumer Prices
HICPX	HICP excluding energy
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
IMF	International Monetary Fund
IOT	input-output tables
kWh	kilowatt hours
LNG	liquefied natural gas
mb/d	million barrels per day
MMBtu	million British thermal units
Mt	million tons
MWh	megawatt hours
NACE	statistical classification of economic activities in the EU
NCB	national central bank
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PMR	OECD Product Market Regulation database
PPI	Producer Price Index
ppm	parts per million
ppmv	parts per million by volume

S(VAR)	(Structural) Vector AutoRegression
toe	tons of oil equivalent
TWh	terawatt hours
USD	US dollar

In accordance with EU practice, the EU Member States are listed in this report using the alphabetical order of the country names in the national languages.

EXECUTIVE SUMMARY

Energy plays an important role in modern society, touching almost every aspect of our daily lives. It provides fuel for transport and heating, power for domestic uses and affects almost every business in industry, services and agriculture. Indeed energy is so inextricably interlinked with our modern lives that we take it for granted until either a system failure (e.g. blackouts or shortages) or large price movements (as witnessed in the 1970s and again since 1999) remind us of its importance. The price gyrations over the last number of years have been particularly dramatic. International oil prices fluctuated around USD 20 per barrel in the 1990s, before rising, especially since 2004, to reach an all time high of close to USD 150 per barrel in mid-2008, and subsequently declining to USD 30 per barrel by end-2008. Since then, oil prices have rebounded and averaged around USD 75 per barrel in the final quarter of 2009.

Central banks, when facing energy price fluctuations, must understand their nature and how they will propagate through the economy to affect output and prices. The nature of energy price fluctuations refers to their driving forces, whether they are driven by fundamental demand, supply-side factors or financial market activity, and to their persistence. An increase in international energy prices can, for example, be a short-term phenomenon (as witnessed in 1990 during the Persian Gulf War) or a medium to long-term change in the terms of trade driven by structurally rising demand, as seems to have been the case over the past decade. Energy supply shocks, which have countervailing impacts on inflation and activity, pose particular challenges for monetary policy-makers. The propagation of shocks, on which most of this report will focus, depends on the energy mix, the energy dependency of a country and the energy intensity of consumption and production as well as the effective competition in energy markets, which are generally characterised by a high degree of complexity. Moreover, the transmission of energy price shocks is shaped by the real adjustments in the economy in the short and medium to long run, as well as structural determinants of the pass-through to consumer prices. The combination of these factors and the policy response of central banks eventually explain the transmission of energy price fluctuations to overall inflation.

Two key factors determine the vulnerability of the euro area economy to large energy price changes in international markets: energy intensity and energy dependency. The energy intensity of the euro area (i.e. energy used per unit of output) has, in common with other industrialised economies, generally fallen over the past 50 years owing to technological advances as well as sector shifts. On its own, this trend, coupled with the increased diversification of energy sources, would have served to attenuate the impact of international energy price changes. However, despite an increase in electricity generated within the euro area from nuclear and renewable sources, the overall energy dependency (i.e. the ratio of net energy imports – including intra-euro area imports – to energy consumption) of euro area countries has remained high, with two-thirds of overall energy consumption being imported, and oil remaining the main component of final energy consumption. High energy dependency may also have implications for energy security. In terms of both intensity and dependency, substantive diversity exists across markets and countries. Country energy markets remain largely national or regional in nature, although their integration has increased. Further integration, in particular in gas and electricity markets, would not only have beneficial impacts on security, but could also help to cushion idiosyncratic energy price changes and improve overall efficiency and competition in European energy markets.

Looking ahead, the main factors impacting on the future of euro area energy markets point to a further reduction in the degree of energy intensity making the euro area economy less vulnerable to price changes. However, energy dependency is expected to remain high and energy prices may remain volatile. Energy supply may have been adversely affected by the downscaling of investment during the crisis, and tightness in the global energy market may re-emerge as global activity growth resumes. In recent years the increasing "financialisation" of commodity markets, combined with high global liquidity, may have had some impact on commodity price volatility and, in perspective, this factor is likely to continue to play a role. Similarly, climate change policies, particularly those related to greenhouse gas emissions, may also influence price volatility. All in all, the outlook for energy markets and prices remains uncertain in the long run.

The impact of energy price changes depends not only on their driving force, but also on their persistence and how they are absorbed by the economy, including the monetary policy response. The adjustment costs are to a significant extent determined by the structure and the flexibility of the economy. In the short run, they cannot be easily countered by changes in the production process and impact on firms' costs or households' real income, thereby affecting investment and consumption. These effects show strong cross-country heterogeneity linked to the degree of energy intensity in consumption and production. However, the transfer of income emerging from a deterioration of terms of trade associated with higher international energy prices may be counteracted to some extent by the degree to which countries benefit from higher demand from energy-exporting countries. In this respect, countries that are favourably positioned in terms of export specialisation, historical ties and geographical proximity are better able to compensate the moderation in domestic demand through higher exports. There are some indications that the overall impact of energy fluctuations on activity may have moderated compared with the 1970s and early 1980s, owing not only to decreased energy intensity, but also to the evolution of other factors including wage-setting institutions and monetary policy.

In the long run, increases in the relative price of energy may lead to substitution effects and to a reduction in the overall energy intensity of production and consumption. Therefore the impacts of long-run relative price changes are stronger the more energy intensive the economy and the less flexible the production process. In addition, the losses of output and labour input into the production process are less pronounced if wages and prices allow for a more speedy adjustment process.

Wage and price-setting behaviour and credibility of monetary policy are key determinants of how energy prices feed into inflation over a medium-term horizon. The pass-through of energy prices can be broken down into direct and indirect first-round and second-round effects. Direct first-round effects refer to the impact on consumer energy prices. The indirect first-round effect captures the impact of energy prices on producer and distribution costs which then feeds into consumer prices. Second-round effects arise when energy prices impact on wages, profit margins and inflation expectations. First and second-round effects are interlinked and difficult to disentangle empirically, yet conceptually different. Monetary policy can do little about the first-round effects of energy price shocks, in particular international oil price changes, but it shapes second-round effects.

The direct pass-through of changes in international oil prices to consumer prices for liquid fuels is very quick (mainly within two to three weeks), complete and, at the aggregate level, there is little evidence of substantial asymmetry. For gas prices the pass-through takes longer, approximately six to nine months; for electricity prices an estimate of the pass-through is more difficult because of price regulation, cost structures and market arrangements. Owing to the full pass-through into pre-tax prices for liquid fuels and natural gas, as well as the important role of excise taxes and the broad constancy of production margins in these sectors, the elasticity (percentage response) of consumer energy prices with respect to crude oil prices is larger the higher the level of crude oil prices. The level of excise taxes also impacts on the elasticity of consumer oil prices:

other things being equal, a higher level of excise taxes increases the level of consumer energy prices, but dampens their elasticity.

Price levels vary across energy markets owing to taxes, energy policies and cost structures. Differences in competition and market concentration as well as the degree of vertical integration also exert an influence. Although European energy markets have been liberalised and competition has increased, de facto competition still remains lower than de jure competition. Pre-tax price dispersion remains sizeable in electricity and gas markets. Nonetheless, evidence can be found that past market liberalisation has supported price reduction in these sectors. Further reforms towards a more competitive environment creating a level playing field across the euro area would diminish price dispersion and benefit consumers and firms.

Results from different econometric approaches suggest that indirect first and second-round effects account for roughly half of the overall impact of energy price fluctuations on non-energy components of inflation. At the country level there are important differences in the transmission of energy commodity prices to non-energy consumer prices. Whilst this is attributable in part to sector specialisation and the intensity of energy use, a more important factor is the automatic link between wages and inflation through formal indexation schemes in some countries, which is found to have a role in amplifying the transmission of oil price changes to the prices of non-energy products. With regard to both energy intensity and wage-setting behaviour, there is some evidence of a reduced impact on inflation compared with the 1970s and early 1980s. Further progress in reducing downward wage rigidities and wage indexation could prevent unnecessary inflationary pressures in the future.

Inflation expectations can become unanchored by energy price changes if monetary policy is not credible. However, in an environment with a credible central bank, energy price fluctuations should not affect inflation expectations over the medium to long term. The fact that, despite the recent period of high and volatile energy prices, medium to long-term inflation expectations in the euro area have remained at levels consistent with price stability, the primary objective of the ESCB, can be seen as a sign of its credibility.

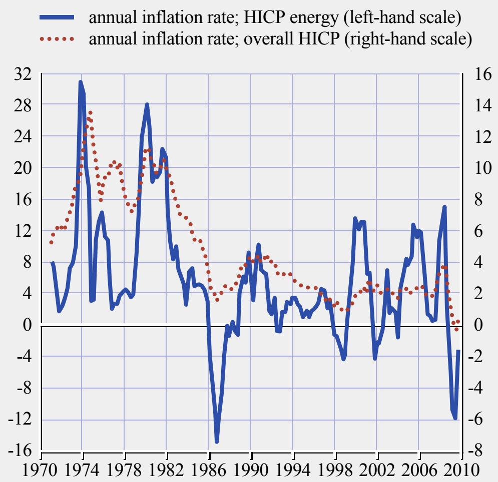
The ability of the euro area to weather future energy price fluctuations relies on the continued stability-oriented conduct of monetary policy and appropriate government and institutional policies. The promotion of energy efficiency and the flexibility of the euro area economies remain crucial in order to minimise the costs of energy price volatility.

INTRODUCTION

This report aims to analyse euro area energy markets and the impact of energy price changes on the macroeconomy from a monetary policy perspective. The core task of the report is to analyse the impact of energy price developments on output and consumer prices. Nevertheless, understanding the link between energy price fluctuations, inflationary pressures and the role of monetary policy in reacting to such pressure requires a deeper look at the structure of the economy. Energy prices have presented a challenge for the Eurosystem, as the volatility of the energy component of consumer prices has been high since the creation of EMU (see Chart 1). At the same time, a look back into the past may not necessarily be very informative for gauging the likely impact of energy price changes on overall inflation in the future. For instance, the reaction of HICP inflation to energy price fluctuations seems to have been more muted during the past decade than in earlier periods such as the 1970s.

Chart 1 Long-term evolution of overall HICP and HICP energy inflation

(percentages)



Sources: Eurostat, national sources and Eurosystem staff calculations.

Chapter 1 provides an overview of energy markets, presenting both the supply (primary production, imports and trade, and secondary transformation) and demand (consumption and intensity) sides. The regulatory and policy aspects and market structures are also considered as they have a significant bearing on the functioning of the economy.

Chapter 2 considers the impact of energy prices on economic activity. First, the conceptual framework for the channels through which energy price movements impact on activity is outlined, with particular emphasis on the distinction between supply and demand-side channels, and empirical estimates of the impact on activity derived from large-scale macroeconometric models are presented. Second, the consequences of energy price changes for output in the long run are also considered. The main channels through which this may occur are discussed and then some empirical evidence in support of these effects on long-run output is presented. Finally, as the euro area is a large net importer of energy, energy price movements may have a significant impact on trade balances specifically and macroeconomic imbalances generally. This issue is addressed in the final part of the chapter.

Chapter 3 discusses energy prices and inflation in some detail. The discussion is structured along a stylised framework for considering price developments: direct and indirect first-round effects and the possibility of second-round effects. Given their relatively immediate and substantial impact, direct first-round effects on consumer energy prices are discussed with a distinction made between liquid fuel (i.e. transport and heating) prices and non-oil energy prices (primarily gas and electricity). Several approaches are then adopted to assess indirect first and second-round effects in view of the difficulties in distinguishing and empirically identifying these effects. Indirect first-round effects are analysed using different approaches: input-output analysis, small-scale structural models and larger macroeconometric models. Energy price changes may also give rise to second-round effects, which are more likely to be a function of institutional features of the economy, in particular the structure of product and labour markets, than of features of the energy markets themselves. These effects are mainly identified using larger macroeconometric models.

There are other highly relevant issues – such as the international drivers of energy prices, energy security and environmental issues – which are not part of the core of this report. They are nevertheless addressed in boxes, since they clearly have repercussions on the economic outlook for the euro area. In the same way, the report highlights the role of inflation expectations in the conduct of monetary policy.

1 OVERVIEW OF ENERGY MARKETS

This chapter provides the basis for further analysis. It describes the three main stages of euro area energy markets – primary energy extraction, final energy production (in particular electricity generation) and energy consumption. In doing so, it presents evidence on the energy dependency and intensity of the production process and consumption. The main pattern and major trends in the energy mix of production and consumption provide the background to which later chapters will refer in explaining the macroeconomic impact of energy prices. Further, the chapter gives an account of energy market regulations and market structures, which are relevant for cross-country price differentials. To complete the picture on the economic policy setting, reference is also made to European energy policy focusing on energy security and climate change. Aspects of energy security and environmental impact, as well as the international drivers of energy prices are discussed in boxes.

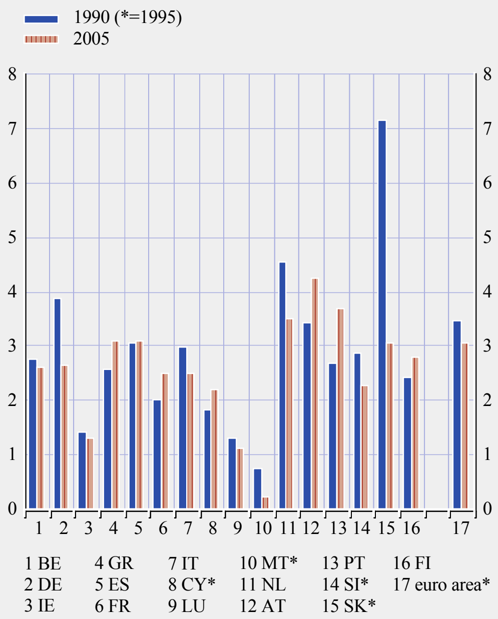
1.1 ENERGY PRODUCTION AND DEPENDENCE

1.1.1 ENERGY PRODUCTION

Energy-related activities represented around 3% of total euro area gross value added in 2005 (see Chart 2) and this share has remained broadly stable over the last 15 years. However, this broad stability hides noteworthy composition effects. There has been a decreasing trend in primary energy production that was broadly compensated by an increase in final energy production. In terms of employment, the energy sectors accounted for over one million jobs in 2005, corresponding to around 1% of employment in the euro area (see Chart 3). Employment in the energy sector has been declining both in relative (1.3% of total employment in 1990) and in absolute terms. Given this relatively small size, the impact of the energy sector on the economy derives primarily from the fact that it represents a crucial production factor and consumption component, rather than from its direct contribution to value added and employment.

Chart 2 Share of energy sector in value added

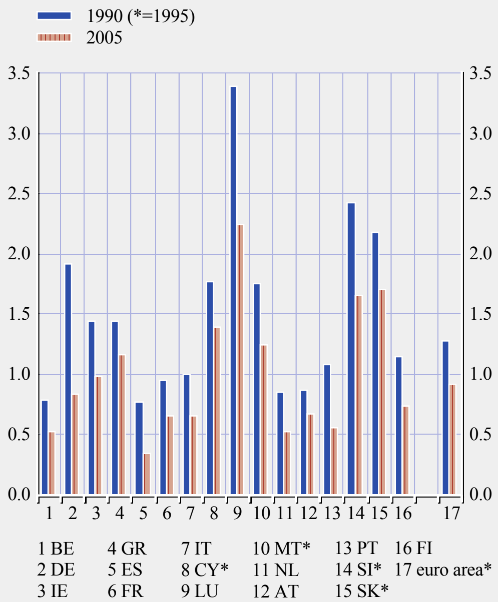
(percentages)



Sources: EU KLEMS and Eurosystem staff calculations.

Chart 3 Share of energy sector in employment

(percentages)



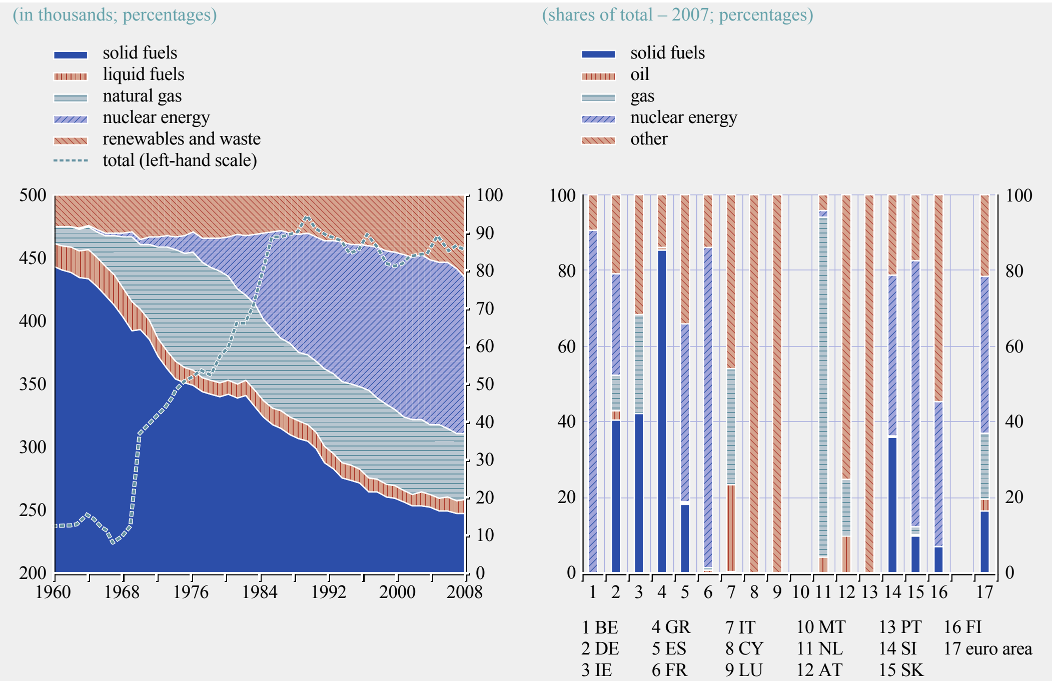
Sources: EU KLEMS and Eurosystem staff calculations.

Primary energy production increased substantially in the 1970s and early 1980s and has remained fairly stable since then. The change in the composition of primary energy, by comparison, has been more continuous. The share of solid fuels has declined almost constantly, whilst natural gas and nuclear emerged as key energy sources in the 1970s and 1980s respectively. More recently, the share of renewable energy sources has started to grow to more significant proportions, stemming mainly from combustible renewables and waste and, to a lesser extent as yet, from wind and solar energy. Before this most renewable energy was derived from hydro sources. Nowadays, primary energy production in the euro area comes mostly from nuclear power, representing around 40% of total production (see Chart 4, left panel). The second largest primary energy product is the category "other", which includes renewable primary energy production (hydroelectric, solar, wind, geothermal, biomass) and waste. This category represented 22% of total primary energy production in 2007, while solid fuel (coal and peat) and gas represented 16% and 18% respectively.

Primary energy production is very heterogeneous across euro area countries (Chart 4, right panel). Belgium, Germany, Spain, France, Slovenia, Slovakia and Finland have large shares of nuclear energy, while other countries have not adopted this technology. Other relevant cases in terms of energy production are associated with countries' natural endowments, such as the Netherlands with a sizeable production of gas and Greece with a relevant contribution of solid fuels. The evolution from 1990 to 2007 generally matches the aggregate trend (see Chart A1 in Annex 1) that solid fuels have decreased their share in most euro area countries, while nuclear and renewable energies increased in importance. This pattern is especially important in Germany, but is also visible in Belgium, Spain, France, Slovenia and Slovakia.

Approximately 40% of the primary energy supply, including own and imported primary

Chart 4 Share of primary energy production by fuel type



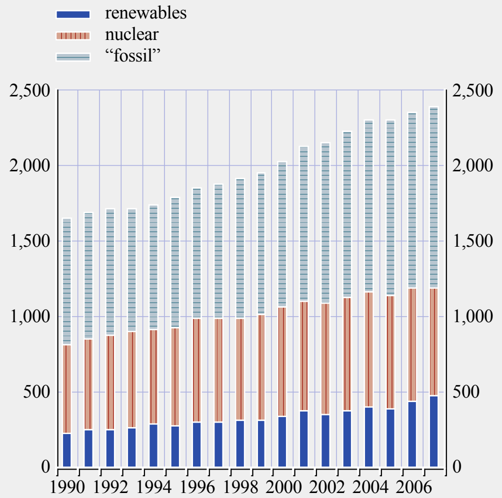
Sources: Eurostat, IEA and Eurosystem staff calculations.

energy, is used to generate *electricity*, which is a key step in the transformation of primary energy for final consumption. Total electricity generated in the euro area has grown by an average of 2.2% per annum from 1,630 TWh in 1990 to 2,319 TWh in 2007 (see Chart 5). This rate of growth is broadly in line with average euro area GDP growth over the same period. As electricity is not easily stored supply must match demand in real time or else the stability of the system may be compromised. The average annual rate of growth in electricity generated was lowest in Germany and Slovakia at 0.9% per annum. Ireland, Spain, Cyprus, Luxembourg and Malta all had annual growth rates in excess of 4% per annum – see Table A1 in Annex 1.

In 2007 the largest single source of energy for electricity generation was nuclear fuel, accounting for 31% at the aggregate euro area level. All the so-called conventional thermal power plants grouped together accounted for 52%. Among the conventional thermal power plants, natural gas had the most weight, at 22%.[1]

Chart 5 Evolution of electricity generated in euro area by fuel type

(TWh)



Sources: Eurostat and Eurosystem staff calculations.
Notes: Renewables comprises hydropower, geothermal, biomass, wind turbines, photovoltaic, solar thermal, municipal solid waste, wood, biogas and industrial waste. "Fossil" denotes non-renewable conventional thermal and comprises coal, lignite, oil, gas and other thermal stations.

Coal and lignite accounted for 15% and 10% respectively. Hydropower plants and wind turbines represented 10% and 4%. The share of the latter has been increasing rapidly as has that of biomass. Oil was used relatively sparingly with a weight of 4%.[2]

In terms of trends since 1990, a number of features are noteworthy. First, although nuclear fuel remains the largest single source of input fuel, its share has declined from a peak of 38% in the early 1990s to 31% in 2007. Second, the overall constancy of the share of non-renewable conventional thermal power plants – around 50% – masks considerable shifts in the relative share of different types of conventional fuels, with an increase in natural gas and declines in coal and oil.[3] Third, the share of renewables in electricity generation has increased from around 15% in the early 1990s to 20% currently. Electricity generated from renewable sources has risen by an average of 4.4% per annum since 1990. The increasing importance of renewable energy in electricity generation (which has occurred notwithstanding some decline in the share of hydropower) is mainly attributable to substantial growth in recent years in the use of sources such as biomass and wind turbines – these have increased by 15% and 25% per annum respectively over the last five years.

The three countries with the most diversified portfolio of fuel types used in electricity

1 The preference for gas-fuelled power stations is motivated by several factors. Gas power plants are more efficient and can be used to satisfy both intermediate and peak load demand; natural gas combustion is also less carbon intensive. Gas-fired power stations provide the marginal supply of electricity.

2 Remaining fuel types (geothermal, derived gas, miscellaneous, photovoltaic, solar, municipal solid waste, wood, biogas and industrial waste) only had marginal shares in terms of overall electricity generation.

3 Natural gas has almost tripled its share from 8% in 1990 to 22% in 2007. This development has occured in most euro area countries. The share of coal has decreased from around 20% in 1990 to 15% in 2007, whilst that of lignite has remained broadly constant at around 10%. In terms of climate change, lignite and coal, in particular the former, result in significantly higher carbon emissions relative to, for example, natural gas. The fall of the oil share from around 10% in the early 1990s to 4% has been driven primarily by Italy, which reduced the share of oil in electricity generation from around 50% in the early 1990s to around 10% in 2007.

generation were Germany, Spain and Finland (see Table A1 in Annex 1 for an overview of key individual country electricity characteristics). Unsurprisingly, small countries tended to have relatively undiversified electricity generating systems. Among the larger countries, France is a notable exception as it derives the largest share of its electricity from nuclear fuel.

Another key feature of electricity markets is the relatively small amount of *trade* in comparison with other more storable fuel types such as oil, gas and coal. A progressive increase of trading volumes since the 1970s has been a feature of European economic integration. According to figures from the Union for the Coordination of Transmission of Electricity (UCTE), which covered most of the euro area market, the volume of electricity exchanged in the euro area as a percentage of total electricity consumption increased relatively steadily from 6% in 1975 (8% in 1985 and 10% in 1995) to 14% in 2007.[4] In the euro area as a whole gross trade flows (i.e. imports and exports) of electricity as a percentage of domestic generation have even increased progressively from 14% in 1990 to 19% in 2007. Net trade flows, on aggregate, are close to balance at 1% of total domestic electricity generation. This is also the case across most countries with some exceptions. France, and until recently Slovenia, have been net exporters of electricity, whilst four countries, namely Italy (16% of domestic generation on average), Luxembourg (293%), the Netherlands (16%) and Finland (13%) have been net importers of electricity. Cross-border electricity flows may run in both directions (i.e. a country may be both an importer and exporter of electricity depending on its situation at a given point in time). Despite larger flows of electricity within the EU, the overall volume remains relatively small and most electricity markets are still essentially "national", partly owing to remaining interconnection bottlenecks (see European Commission 2007). This limits the competitive pressure which can be exerted on national electricity prices through international flows and constrains the smoothing of electricity supply in the euro area.

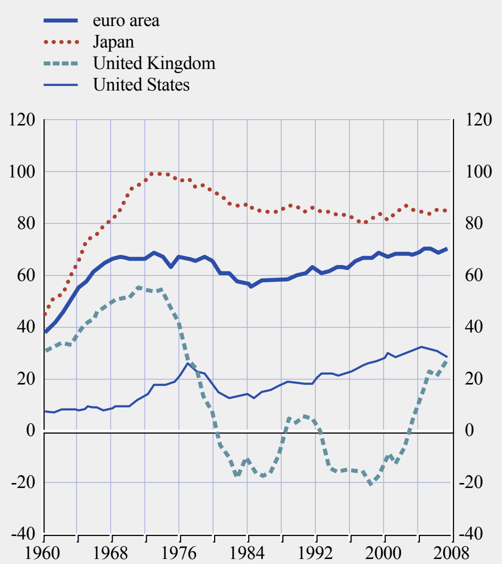
1.1.2 ENERGY DEPENDENCE

Europe's primary energy production sector is largely "undersized" compared with the amount of energy required for final consumption, mainly owing to endowment reasons. Energy dependence, defined as net imports – including intra-euro area trade – as a percentage of total gross inland consumption, of euro area countries was 66.5% on average in 2007 (see Chart 6a). This share is substantially above the energy dependency observed for more fossil-energy-rich countries, like the United States and the United Kingdom, but below that of Japan. Energy dependence is higher in the case of small countries like Ireland, Cyprus, Luxembourg, Malta and Portugal, but also Italy, with figures above 80% (see Chart 6c). The Netherlands is the euro area country least dependent on imported energy, showing an energy dependency lower than 40%.

4 Historically Europe was divided into five regional networks of electricity transmission system operators (TSOs). However, on 1 July 2009 the European Network of Transmission System Operators for Electricity (ENTSO-E) became operative merging these regional associations.

Chart 6a Energy dependence – international comparison

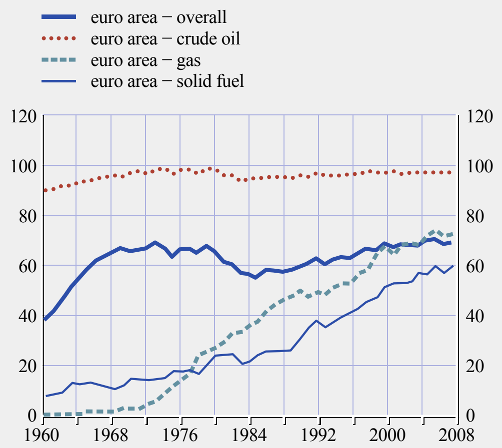
(net imports as percentage of gross inland consumption)



Sources: Eurostat, IEA and Eurosystem staff calculations.

Chart 6b Energy dependence – development in euro area by fuel type

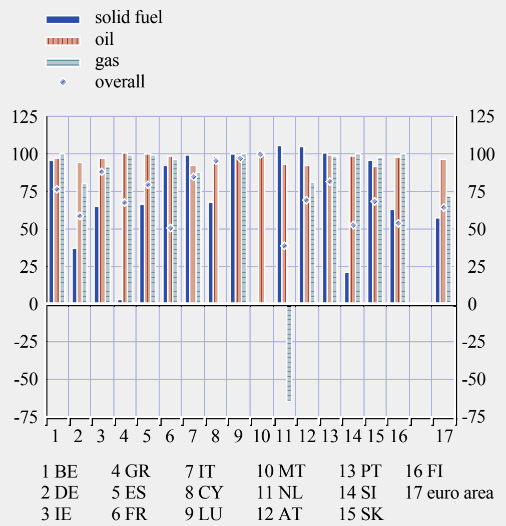
(net imports as percentage of gross inland consumption)



Sources: Eurostat, IEA and Eurosystem staff calculations.

Chart 6c Euro area energy dependence by fuel type

(net imports as percentage of gross inland consumption; 2007)



Sources: Eurostat, IEA and Eurosystem staff calculations.

Overall energy dependency has remained broadly unchanged, fluctuating around a rate of 60% since the early 1970s. However, these aggregate data hide differences across products and time (see Chart 6b). Dependence has always been high for crude oil products. Whilst it was low for solid fuel in the 1960s, it has increased steadily over time owing mainly to declining production. Dependence has also been steadily increasing since the 1970s for natural gas, mainly as the result of increased demand owing to the move away from solid fuel power plants and increased residential use, and now stands at around 70%. Energy dependence by type of fuel product hinges primarily on two key aspects. First, countries' endowments determine net imports. Second, energy imports depend on the technological choices related to the production of final energy for consumption, notably on the production of electricity. The Netherlands is the only euro area country with a negative dependence (net exporter), which is located in the gas segment and is associated with the endowment of this natural resource.

Box 1

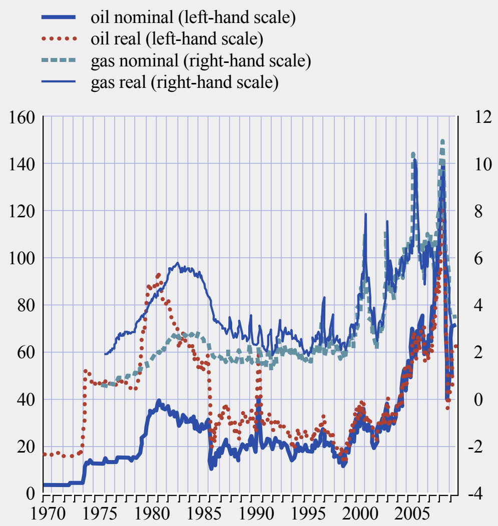
DRIVERS OF INTERNATIONAL OIL PRICE DEVELOPMENTS

The prices of energy commodities, particularly oil, have risen sharply over the past decade, bringing oil and gas prices to new historical highs (both in nominal and real terms) in the summer of 2008 (see Chart A). This rise was unprecedented over the course of the previous 40 years, both in terms of magnitude and duration. Real oil prices are also high by historical standards, although still below the real price levels recorded from the mid-1970s to the mid-1980s. The energy (and more general commodity) price boom came to an end in the second half of 2008, and the subsequent price fall was exacerbated by the onset of the financial crisis and the sharp decline in economic activity. The decline in prices was sharp and fast, but more recently prices have started to rebound. In this box, we analyse the main drivers of international oil price developments over the last number of years, and try to assess their potential impact on future developments.

Natural gas prices are closely linked to oil prices, both because of indexation in long-term contracts and competition between different energy sources in power generation and end-user markets. However, given that only a relatively small share of natural gas is traded on global markets, regional differences and discrepancies can originate and persist. This makes prices more sensitive to local factors and disruptions.[1]

Chart A Nominal and real oil and gas prices

(USD per barrel)



Sources: Energy Information Administration, IMF.
Note: Real prices are expressed in 2005 USD. Last observation refers to June 2009.

Causes and consequences of the oil price shocks of the 1970s

To understand the determinants and prospects of energy markets, we start by looking at the background against which past oil price shocks took place. During the 1960s, the spare capacity in the United States, which had to date been the marginal producer of oil, began to erode owing to economic growth and the increasing demand for automobile fuels. Parallel to that, OPEC started to test its newly acquired market power: the oil price shocks of 1973 and 1979 were associated with significant reductions in OPEC's supply and operable capacity.

Higher prices had an impact on both supply and demand. Following the second oil price shock, global demand declined markedly, especially in OECD countries, where several measures were undertaken to reduce dependence on oil. At the same time, higher prices generated incentives to increase supply, also by enhancing the viability of some fields previously considered unprofitable. Capacity was expanded with new fields being developed in several non-OPEC countries. The steady growth of non-OPEC supply, from 25 mb/d in 1973 to 38 mb/d in the late 1980s, eventually offset OPEC's output cuts. This weakened OPEC's control on the marginal supply, and created greater incentives for the cartel members to exceed the agreed quotas. Against this background, prices progressively declined (Kaufmann et al. 2008).

More recent developments in oil demand and supply

After more than a decade of persistently low levels, from 1999, oil prices became substantially more volatile and surged with increasing momentum between 2004 and mid-2008, rising by

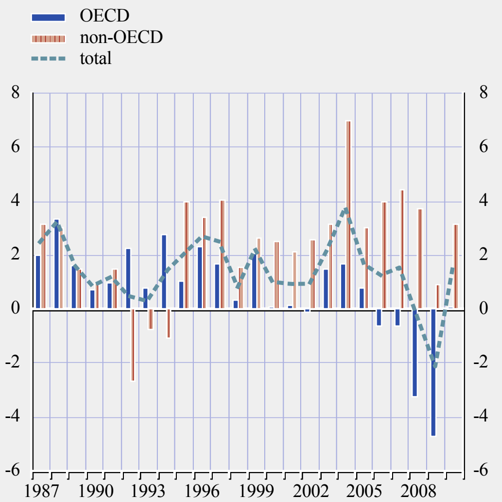
1 See Section 3.2.2 for a short discussion of differences between the euro area and the United States.

almost 400% in nominal USD terms. This hike in crude oil prices was triggered by increasing demand from non-OECD emerging economies, particularly China and the Middle East (see Chart B) (Hamilton 2008, Kilian 2009). Initially, both the failure of oil producers to anticipate the fast growth of the emerging economies and the low levels of exploration investment owing to low crude oil prices in the 1990s caused supply to lag behind growing demand. One indication of increasing difficulties was skyrocketing exploration costs. In turn, future supply prospects increasingly became a matter of concern, as global crude oil production stagnated (see Chart C). Given the fact that scope for increased non-OPEC production was constrained because of geological restrictions especially in the more mature fields (e.g. in the North Sea and Mexico), the only hope for meeting increasing demand was the oil production by OPEC countries. The low level of spare capacity in OPEC countries added to market tightness and generated concerns that, in the event of political instability and disruptions in some regions, the cartel would be unable to match world oil demand (Hamilton 2008).

The oil price boom was disrupted by the slowing in economic growth during the first half of 2008. The fall in oil prices was exacerbated by the onset of the financial crisis and the subsequent very sharp decline in economic activity from the third quarter of 2008 onwards, which also led demand to decline in emerging economies. The downward price adjustment was particularly sharp and fast, with prices falling to around USD 37 per barrel in late December. Since the beginning of 2009, however, as less pessimistic sentiments pervaded markets, prices rebounded and stood at around USD 75 per barrel at the end of 2009, i.e. the same levels as mid-October 2008. OPEC responded swiftly to the slowdown in global oil demand by announcing a reduction in production quotas by a total of 4.2 mb/d, and member countries showed a compliance rate well above historical averages. OPEC is now experiencing a revival of some of its market power, as announced production cuts have now again been at least partly effective.

Chart B Global oil demand changes by region

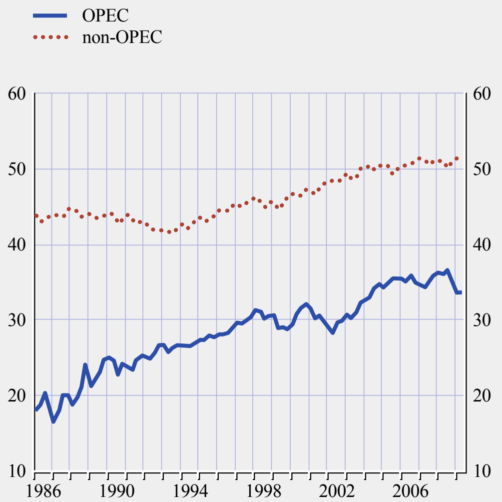
(year-on-year percentage changes)



Source: IEA.

Chart C Global oil supply by producer

(millions of barrels per day)



Source: IEA.

Global liquidity and the financialisation of the oil market

The speed and size of the recent movements in prices have led many to argue that there has been a disconnect between market prices and those warranted by fundamentals and to discuss the potential role of other factors in driving price movements. Some evidence points to the impact of exchange rate fluctuations – in particular the USD/euro exchange rate – on crude oil prices (Breitenfellner and Crespo Cuaresma 2008). While it appears that oil prices and the USD rate have become increasingly correlated over the last decade, this correlation does not seem to be stable across a longer span of time.

Theoretical results by Frankel (2006) suggest that interest rates play a role in determining commodity prices. Based on this, there has been wide discussion on whether the accommodative monetary policy stance deployed at the global level has somehow fuelled the oil price increases, either via incentives for producers to postpone extraction, or via portfolio shifts into commodity markets.

There is strong evidence of a sharp increase in the "financialisation" of commodity markets, particularly those for oil, during the last number of years: the volume of crude oil derivatives traded on NYMEX (New York Mercantile Exchange) quintupled between 2000 and 2008. Nevertheless, it is hard to find clear-cut evidence that financial activity can exert an impact on physical oil prices, at least in the short term. It could also be argued that "speculation" speeds up the price discovery mechanism in the market place and the response to changes in market fundamentals. However, it is very difficult to measure its direct impact on prices owing to the intrinsic difficulties in clearly defining and identifying "speculators". Empirical studies have so far been unable to find robust evidence of systemic causality between investment positions held by non-commercial agents in oil futures markets and spot prices as well as their volatility (Commodity Futures Trading Commission 2008; Haigh et al. 2005; International Monetary Fund 2006). Other studies examining the co-movement between future and spot prices or between financial market and oil market indicators do suggest that some overshooting of oil prices above their fundamentally justified equilibrium level took place at least temporarily (Khan 2009, Miller and Ratti 2009, and Kaufmann and Ullman 2009). On the other hand, it is also important to keep in mind that, as documented by the literature, oil demand and supply are not very sensitive to prices, especially in the short term. This implies that relatively small changes in fundamentals can exert a large impact on prices.[2]

In any event, it is crucial that market participants can operate on the basis of reliable data in order to avoid undue uncertainty and thereby contain price volatility. Accordingly, it is important to foster the compilation of appropriate supply, demand and, particularly, stock and inventory statistics.

Medium and long-term prospects of energy markets

Looking ahead, in the medium term the supply and demand balance may turn out to be tighter. As soon as the world economy recovers, oil demand is expected to start increasing vigorously again in emerging economies. The IEA estimates that by 2014 up to 4 mb/d of crude oil could be needed to match growing demand (International Energy Agency 2009a).

2 It has indeed been argued that the extent of the recent price gyrations is compatible with elasticities estimated in the literature (International Energy Agency 2009a).

However, supply prospects have also been affected by the economic downturn, with investment in upstream capacity and maintenance declining by almost 20% in 2009 (International Energy Agency 2009b). As a consequence, around 2 mb/d of new capacity is estimated to have been deferred since the inception of the crisis, and a further 4 mb/d may suffer delays of 18 months or more. Overall, capacity is expected to grow by around 4 mb/d by 2014. All this increase is projected to come from OPEC member countries, Saudi Arabia in particular. Hence, OPEC's production capability and policy are likely to be decisive in shaping future prices (Nakov and Pescatori 2009). Saudi Arabia, despite representing only 12% of the total oil production, is the only country with significant spare capacity and hence has a crucial role as marginal supplier, so its decisions can exert a significant impact on prices (Nakov and Nuño 2009).

In the longer term, regardless of OPEC's economic willingness to expand capacity, its physical ability to do so depends on the resource base: should global oil production peak, no production expansion will be possible, regardless of price.[3] There is considerable uncertainty surrounding the amount of oil left in the ground. The IEA and the US Energy Information Administration do not envisage a peak in oil production until 2030, provided that the decline in currently producing fields will be offset by new fields going on stream and those yet to be discovered.[4] However, even taking this into account, additional non-conventional sources will be required to match growing demand. Indeed, the IEA estimates the use of unconventional oil sources to increase four-fold by 2030, reaching 7.4 mb/d (International Energy Agency 2009b).

Besides oil sources that could be recovered at higher costs (e.g. using Enhanced Oil Recovery techniques, or located in deep water and in Arctic zones), there are plenty of unconventional oil sources.[5] Among these, the geological resource base for heavy oil such as tar sands and oil shale is quite considerable.[6] However, even if estimated costs of production for tar sands are comparable with current prices, they are subject to wide uncertainty, as it takes considerable amounts of energy to recover alternative fuels and the energy return is considerably smaller than for oil. Similar considerations apply to oil shale, with costs even higher and more uncertain. Apart from environmental considerations, these new extraction technologies are highly capital intensive, with long lead times of up to ten to 15 years. Finally, the uncertainty stemming from the high volatility observed in oil prices in recent years and the increased risk aversion in financial markets may also have served to discourage or postpone investment in this sector, although higher prices should stimulate to some extent investment in supply.

3 The case of the US mainland supply well illustrates this point: production has been steadily declining in the last 40 years despite increasing prices.
4 There is however widespread debate among energy economists and geologists about the peak in oil production. Kaufmann and Shiers (2008), for example, examine several possible scenarios, and place the oil peak somewhere between 2009 and 2031.
5 Here the focus is only on alternative fuels that can be used in the transportation sector, which according to the current technology have to be in liquid form. Renewable resources such as biofuels should also be mentioned, but it is unlikely that they could replace oil: converting the whole US corn crop into fuel would satisfy only 12% of demand for fuels.
6 Tar sands represent a form of heavy oil which is present in Canada and Venezuela. Similarly, oil shale is a type of rock containing oil, a large resource base is available in the United States.

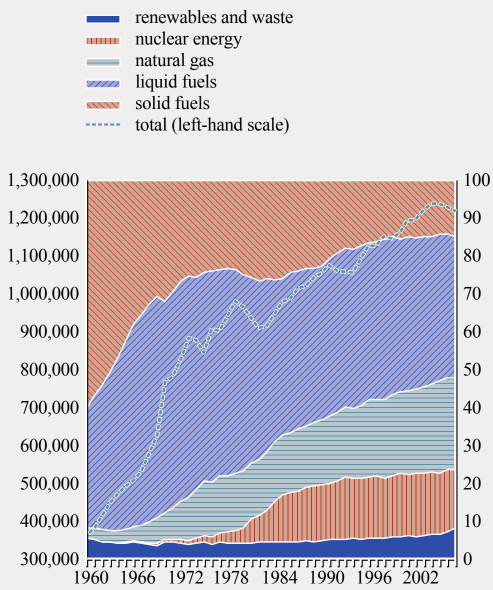
1.2 ENERGY CONSUMPTION AND INTENSITY

1.2.1 CONSUMPTION PATTERNS

Energy consumption may be viewed in two main ways: either in "gross" terms (i.e. the combination of domestic primary production and net imports) or in "final" terms (i.e. after the transformation of primary energy sources into usable forms of energy). A key difference between gross and final consumption is the transformation of primary energy sources (nuclear, gas, solid fuels and oil) into electricity. Both measures have their uses: the "gross" measure is useful for understanding the

Chart 7a Gross inland consumption by fuel

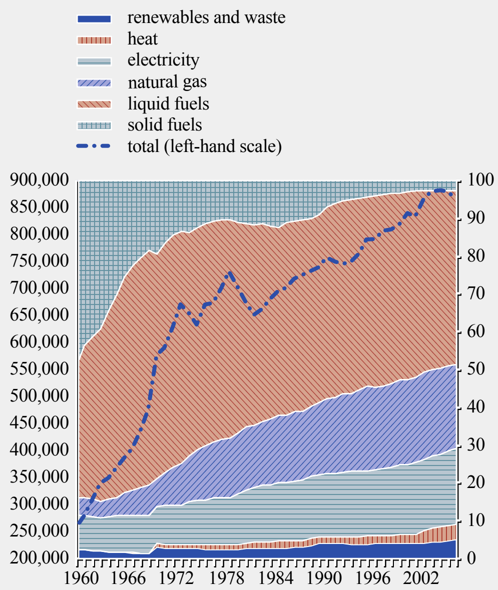
(toe/percentages)



Sources: Eurostat, IEA and Eurosystem staff calculations.

Chart 7b Final energy consumption by fuel

(toe/percentages)

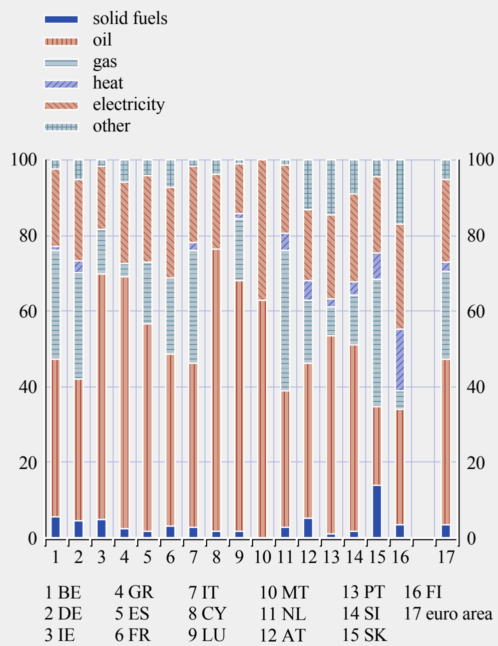


Sources: Eurostat, IEA and Eurosystem staff calculations.

potential impact of raw energy commodity prices whilst the "final" measure is useful for understanding their impact via consumption patterns. Charts 7a and 7b respectively show the evolution and breakdown of gross and final inland consumption of energy. Having increased strongly between 1960 and 1973 at an annual rate close to 10%, growth in overall *energy consumption* has since trended upward at an average rate of around 1% per annum. However, within overall energy consumption there have been a number of significant developments. One of the major trends in the composition of final energy consumption has been the growing share of natural gas and electricity, largely at the expense of natural coal and peat. The share of oil strongly increased until the end of the 1970s but then stabilised. Currently, oil products are the most important component of final energy consumption in the euro area, representing 44% of the total. Gas products are the second largest product of final energy consumption (23%), a share slightly higher than that of electricity (22%). Taking a longer-term perspective, the major trends are the growing shares of natural

Chart 7c Final inland consumption

(shares of total – 2007; percentages)



Sources: Eurostat and Eurosystem staff calculations.

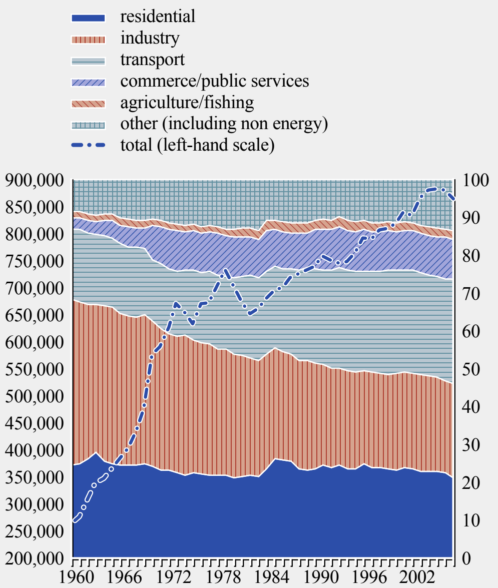
gas and electricity. In almost all countries, oil, gas and electricity account for more than 80% of energy consumption (see Chart 7c)

It is also informative to analyse final *energy consumption according to the sector* where it is consumed. Compared with 1960, the transport and services sectors have gained most in terms of consumption, while industry has shown some decline. Chart 8a reveals that in 2007 the transport sector was the largest consumer of energy in the euro area with a share of 33%, followed by industry (28%) and households (23%). Road transport, representing more than 80% of total transport-related consumption, is by far the largest component within this sector, followed by air transport with a share of around 14%. Although detailed data are lacking, approximately 50% of road transport is accounted for by passenger cars with the remainder accounted for by commercial transport. The profile of fuel consumption across these two categories is very different. Approximately one-third of passenger cars are diesel powered, with most of the remainder petrol powered. On the other hand, the commercial transport sector is almost completely diesel powered. The current sector distribution is broadly similar across euro area countries. Nevertheless, the shares of industry consumption are relatively larger in Belgium, Slovakia and Finland, and relatively smaller in Ireland, Greece, Cyprus, Luxembourg and Malta (see Chart 8b).

An alternative perspective from which to analyse final energy consumption in the euro area is the energy profile of household and industry sectors. Regarding *households*, the energy basket is relatively diversified, with substantial heterogeneity between euro area countries (see Chart 9). Gas represented around 40% of households' energy consumption in the euro area in 2007, but as much as 72% in the Netherlands, 57% in Italy and just 0.7%, 3.3%

Chart 8a Energy consumption by sector

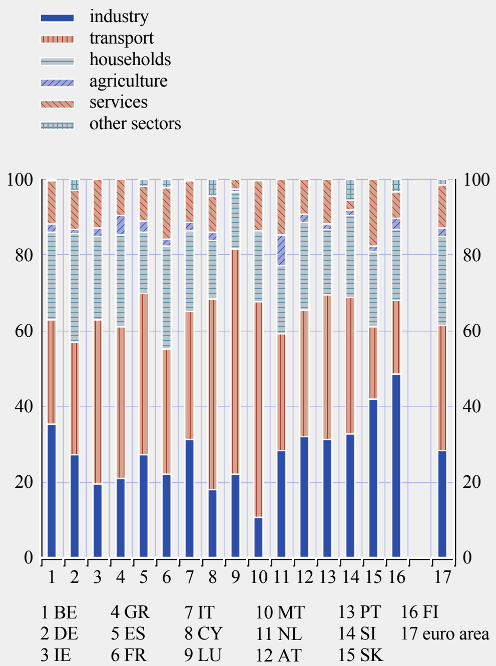
(toe/percentages)



Sources: IEA and Eurosystem staff calculations.

Chart 8b Energy consumption by sector

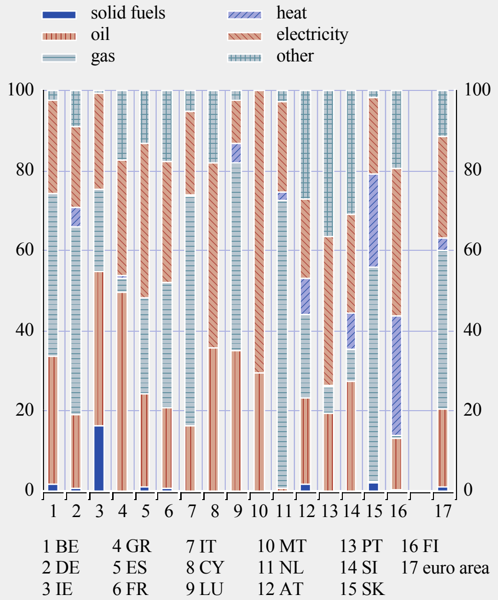
(shares of total – 2007; percentages)



Sources: Eurostat and Eurosystem staff calculations.

Chart 9 Household energy consumption

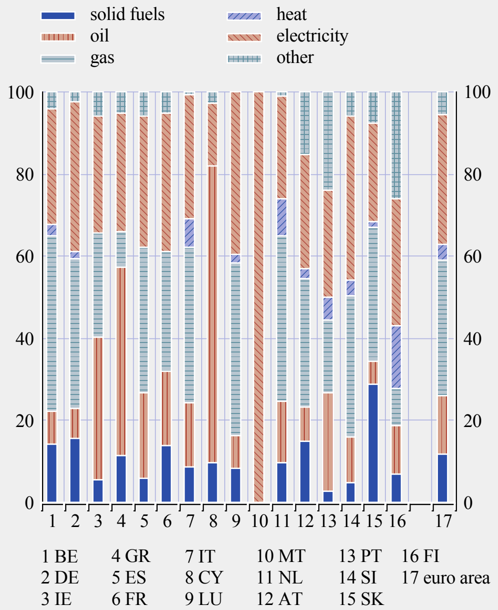
(shares of total – 2007; percentages)



Sources: Eurostat and Eurosystem staff calculations.

Chart 10 Industry energy consumption

(shares of total – 2007; percentages)



Sources: Eurostat and Eurosystem staff calculations.

and 6.8% in Finland, Greece and Portugal respectively. Electricity occupied second position in the euro area households' energy basket (25%), followed by oil products (20%).[5]

As for the energy profile of the *industry sector*, Chart 10 reveals that gas and electricity also play the leading roles, with shares in the euro area of 33% and 32% respectively. The shares of solid fuels and oil as suppliers of energy to the euro area industry sector decreased in the period 1990-2007 (see Chart A5 in Annex 1). The main differences between the energy consumption profiles of households and industry are the higher weight of oil and gas for the former and a higher weight of electricity and solid fuels for the latter.

1.2.2 ENERGY INTENSITY

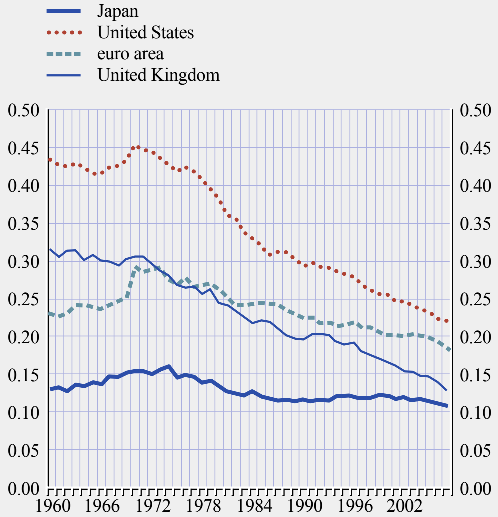
Energy intensity is a useful concept in the analysis of countries' energy developments, as it links energy consumption to activity and is a proxy measure for the efficiency with which energy resources in the economy are used. It should be borne in mind that many factors may impact on energy intensity including living standards, economic structure, climatic conditions, the age of the housing and capital stocks, population density and transport infrastructure. Not all of these are necessarily linked to energy efficiency per se.

After increasing in the 1960s and early 1970s, energy intensity in the euro area has been on a steadily declining path ever since, owing to sector developments but also probably to the occurrence of oil shocks and the progressive adoption of energy-saving technologies. At present, relative to other industrialised economies, the euro area shows a lower energy intensity than the United States, but higher than that of Japan and the United Kingdom (see Chart 11). Whilst the broad pattern of euro area energy intensity is evident in other economies, some convergence in energy intensity has occurred over time in these industrialised countries. In the

5 In terms of evolution, from 1990 to 2007 the consumption of gas has gained share in most countries, while oil decreased its relevance in the energy mix (see Chart A9 in Annex 1).

Chart 11 Energy intensity (1960-2007)

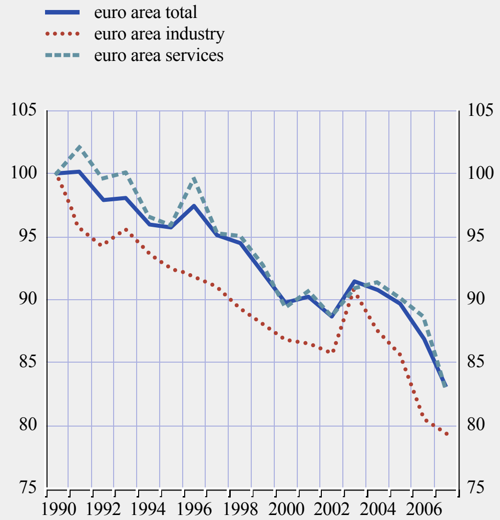
(toe/thousand 2000 USD)



Sources: Eurostat, IEA, European Commission (AMECO) and Eurosystem staff calculations.
Note: The definition of the services sector in the energy statistics (used to calculate the numerator – energy consumption) is not completely aligned with that in the national account statistics (used to calculate the denominator – total output).

Chart 12 Energy intensity by sector

(1990 = 100)



Sources: Eurostat, IEA, European Commission (AMECO) and Eurosystem staff calculations.
Note: The definition of the services sector in the energy statistics (used to calculate the numerator – energy consumption) is not completely aligned with that in the national account statistics (used to calculate the denominator – total output).

1960s the levels of energy intensity were much higher in the United States than in the euro area and Japan. The reduction of energy intensity was much stronger in the United States than in the euro area, while Japan stabilised in the last decades.

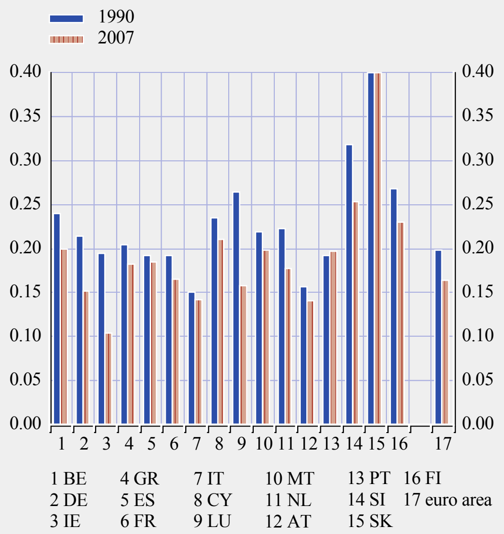
The overall evolution in energy intensity arises from the improvements recorded in each sector of activity, together with the change of share of the different sectors in total economy. Chart 12 describes the evolution of the ratio between the indices of energy consumption in total economy, industry and services and the respective indices of gross value added in the euro area since 1990. This figure shows that the improvement in energy efficiency is common to industry and services. However, as the degree of energy intensity in services is lower than in industry, the increase in the share of services gives rise to a stronger reduction in overall energy intensity.

Virtually all euro area countries stabilised or reduced energy intensity from 1990 to 2007 (see Chart 13). Euro area energy intensity declined notwithstanding an increase in gross inland energy consumption of about 12%, as overall activity (GDP) grew by around 66%. While gas intensity remained broadly constant over time, that of solid fuels and oil declined.

In summary, after increasing substantially in the 1960s, overall economy energy intensity in the euro area has been on a declining trend since the early 1970s. This should reduce the vulnerability of the euro area economy to energy price fluctuations. There are two additional trends in this direction. First, the share of industry in final energy consumption and industrial energy intensity has fallen. Energy price fluctuation should therefore affect industrial production less than in the past. Second, the energy mix has become more diversified with the rise of nuclear power and renewables, although this has to be

Chart 13 Energy intensity

(toe/thousand 2,000 euro)



Sources: Eurostat, IEA and Eurosystem staff calculations.
Notes: Data for the earlier time period for Malta refer to 1991 and for Slovakia to 1992. The data for Slovakia have been truncated for graphical purposes. The values are 1.16 for 1992 and 0.54 for 2007.

seen against the background of an increase in total consumption of fossil fuels (particularly natural gas) and high dependency rates.

1.3 ENERGY MARKET STRUCTURE AND REGULATION

The degree of competition in energy markets determines their functioning in several respects. It affects the margins available to entrepreneurs and therefore incentives to invest, which in turn determine the capacity to innovate and attain higher productivity. The degree of competition also affects the need to react to price signals, as highly regulated and non-competitive markets tend to allow for larger margins and induce frictions in the reaction of prices to changes in input costs. In turn, the deregulation of markets allowing consumers greater choice and an appropriate return on investment tends to have beneficial effects on productivity as well as consumer and producer prices. Market competition increases investment incentives, since companies must ensure service quality and face a stronger pressure to increase productivity to lower prices.

Implementing the appropriate degree of deregulation may be more challenging in energy sectors than in other industries since some elements of the production process may justify regulation or lead to centralised market structures. First, the energy sector is more capital intensive than many other industries, requiring long-term investments (project lifetimes can be as long as 20 and 45 years) and substantial financial commitments.[6] The extent and long-term nature of the financial resources and specificity of energy infrastructures can lead to bottlenecks if highly volatile prices or low margins undermine investment incentives. Second, whilst oil is relatively easily transported and stored, natural gas and electricity have more limited storage and distribution possibilities.[7] Gas and electricity supply are therefore characterised by the predominant role of network infrastructures, configuring a market structure where the transmission of the energy service by a single firm can under some circumstances minimise costs and therefore create "natural monopolies". Finally, vertical integration implies certain advantages in the energy industries. It limits the technical problems that can arise along the different stages of the production chain (e.g. in the electricity sector, where a continuous balance between demand and supply is vital and where the energy source is not storable). Vertical integration also facilitates long-term commitments towards third parties (e.g. the long-term take-or-pay contracts signed with natural gas producers), and helps to avoid "double marginalisation", whereby every stage requires an adequate margin.

6 According to IEA estimates, in 2000, investments in energy infrastructures amounted to USD 413 billion, about 1.3% of world GDP, with the power sector registering the highest ratio of capital investment to unit of value added (IEA 2003).

7 Whilst liquefied gas can be transported, the process of liquefaction and re-gasification is costly in terms of energy losses and the required infrastructures. According to the Energy Information Administration (EIA 2003), the construction of a liquefaction plant could cost USD 1.5 to 2.0 billion; a re-gasification terminal costs around USD 300 million.

Regulatory authorities in these sectors therefore face the complicated task of maintaining investment incentives and implementing efficient market structures to the benefit of consumers, which do not allow incumbent firms to exploit their strategic advantage by limiting competition. Regulatory instruments shaping market structures and energy prices for consumers cover a number of dimensions, most prominently entry and access rules applicable to firms, consumer rights and price regulations.

1.3.1 EVOLUTION OF EU ENERGY MARKET REGULATION

Owing to some of the factors outlined above as well as the strategic nature of energy and the traditionally strong role of national governments in setting energy policy, energy markets were only brought within the remit of the Single Market at a relatively late stage. Since the middle of the 1990s, the EU, recognising that certain segments of the market need not be served by monopoly producers, pursued a more differentiated policy of liberalisation and de-verticalisation of gas and electricity markets. Common rules for the EU markets in electricity and gas were first introduced in 1996 and 1998 respectively. They took the form of general rules and principles and emphasised the need for objective and transparent licensing or authorisation procedures and non-discriminatory technical and access rules governing transmission and distribution systems.[8]

Although these directives were credited with improving the functioning of markets, the dominance of incumbent energy firms limited access to energy networks for new entrants, who also faced discriminatory tariffs, thus impeding the emergence of competition. As a result, stricter, more prescriptive legislation was introduced in June 2003. In order to guarantee non-discriminatory access to energy networks, transmission and distribution systems were to be legally and organisationally separated ("unbundled") from the other activities of integrated energy companies (although they could retain ownership) and endowed with their own decision-making powers. Market opening was speeded up by allowing all industrial and household customers to choose their electricity and gas suppliers by 1 July 2004 and 1 July 2007 respectively. Finally, the powers and remit of national regulatory authorities were widened to include responsibility for effective competition and the efficient functioning of national energy markets.

European Commission monitoring of the energy market during 2006 revealed that the emergence of an EU-wide, integrated and competitive energy market was still held back, owing, inter alia, to persistently high market concentration and insufficient unbundling, limiting effective access to energy networks. According to many institutional actors, including the Commission[9], ownership unbundling of network activity is the only means to resolve the conflict of interest that arises when operators control the network and compete in the upstream or downstream stage of the energy business.[10]

New legislation was adopted in June 2009 and will apply from March 2011. Ownership unbundling, requiring integrated energy firms to divest their network assets, was introduced as a

8 To prevent cross-subsidisation of activities and the distortion of competition, integrated energy companies were required to keep separate accounts for each of their activities, although ownership structures were allowed to remain unchanged. High-volume customers were given the right to choose their own gas and electricity suppliers and the relevant thresholds were progressively lowered in order to increase the share of the market subject to competition. Finally, Member States were required to establish an independent regulatory authority with dispute-settling powers.

9 See for example, Council of European Energy Regulators (CEER) (2007); Kroes "[…] the European Commission sees full ownership unbundling as the most effective option to solve the problems of discrimination, and the distortion of incentives to invest in connecting regional or national networks". Europa press release, SPEECH/07/63.

10 Furthermore, unbundling should stimulate the investments needed to increase network capacity, which in turn can improve efficiency through the pressure of competition. Nevertheless, fair and certain access to networks has been assessed in the literature as a necessary – but not sufficient – condition for the development of competition in energy markets as long-term (e.g. take-or-pay) contracts may also block effective gas sector competition through vertical foreclosure or market segmentation (Polo and Scarpa 2007, 2003 and Buchan 2009).

general principle.[11] To increase the effectiveness of regulatory oversight, the independence and decision-making capacity of national regulators has been strengthened further and their powers harmonised. In addition, a separate regulation establishes a European Agency for the Cooperation of Energy Regulators (ACER) to supplement, harmonise and coordinate the work of national regulators, formalise cross-border cooperation between transmission system operators in European networks and advise the European Commission as to how to improve the functioning of EU energy markets. To promote the integration of European energy markets, the Commission also makes use of its powers to enforce existing legislation. As the implementation of the 2003 directives was deemed insufficient, infringement procedures were launched against 25 Member States in 2009.

1.3.2 OPENNESS AND COMPETITION IN EU ENERGY MARKETS

In the euro area, 99.5% and 96.2% of the electricity and gas markets respectively were open to competition in 2007, meaning that consumers became completely free to choose their energy supplier (see Table 1). However, even if de jure competition is in place, de facto competition is still generally lacking. The market share of the three largest companies (C3) in the euro area countries' wholesale and retail electricity and gas markets in 2007 remained high: in the electricity market the C3 indicator was close or above 75% on average and in the wholesale and retail gas market above 70% and 60% (for an overview of C3 by country, see Chart A6 in Annex 1). A similar picture emerges looking at another indicator of market concentration, the Herfindahl-Hirschman Index, which was above 4,000 in euro area countries' wholesale and retail electricity and gas markets thus pointing to highly concentrated markets.[12] Only a few euro area countries are characterised by a moderately concentrated market: Ireland, Spain, Italy and Austria in wholesale electricity, Slovenia in retail electricity and Ireland in wholesale gas. In all other cases the HHI was above 1,800 (see Table 2).

Additional insight into market liberalisation may be obtained by looking at the OECD Product Market Regulation database.[13] For the gas sector, the market structure indicator ranges from six (market share of the largest player in the gas market bigger than 90%) to zero (market share of the largest player in the gas market less than 50%). This information is particularly valuable because data are available back to 1975. Chart 14 reports both the level of the indicator in 2007 and the progress made since 1990. Several countries (Greece, Luxembourg, Portugal, Slovakia and Finland) made no progress in terms of reduction in the dominant

11 However, as part of the compromise reached between the Council of the European Union and the European Parliament, existing integrated companies can, as an exception and under certain conditions, continue to own such assets. In return, the directives strengthen consumer rights, inter alia by facilitating the switching of suppliers. The Commission is tasked with assessing the competition effects of this exception.

12 The Herfindahl-Hirschman Index is defined as the sum of the squared individual market shares. The HHI ranges from zero (perfect competition) to 10,000 (monopoly).

13 See OECD 2006 and the Product Market Regulation section of the OECD'S website at www.oecd.org.

Table 1 Indicators of market competition in the euro area electricity and gas markets

Euro area	Market open to competition (%) 2007	Market share of three largest companies (C3, in %) 2007	HHI 2007[1)]
Wholesale electricity market	99.5	75.7	4,062.1
Retail electricity market		74.4	4,215.7
Wholesale gas market	96.2	72.4	4,076.4
Retail gas market		63.6	4,078.3

Sources: NCBs, European Commisssion and Eurosystem staff calculations. The euro area is obtained by aggregating country data weighted by private consumption.
1) Data for the gas market refer to 2006.

Table 2 Herfindahl-Hirschman Index (HHI) – country breakdown

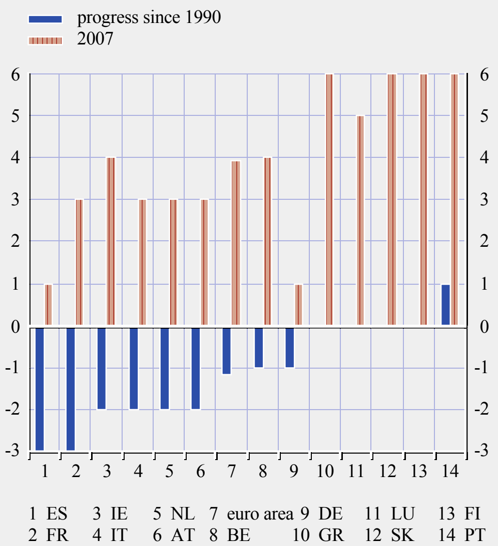
Market concentration (HHI)[1]	Wholesale electricity market	Retail electricity market	Wholesale gas market	Retail gas market
Very highly concentrated (HHI>5,000)	BE, GR, FR, LU, MT, SI, SK	BE, GR, MT, PT, FI	BE, GR, MT, NL, SI, SK	BE, IE, MT, SI, SK
Highly concentrated (HHI 1,800-5,000)	DE, NL, PT	IE, ES, NL, AT, SK	ES, IT	ES, NL
Moderately concentrated (HHI 750-1,800)	IE, ES, IT, AT	SI	IE	

Sources: NCBs, European Commission and Eurosystem staff calculations.
Note: The HHI takes into account the relative size and distribution of the firms in a market and is computed as the sum of the squared market share of each company operating in a market segment.
1) Latest available year – generally 2007/2008.

position of the incumbent operator in the gas market while other countries (Ireland, Spain, France, Italy, the Netherlands and Austria) made good progress over the same period.

It is worth mentioning that in some energy markets nationwide indicators of competition may not fully reflect effective competition. Some euro area countries (Germany, Spain and Austria) were characterised by a decentralised energy market structure originating historically from regional monopolies. Germany, for example, was dominated by regional monopolies in the electricity and gas markets until 1998. Even after liberalisation took place the gas transmission network was segmented into 19 "market areas" and gas suppliers had to negotiate entry and exit conditions both between and within market areas. Since 2007 access has been facilitated and the number of market areas reduced, although former incumbents retain dominant positions in their original market areas.

Chart 14 OECD market structure indicator for the gas market



Sources: OECD and Eurosystem staff calculations.
Note: A higher index indicates a larger market share of the largest incumbent company. The euro area is a simple average of available countries.

One requirement for fully-fledged liberalisation is the creation of a level playing field for new entrants through fair and certain access to network services. Despite progressively stricter regulation (see previous section), *ownership unbundling* is implemented only in half of the euro area countries (Ireland, Spain, Italy, the Netherlands, Portugal, Slovenia, Slovakia and Finland) in electricity transmission[14] and the framework for *legal* unbundling is considered by several commentators to be generally insufficient and weak (ERGEG 2008). In the gas market vertical integration is very common and is evident to a higher degree than in the electricity market (OECD 2006). Only five euro area countries (Germany, Spain, Italy, the Netherlands and Portugal) have at least one transmission system operator (European Commission 2009).

14 See EC 2009. According to information provided by the Deutsche Bundesbank, in Germany, a recent tendency towards unbundling is apparently emerging, with some large electricity providers agreeing to divest their transmission networks in return for being spared anti-trust measures by the European Commission.

These different elements of market structure can be traced jointly by looking at the indicators of *overall regulation/liberalisation* of the electricity and gas markets provided by the OECD PMR database. These aggregate indicators are based on entry regulation, the extent of public ownership and vertical integration (a higher overall index indicates weaker competition). Chart 15 reports the level of the index in 2007 and its progress since the 1990s in the electricity and gas markets respectively (see Annex 1 for the individual sub-indices). Several observations are worth mentioning. First, since the beginning of the 1990s the electricity and gas markets have made important steps towards liberalisation, especially in facilitating market entry. This reflects the efforts of the European Commission to implement a single European energy market mentioned above. Second, progress made in the euro area to liberalise energy markets since the 1990s in the electricity sector appears on average greater than that for the overall PMR indicator which includes other network industries.[15] By contrast, progress is smaller in the case of gas. Third, large heterogeneity across countries still exists. In 2007 regulation in the electricity market was stricter (and competition lower) in Belgium, Ireland, Greece, France, the Netherlands and Slovakia compared with the euro area average. Regulation in the gas market was stricter in Ireland, Greece, Luxembourg, the Netherlands, Portugal, Slovakia, and Finland.

Overall, effective competition in the euro area gas and electricity markets is still lacking and, in the majority of countries, has failed to emerge fully. Limited competition in wholesale markets is particularly worrisome given that well-functioning and integrated wholesale markets are a prerequisite for competitive retail markets. Low rates of customer switching, especially in the gas market and for households and small commercial customers, tend to confirm that there is only limited competition in the market.[16]

Two issues are not addressed by these indicators. First, the interdependence of gas and electricity is relevant in promoting competition in these markets. In Europe (and in the euro area) almost one-quarter of electricity is generated using gas (see Section 1.1.1). This share is expected to

Chart 15 OECD overall regulation indicator for electricity and gas markets

Sources: OECD and Eurosystem staff calculations.
Notes: A higher index indicates stricter regulation. The euro area is a simple average of available countries.

15 This indicator consists of seven non-manufacturing industries (airlines, telecoms, electricity, gas, post, rail and road).
16 EC 2009 and ERGEG 2008. On the contrary, high switching rates were recorded in the Netherlands where between July 2007 and July 2008 approximately 8% of consumers switched between energy suppliers. Low switching rates may, however, also be associated with other factors including high customer satisfaction, low price elasticity of consumers, long lock-in contract agreements, or simply consumer inertia.

continue to rise (IEA 2008a), which suggests that the interconnection between gas and electricity price dynamics will be further amplified in the coming years. Thus, while *vertical integration* may be diminishing, certain forces may give rise to increased *horizontal integration*: electricity generators may seek to manage gas input price risk, and multi-utility companies might seek to exploit economies of scope by providing a complete set of energy services (gas and electricity) to their customers (Finon and Glachant 2004).

Second, around 80% of EU consumers in countries with end-user regulated electricity and gas prices were being supplied at regulated prices in 2008. Despite the opening up of energy markets for households in 2007, regulated end-user prices continued to exist in a large number of countries. In fact, more countries opened up markets with price regulation in place than without. In the euro area, electricity price regulation for households and businesses continued in eight countries, and gas price regulation in seven countries (ERGEG 2009).

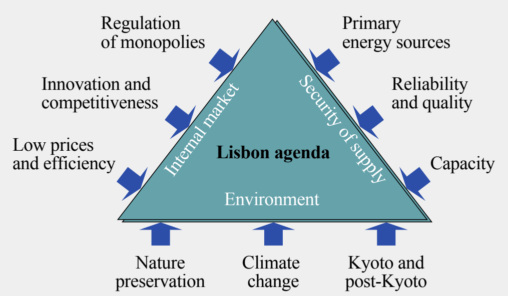
With regard to the *liquid fuel market*, the situation is somewhat different since the liquid fuel distribution system is not characterised by such strong network properties. Nonetheless, although it is a relatively homogenous product with a relatively large number of individual retail outlets, there are a relatively small number of large-scale retailer chains who tend to be vertically integrated.[17] A relatively common trend across the euro area, potentially affecting local level competition, is that the number of petrol stations in the euro area has been declining steadily since the early 1970s (from more than 200,000 in 1973 to around 80,000 in 2007).[18] The number of stations per capita and per passenger vehicle varies considerably across countries reflecting many factors including, inter alia, market regulation, preferences, geographic country characteristics and the number of vehicles per inhabitant. While the declining number of petrol stations might appear to have negative implications for competition, it may at the same time represent an improvement in efficiency and have, on balance, beneficial effects for consumers. The C3 indicator in the euro area liquid fuel distribution market, which was close to 48% in 2005 (see Chart A7 in Annex 1), is clearly below the level of concentration seen in the gas market.[19] The C3 indicator varies substantially across countries, ranging from 21% in France to 100% in Malta and Slovenia. Vertical integration is a key issue in the liquid fuel market, since local retailers are often part of a large vertically integrated company or have a contractual relationship.[20] Moreover, vertically integrated companies tend to have upstream activities in parts of the production chain that are relatively concentrated, such as refining. Petroleum companies frequently share such upstream facilities, which may also limit the degree of competition. On the other hand, a growing phenomenon in some countries is the entry of large supermarket chains into the transport liquid fuel market. These supermarkets often sell petrol relatively cheaply, relying either on scale economies or loss-leading on a "known-value item" such as petrol to attract customers.[21] Nonetheless, the main players remain large international companies in most markets, as reflected by the C3 indicator.

1.3.3 OTHER ELEMENTS OF THE EU ENERGY POLICY FRAMEWORK

The scope of EU legislation has broadened significantly since the 1990s to encompass

17 For a detailed discussion of the issue of vertical integration in petrol retailing, see OECD 2009.
18 A notable exception to this trend is the Spanish market which was opened to competition in the 1990s.
19 An additional factor impacting on effective competition is fuel tourism. This is particularly the case in small countries with shared borders. Population density may also have an impact on competition, ceteris paribus.
20 Generally there may be five broad classes of petrol retailers: (i) those owned and operated by a vertically integrated company, (ii) those owned by a vertically integrated company but leased to another company, (iii) those operated but not owned by a vertically integrated company (iv) franchises issued by a vertically integrated company, and (v) independent operators.
21 See Walsh and Whelan 1999 for a discussion of the concept of known-value items (KVIs) and their pricing in an environment where consumers lack complete knowledge of all prices retailers offer. A 2007 study by the Australian Competition and Consumer Commission found that increased market penetration by supermarkets reduced retail prices for petrol, and was not at the expense of increased prices for other items.

Chart 16 Stylised overview of EU energy policy



Source: Drawn from European Commission (2007a).

not only well-functioning energy markets, but also energy security concerns and climate change objectives. (Chart 16 provides a stylised overview). The three pillars are seen as interdependent and mutually reinforcing. The piecemeal approach in the 1990s towards energy and climate change/environmental problems has progressively given way to an integrated EU approach.

The aim of increasing the EU's *security of energy supply* is pursued through a number of different, but complementary, avenues. As part of the short-term response to recent disruptions in the supply of energy products, such as the January 2009 Russia-Ukraine gas crisis, existing legislation on oil and gas is being revised. This encompasses the harmonisation of minimum stocks, enhanced monitoring and transparency, as well as the development of detailed emergency response procedures in the case of a major disruption of oil or gas supplies, both intra-EU and with major energy suppliers.[22] Longer-term, additional investment in energy infrastructure, in particular cross-border energy interconnections – the physical backbone of an integrated energy market – is key to enhancing energy security. Initiatives have also been taken to strengthen the external aspects of energy security via the 2009 internal energy market legislation and, in 2006, the establishment of the "Energy Community" by the EU together with a number of countries in south-eastern Europe. Box 2 provides more conceptual and empirical information on different aspects of energy security in the EU, as well as an international comparison.

A third area of EU legislation affecting the functioning of energy markets aims to reduce the *carbon intensity* of the European economy. In April 2009 legislation was introduced that commits the EU to ambitious targets to combat climate change, increase the role of renewables in energy production and improve energy efficiency, commonly known as the "20-20-20 agenda". This plan aims to reduce CO2 emissions in the EU by 20% compared with 1990, increase energy efficiency by 20% and increase the contribution of renewable energies to 20% of total energy consumption by 2020. These targets are to be reached through a variety of means, including emissions trading and the promotion of renewable energy sources. Box 3 provides more conceptual and empirical information on different aspects of carbon emissions and climate change policies.

22 Examples are the current proposal to revise the security of gas supply directive (2004/67/EC) as well as the Memorandum on an "Early Warning Mechanism" in the energy sector within the framework of the EU-Russia dialogue signed in November 2009.

Box 2

THE SECURITY OF ENERGY SUPPLY IN THE EURO AREA

The notion of energy security has short-term dimensions encompassing the risk of temporary supply disruptions and the ability of the system to react to sudden changes in demand for energy such as electricity, as well as longer-term dimensions such as the possible depletion of crude oil and gas reserves (availability), and their geopolitical distribution and transportation via transit countries (accessibility).[1] More recently, broader definitions have included other aspects of energy security, such as exposure to the volatility of fossil fuel prices and the acceptability of energy sources on environmental grounds.[2] Whereas concerns about physical availability are mostly relevant when prices cannot immediately respond to a shortfall in supply (e.g. in the natural gas market where prices are often linked to the price of oil), they are less relevant in globally integrated markets such as the crude oil and coal markets (Nordhaus 2009). Here, price volatility is the main concern.

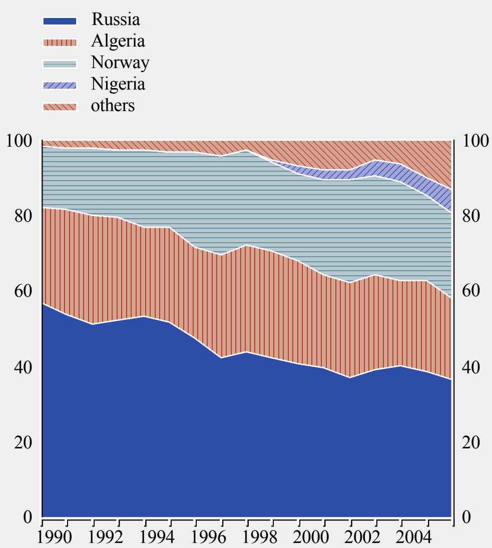
For the euro area as a whole, Russia has remained the most important supplier of natural gas, even though its importance has diminished over the past decade (see Chart A) and dependence on Russian gas imports varies considerably by Member State. At the same time, the share of euro area oil imports from Russia has increased over the past few years (see Chart B). Owing to the integrated nature of the global oil market, the geographic composition of oil imports has triggered fewer energy security concerns than in the case of the natural gas market.

In this box, energy security in the euro area is measured along the following dimensions[3]: (i) degree of self-sufficiency of primary energies defined as the proportion of consumption covered by a country's primary energy production, (ii) reliability of imports, calculated by multiplying the share of each source in the supply of a given fuel (oil or gas) by the political security of that country (measured by the OECD's country risk rating), (iii) negotiating power in gas markets defined as each country's share in total gas exports of its main supplier of gas,

1 For a comprehensive discussion of the concept of energy security, see Kruyt et al. 2009.
2 According to the IEA, energy security can be described as "the uninterrupted physical availability [of energy] at a price which is affordable, while respecting environment concerns". Energy insecurity may thus occur as a result of a change in the price or the physical availability of energy (Bohi and Toman 1996).
3 The indicators are drawn from, but develop, the methodology proposed by Avedillo and Muñoz (2007).

Chart A Euro area natural gas imports by geographic origin

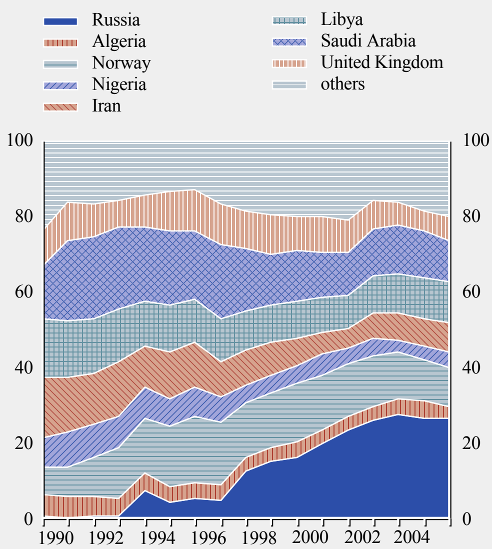
(percentage of total natural gas imports)



Sources: Eurostat and Eurosystem staff calculations.

Chart B Euro area crude oil imports by geographic origin

(percentage of total crude oil imports)

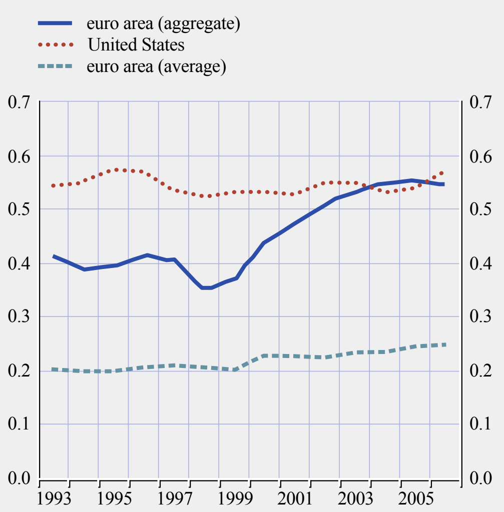


Sources: Eurostat and Eurosystem staff calculations.

(iv) imports of liquefied natural gas computed as LNG imports as a proportion of total gas imports[4], (v) degree of electrical connectivity calculated as imports plus exports as a fraction of electricity consumption, (vi) self-sufficiency in electricity production defined as the proportion of total electricity that is produced with domestic energy (renewable and nuclear) and (vii) degree of diversification of primary energies defined as one minus the Herfindahl index for primary energy sources. These seven indicators are computed for 13 euro area Member States (see Annex 2.1).[5] A euro area aggregate is computed in two ways, namely (i) as an unweighted average and (ii) as a composite aggregate, hypothetically treating the euro area as a single integrated energy market, excluding intra-euro area trade in energy and electricity where relevant.

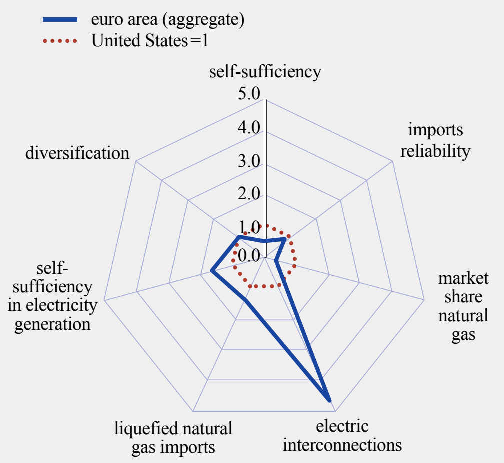
The main findings from this analysis are summarised in Charts C and D. In Chart C, all indicators are aggregated into a single indicator for energy security, using weights from a principal factor analysis[6], whose evolution is shown over time. Chart D compares the two euro area aggregates with the United States using the latest available information (2006) for all seven indicators. As can be seen in Chart C, energy security in the euro area has tended to increase over the past decade. To a great extent, this was a result of increases in the reliability of euro area oil and gas imports, attributable to the diversification of some supplies to countries with lower geopolitical risk. To a lesser extent, other indicators have also improved, with the exception of the degree of self-sufficiency of primary energies and the degree of electrical connectivity, owing to physical endowment and capacity constraints respectively. The aggregate indicator also suggests that the euro area might considerably benefit from a closer integration of energy markets and reach a level of energy security comparable to that of the

Chart C Energy security index for the euro area and the United States



Sources: EIA, Eurostat, Eurosystem staff calculations and OECD.
Note: The principal factor applied to the seven indicators analysis yields one factor with eigenvalue greater than one, which explains 82% of the overall variance (see Annex 2.1 for details).

Chart D Indicators of energy security for the euro area and the United States (2006)



Sources: EIA, Eurostat, Eurosystem staff calculations and OECD.
Note: The principal factor applied to the seven indicators analysis yields one factor with eigenvalue greater than one, which explains 82% of the overall variance (see Annex 2.1 for details).

4 During shortages of natural gas supply, countries with LNG infrastructure tend to be able to respond more flexibly than countries receiving natural gas through pipelines (see also Annex 2.1).
5 Due to a lack of data, Cyprus, Luxembourg and Malta are not included in the analysis.
6 Weights are chosen according to their contribution to the overall variance in the data. See Annex 2.1 for details.

United States. At the Member State level, energy security has on average remained below the level in the United States, barring notable exceptions, namely euro area countries in which either nuclear power or renewables are important sources for electricity generation or where access to the global LNG market is available.

Chart D suggests that with an integrated energy market, the euro area, compared to the United States, might achieve particularly high scores with respect to electricity interconnections (given the very low level of this indicator in the United States), LNG imports and the degree of self-sufficiency in electricity generation.

In the long term, energy security in the euro area might also be affected by the EU's climate change policies. Indeed, recent studies on a possible link between climate policies and energy security find that there may be a "double dividend" of global climate policies in terms of enhanced energy security (see Criqui and Mima 2009). Work by the IEA (2007) suggests that the impact of a reduction in CO2 emissions on energy security would depend on how it is implemented. For example, an increase in end-use energy efficiency and enhanced reliance on non-fossil technologies (renewables and nuclear) are likely to have a positive impact on energy security.

Box 3

GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE POLICIES

This box provides information about the main greenhouse gas emitting countries and sectors in the euro area, the current European climate change policies and considerations related to other possible ways to reduce carbon emissions, such as carbon taxes.

Since pre-industrial levels, the concentration of GHGs included in the Kyoto Protocol has increased from 280 to 430 parts per million by volume of carbon dioxide equivalent, with a rise in global mean surface temperature of 0.7°C. Under the "business as usual" scenario, GHG concentration would continue to increase and global temperature could rise to a range between 2.4°C and 6.4°C (2090-99 relative to 1980-99). While a mild increase in temperature entailed by CO2 concentration might have beneficial effects in northern hemispheric countries (increasing crop yields, reducing winter deaths and heating costs), elsewhere such a warming could lead to more frequent extreme weather events, increasing stress on water resources and a major rise in sea level that could endanger coastal areas.

The available estimates of climate change policies' costs are uncertain, because of uncertainties about, among other things, technological change, estimates of which often vary significantly. However, some recent estimates suggest that the costs of mitigation and adaptation could reach around USD 200 billion to USD 300 billion (i.e. about 0.4% to 0.6% of world GDP) per year by 2030 (UNFCC 2008). In the case of inaction some studies assess that global damage from climate change would amount to a 5% loss of GDP each year at least; others estimate the potential loss of a 2.5°C increase – with respect to the pre-industrial level – at about 1% of GDP (see Stern 2007 and Tol 2008). In order to overcome the "greatest market failure" which climate change constitutes, the Stern Review recommends three elements of policy for an effective global response: the pricing of carbon, supporting low-carbon technologies and education about energy-efficient behaviour.

In order to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, there is wide agreement that the overall global annual mean surface temperature increase should not exceed 2°C above pre-industrial levels.[1] In order to achieve this, the overall GHG concentration should not exceed 450 ppmv CO2-e, which means that the global emissions of GHGs should peak by 2020 and then begin a sharp decline, if they are to be halved by 2050. According to the fourth assessment report of the IPCC (2007), to achieve this, developed countries should at least reduce their emissions by 80% compared with 1990 levels, whereas other countries should make a substantial deviation from their baseline emissions.

GHG emissions in the euro area

Total GHG emissions, without international bunkers (aviation and maritime emissions) and LULUCF (land use, land use change and forestry), represented around 3,364 million tons of CO2-e in the euro area in 2007. They have decreased by only 1.6% since 1990 (see Table A).[2] In 2007 euro area countries were responsible for 67% of the EU27's total GHG emissions. Unsurprisingly, the share of emissions is closely linked to country size, particularly in terms of population.

In parallel with the decrease in the overall level of GHG emissions since 1990, the quantity per unit of real GDP has also decreased owing to improvements in energy efficiency, the change in

1 UN Climate Change Conference Copenhagen, 2009. "We underline that climate change is one of the greatest challenges of our time. … To achieve the ultimate objective of the Convention to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, we shall, recognizing the scientific view that the increase in global temperature should be below 2 degrees Celsius, on the basis of equity and in the context of sustainable development, enhance our long-term cooperative action to combat climate change."

2 The most important GHG by far is carbon dioxide, accounting for 83.5% of total euro area emissions in 2007 (excluding international bunkers and LULUCF). In 2007 euro area CO2 emissions were around 2,809 Mt, 2.3% above the 1990 level.

Table A Total greenhouse gas (GHG) emissions in the euro area[1)]

	GHG Mt CO2-e			Shares (%)			GHG per capita t CO2-e			GHG per unit of output Kg CO2-e per GDP		
	1990	2000	2007	1990	2000	2007	1990	2000	2007	1990	2000	2007
BE	143.2	145.1	131.3	4.2	4.3	3.9	14.4	14.2	12.4	0.70	0.58	0.45
DE	1,215.2	1,008.2	956.1	35.5	29.9	28.4	15.4	12.3	11.6	0.69	0.49	0.43
IE	55.4	69.0	69.2	1.6	2.0	2.1	15.8	18.3	16.0	1.06	0.66	0.45
GR	105.6	127.1	131.9	3.1	3.8	3.9	10.4	11.7	11.8	0.98	0.93	0.73
ES	288.1	385.8	442.3	8.4	11.4	13.1	7.4	9.6	9.9	0.60	0.61	0.55
FR	562.6	556.8	531.1	16.5	16.5	15.8	9.9	9.5	8.6	0.47	0.39	0.32
IT	516.3	549.5	552.8	15.1	16.3	16.4	9.1	9.7	9.3	0.51	0.46	0.43
CY	5.5	9.3	10.1	0.2	0.3	0.3	9.5	13.5	13.0	0.86	0.95	0.80
LU	13.1	10.0	12.9	0.4	0.3	0.4	34.6	23.0	27.1	0.97	0.45	0.44
MT	2.0	2.6	3.0	0.1	0.1	0.1	5.8	6.8	7.4	0.79	0.65	0.67
NL	212.0	214.4	207.5	6.2	6.3	6.2	14.2	13.5	12.7	0.69	0.51	0.43
AT	79.0	81.1	88.0	2.3	2.4	2.6	10.3	10.1	10.6	0.49	0.39	0.37
PT	59.3	81.7	81.8	1.7	2.4	2.4	5.9	8.0	7.7	0.64	0.67	0.62
SI	18.6	18.9	20.7	0.5	0.6	0.6	9.3	9.5	10.3	1.21	1.02	0.83
SK	73.3	48.4	47.0	2.1	1.4	1.4	13.9	9.0	8.7	3.12	1.55	0.99
FI	70.9	69.5	78.3	2.1	2.1	2.3	14.2	13.4	14.8	0.65	0.53	0.48
euro area	3,420.1	3,377.4	3,364.1	100.0	100.0	100.0	11.4	10.9	10.4	0.61	0.50	0.44
EU27	5,564.0	5,053.6	5,045.4				11.8	10.5	10.2	0.74	0.55	0.47

Source: DG TREN (2010) "EU energy and transport in figures – Statistical pocketbook 2010".
1) Excluding international bunkers (international aviation and maritime transport) and LULUCF (land use, land use change and forestry) emissions.

Table B Total greenhouse gas (GHG) emissions 1) by main source category in the euro area

	Mt CO2-e			Shares (%)		
	1990	2000	2007	1990	2000	2007
Energy	2,621	2,630	2,652	76.6	77.9	78.8
Fuel combustion	2,559	2,581	2,615	97.6	98.1	98.6
Energy industries	913	911	994	35.7	35.3	38.0
Manufacturing and construction	531	464	444	20.8	18.0	17.0
Transport	560	684	711	21.9	26.5	27.2
Other sectors	538	515	460	21.0	19.9	17.6
Other (not elsewhere specified)	18	7	5	0.7	0.3	0.2
Fugitive emissions from fuels	62	49	37	2.4	1.9	1.4
Industrial processes	318	295	303	9.3	8.7	9.0
Solvent and other product use	13	11	10	0.4	0.3	0.3
Agriculture	352	340	316	10.3	10.1	9.4
Waste	116	101	82	3.4	3.0	2.4
Total emissions	**3,420**	**3,377**	**3,364**	**100.0**	**100.0**	**100.0**

Source: DG TREN "EU energy and transport in figures – Statistical pocketbook 2010".
1) Excluding international bunkers and LULUCF (land use, land use change and forestry) emissions.

the fuel mix away from solid fuels, and structural shifts in the sectoral composition of economic activity.

Table B gives an overview of euro area GHG emissions in the main source categories for the period 1990-2007. Energy is the most important source of GHG by far, accounting for 79% of total euro area emissions in 2007. Energy-related emissions in 2007 were 1.2% above the 1990 level. The second largest sector is agriculture (9.4%), followed by industrial processes (9.0%).

Concerning the main sub-categories of energy[3], the most important were energy industries – with electricity and heat production the major contributors to GHG emissions – accounting jointly for 38.0% of emissions in 2007 (994 Mt CO2-e). The second largest was transport (27.2%, 711 Mt CO2-e), followed by other sectors – mainly households – (17.6%, 460 Mt CO2-e) and manufacturing and construction (17.0%, 444 Mt CO2-e).

European climate change policies

Because of the close links between climate change and energy policies (for instance the majority of the total CO2-e emissions result from the production and consumption of energy), the EU is pursuing an integrated climate change and energy strategy. Legislation was introduced in April 2009 which envisages a reduction in EU CO2 emissions by 20% compared with 1990 (to be scaled up to 30% under a binding global agreement), a 20% increase in energy efficiency and an increase in the contribution of renewable energies to 20% of total energy consumption by 2020 (the "20-20-20 agenda"). These targets are to be reached through (i) an improved and extended EU Emission Trading Scheme with progressively stricter emission caps, (ii) stricter energy-efficiency standards, such as for cars and buildings, (iii) the geological storage of carbon dioxide and (iv) the promotion of renewable energies, including a 10% biofuel target in transport.

"Cap and trade" systems, such as the ETS, play a central role in the EU's long-term strategy for reducing GHG emissions. The EU ETS, established in January 2005, covers around 40% of

3 The energy sector consists of fuel combustion and fugitive emissions from combustion. Fuel combustion consists of the energy industries, manufacturing and construction, transport, other sectors and other (not elsewhere specified).

all EU27 emissions. Applicable between 2005 and 2012, emission caps have been established according to national allocation plans, and will be replaced from 2012 onwards by an EU-wide cap. In 2008 more than 3 gigatons of CO2-e allowances were traded on the EU ETS, representing a total value of €63 billion (up 87% when compared with 2007 levels) and amounting to 73% of the global carbon market (World Bank 2009). From 2012 onwards about half of allowances will be auctioned, rising to 80% by 2020. The proceeds of the auctioning can be used to reduce distortionary taxes (e.g. labour taxes), reap the benefits of the so-called double dividend, or to finance climate change policies in the EU or in developing countries. According to the European Commission's estimations, auction revenues could be substantial: assuming that all sectors covered under the EU ETS would have to acquire allowances using auctions, in 2020 revenues could represent 0.5% of GDP (assuming a price of about €40/t CO2-e) (see EC 2008).

Current considerations on pricing carbon emissions

Whatever instrument is used, a stable, transparent and credible price signal as well as long-term expectations of rising carbon prices are needed in order to make GHG mitigation cost effective and politically sustainable. From this perspective, energy subsidies and other price distortions in the developing and developed countries undermine the effectiveness of price signalling. An international carbon market could be developed in which existing markets are linked and integrated. Such linking and the broadening of the sectors covered would increase the possibility of achieving a global emission target at the lowest cost.

1.4 FUTURE TRENDS

Future developments in *European energy markets* will be largely shaped by two main forces: (i) trends in global energy markets in terms of supply, demand and technology and (ii) the implementation of energy market policies both at the European and global level, the latter particularly in relation to climate change. However, although identifying the main forces may be straightforward, estimates of future developments in energy markets are subject to great uncertainty. This uncertainty stems from a number of sources including the high volatility in energy markets themselves, the fact that global policies are still evolving, and lastly the fact that global supply, demand and technology trends may react endogenously to changes in policy in ways that are hard to anticipate a priori.

This section reports estimates from the European Commission (2008a) and the IEA (2009) on likely future trends up to 2020. Both institutions report "baseline" scenarios, which are based on currently agreed policies and global market trends in terms of supply, demand and technology, and "policy change" scenarios.[23] The Commission considers the scenario of full implementation of the EU's current energy and climate policy plans, whilst the IEA reports a 450 ppm scenario.[24] The Commission presents its baseline estimates for two different profiles of oil prices (moderate and high). The IEA bases its oil price assumption on a model which balances forecast supply and demand.[25] Different oil prices account for some of the most salient differences between the two baseline scenarios.

23 Whilst this distinction is useful, it should also be borne in mind that some current market developments may be driven by an anticipation of future policy developments. Hence the baselines and alternative scenarios may not be completely independent. Furthermore, the two estimates are based on different assumptions and are thus not fully comparable.

24 This refers to greenhouse gas concentrations limited to 450 parts per million in the atmosphere.

25 The IEA reports that in its model USD 100 in constant 2008 prices equates USD 131 in nominal terms. In terms of sensitivity analysis the IEA also reports the impact of assuming higher or lower GDP growth and oil prices compared to its reference scenario.

Although there are considerable differences between the Commission and IEA regarding their baseline/reference scenarios, these differences stem more from the timing of when the forecasts were made than from other factors such as modelling assumptions. The impact of financial market developments on economic activity and energy consumption was not anticipated when the Commission compiled its forecasts in early 2009. Thus whilst the Commission anticipates an increase in primary energy demand up to 2020, the IEA now suggests a decline (see Table A2). Energy demand is a function of many factors including prices and general economic activity, but also more structural determinants such as population demographics or societal behaviour with regard to energy efficiency.[26] With respect to the expected decomposition by fuel type the broad patterns are the same: i.e. a strong increase in renewables, some increase likely in natural gas and a decline in nuclear power. There are some differences with respect to oil and solid fuels, but these may, in part, be accounted for by recent developments as well as by different oil price assumptions. Overall, fossil fuels will remain the dominant fuel source. Energy efficiency should improve arising both from structural improvements driven by R&D and technological change, as well as a result of the increasing importance of services in the economy's structure. On the other hand, the Commission envisages that energy dependency will increase further as the overall reduction in primary energy production is combined with increased fossil fuel consumption in Europe. Regarding greenhouse gas emissions, the Commission forecasts suggest at best a levelling off from 2005/06 levels, which clearly would not meet the Kyoto obligations. However, the large uncertainty surrounding these estimates may be underscored by the impact of the economic slowdown in the period 2008-09 and its effects on energy demand. In part reflecting this, between 2008 and 2009, the IEA revised down estimated energy demand in the OECD countries up to 2015 by 6% compared with its 2008 World Energy Outlook.

Alternative *policy scenarios* reveal some important differences from the baseline scenarios. First, rather than increasing slightly, energy demand in the EU would decrease slightly, arising mainly from greater gains in energy efficiency.[27] These improvements in energy efficiency, which arise from the assumption of additional R&D and enhanced technological change, underscore the interaction of likely future trends and energy policy. There would also be some differences in the likely fuel mix. Demand for fossil fuels, in particular solid fuels, would decrease owing primarily to the higher price of carbon. Renewables would gain even more in importance. Energy dependency would still be likely to increase.

In terms of the possible *macroeconomic impacts*, a wide range of estimates exists for the likely impact of carbon reduction measures on economic growth. Depending on the scenario, the underlying assumptions on how this is achieved (for example, actions in developed and developing economies, technology sharing, etc.) and the model used, current estimates range from 0.2% to 3.0% of GDP (see, for example, IEA 2009, OECD 2008, IMF 2008, and IPCC 2007). These costs should be seen as "gross" in the context of climate policy since damages of climate change owing to inaction would have to be netted out (see Box 3 for further discussion of this issue). Regarding prices, climate change policies will increase the price of energy products according to their carbon content. In its 2009 study, the IEA assumes a price of USD 50 per ton of CO2 by 2020, which is equivalent to adding USD 20 per barrel to the cost of oil without carbon pricing. At the same

26 For instance, recent proposals to amend EU energy labelling for consumer products (agreed on 17 November 2009 by the Council, Commission and Parliament) should increase consumer awareness of energy consumption and encourage lower energy intensity in consumption.

27 The Action Plan for Energy Efficiency suggests that the services and commercial sector is that with the highest saving potential, estimated around 30% by 2020. Other sectors have potential savings of 25-27%. Great importance is given to the development of a proper regulation for avoiding stand-by electricity losses from various products, which could spare 35 TWh of the 50 consumed yearly by residential equipment in stand-by mode.

time, the price of fossil fuels excluding carbon penalties could be lower than under baseline scenarios owing to their dampening impact on fossil fuel demand. Furthermore, changes in relative prices, in particular that of carbon, should not be confused with overall inflation. Given that carbon pricing will be announced in advance (and hence anticipated by agents) and that climate change policies may have a small downward impact on overall activity, these factors may counteract the upward pressure on energy prices.

Overall *at a more global level*, it is likely that energy markets will remain a source of macroeconomic volatility. In oil markets, although prices have declined from the peaks reached in 2008 and overall demand has fallen, it is likely that tightness in the supply-demand balance will re-emerge once global economic activity resumes its upward trajectory. This tightness could be intensified by the slowdown in investment in oil supply as many projects have been postponed or cancelled. Moreover, energy dependency is expected to remain high in the long run. On the other hand, the increasing penetration of renewable energy and ongoing declines in energy intensity could reduce European energy dependency and dampen the macroeconomic impact of energy price volatility of international markets on euro area economic activity and inflation.

2 THE IMPACT OF ENERGY PRICES ON ECONOMIC ACTIVITY

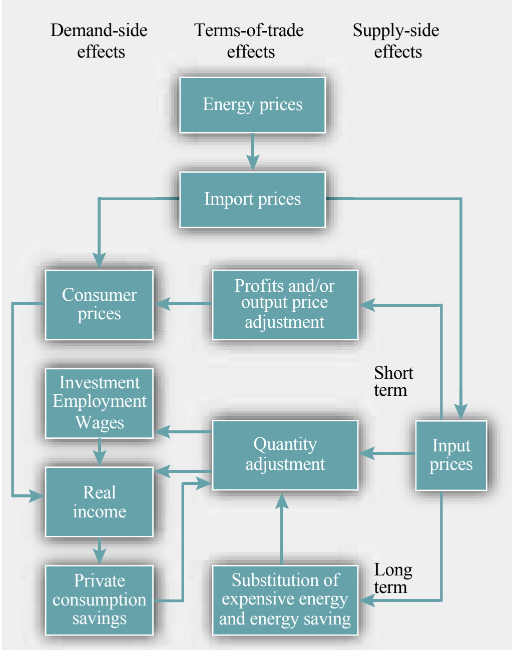
This chapter studies the short and long-term impact of energy prices on economic activity in the euro area, in the context of the energy market features analysed in Chapter 1. The chapter starts with conceptual considerations on the main channels through which energy prices can affect output. Second, empirical evidence on the short and medium-term impact of energy prices on activity in the euro area as a whole as well as in individual Member States is discussed on the basis of simulations with macroeconometric models. Finally, the chapter turns to the long-run effects of energy price changes on output.

2.1 IMPACT ON ECONOMIC ACTIVITY – CONCEPTUAL CONSIDERATIONS

The impact of energy prices on euro area economic activity can be disentangled into terms of trade, demand and supply-side effects (see Chart 17). Terms-of-trade effects arise from an increase in import prices of energy, which leads to an increase in total import prices relative to export prices. The deterioration in the terms of trade may trigger adverse real income and wealth effects in net energy-importing countries. Unless savings are reduced or borrowing increases, this will depress consumption in the domestic economy. Demand-side effects are linked to the impact of energy prices on inflation. As prices increase, real disposable income and, therefore, consumption is reduced. Supply-side effects arise from the importance of energy as an input factor in the production process. As a result, production costs increase along with increases in energy prices.

The mechanism underlying the direct *demand-side effect* is rather immediate. Chart 18 shows the evolution of real private consumption, real disposable income and oil prices[28] since the 1970s. Oil prices seem to have had some impact on real disposable income after the oil price hikes in 1973 and 1999, when both real disposable income and consumption declined

Chart 17 Energy prices and economic activity



Source: Eurosystem staff.

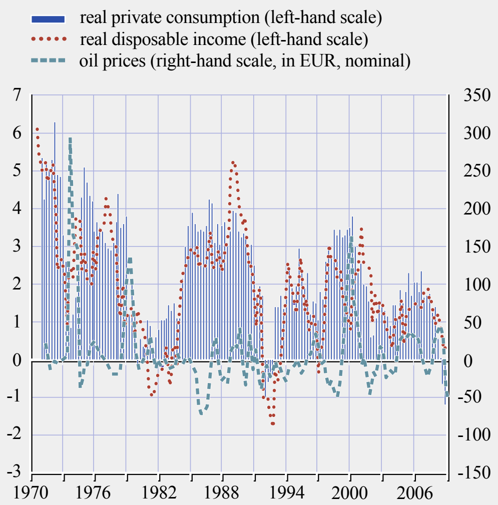
shortly after the hikes. The link is less apparent for the oil price shock in 1979 which started when real disposable income and consumption were already on a declining path. The impact of smaller increases in oil prices is more difficult to detect by visual inspection.

Turning to the *supply side of the economy*, in the short term, the ability of firms to react to oil price increases by substituting energy with other inputs is limited. Past investment represents sunk costs so that the energy intensity of production is largely given. As a result, an increase in energy prices inevitably leads to higher production costs. Firms may then react to this shock either via their pricing or their production behaviour. In terms of the former they can either buffer the increase in energy prices by diminishing their profit margins, or they can pass through the

28 Oil prices are used as no equally long series for energy prices is available. This is justified as oil prices and energy prices co-move closely together. Furthermore, as explained above, different sources of energy are hard to substitute in the short term.

Chart 18 Oil prices, disposable income and private consumption

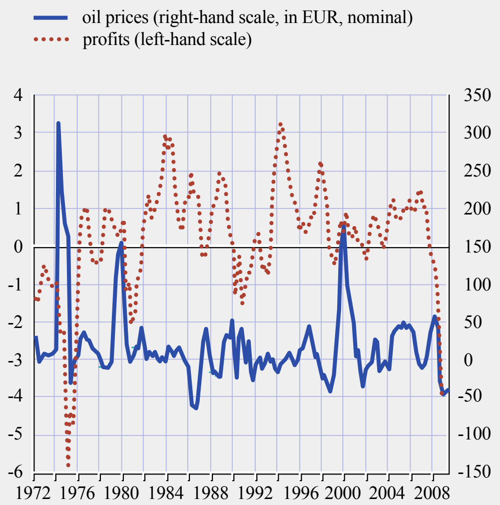
(annual percentage changes)



Sources: Eurostat, IMF, Area-Wide Model (AWM) database and Eurosystem staff calculations.

Chart 19 Oil prices and profit growth

(annual percentage changes)



Sources: Eurostat, IMF, Area-Wide Model (AWM) database and Eurosystem staff calculations.

higher production costs by increasing selling prices, thereby generating indirect effects on inflation. In terms of their production behaviour, firms react to new market conditions by adjusting the quantities produced, therefore reducing the amount of energy needed for production. As a result, investment, employment and wages tend to go down.

To illustrate the link between profit margins and energy prices over time, Chart 19 shows oil prices and profit growth since the 1970s. After the oil price hikes in 1973 and 1979, profit growth (approximated by the GDP deflator growth minus unit labour cost growth) declined substantially owing to a stronger increase in unit labour costs than in the GDP deflator. However, the oil price hike in 1999 did not have an effect of similar magnitude on profits, given that both the GDP deflator and unit labour costs grew at similar rates.[29] At the same time, the oil price decline in 1986 was accompanied by an increase in profit growth.

The adjustment path to a new long-run equilibrium is smoother the less nominal rigidities exist in the economy. The resulting long-term decline in output depends considerably on the overall energy intensity of production and on the degree to which energy can be substituted by other means of production. Producers can exploit more and more possibilities to substitute energy so that the energy intensity of production will decline somewhat in response to a positive energy price shock. Indeed, as shown in Chapter 1, the share of oil in production and the oil intensity of consumption have declined in the OECD countries compared with the 1970s. These long-run trends cushion the effects of higher production costs. Therefore, the long-term effects on output are typically less pronounced than the short-term effects (see Section 2.3). Obviously, this substitutability of expensive energy for less expensive energy can differ across sectors and countries.

The above-mentioned effects depend also on the expectation of the duration of energy price changes. In general, energy price increases which are perceived as permanent have stronger adverse long-run impacts on output, while an

29 Profit mark-ups may have been supported to some extent by the depreciation of the euro around the time of its launch.

increase in energy prices which is anticipated to be temporary induces an inter-temporal shift in consumption and output, decreasing current output to a greater extent, but less so in the long run. In addition, a fall in output could be the consequence of uncertainty when major disruptions in energy supply raise doubts about the future availability of oil and its price. In such a case, purchases of investment and durable consumption goods which are complementary to energy and are irreversible are likely to be put on hold since there is a positive option value of waiting to invest or to consume. Consequently, the capital stock grows less or even declines, weakens the economy's aggregate demand (Bernanke 1983) and consumption of energy-intensive items, such as cars, may be depressed. In this vein, Kilian (2008a) found evidence for a much stronger effect of energy price shocks on the demand for vehicles than on the consumption of other consumption goods. However, the overall empirical evidence in favour of such a channel has so far been limited (see, for example, Peersman and Robays 2009 and Edelstein and Kilian 2008).

2.2 IMPACT ON ECONOMIC ACTIVITY – EMPIRICAL EVIDENCE

According to the results of a set of ESCB macro econometric models, oil price increases lead to output losses, which are quite heterogeneous across countries. Table 3 shows the impact of a 10% permanent rise in oil prices in US dollar terms on real GDP over three years. As these models usually assume that oil is the only source of energy, the simulations are done for a change in oil prices and not a change in total energy prices. Model simulations are largely harmonised, but some important differences remain.[30] These simulations are based on the assumption that the impact of energy price changes on activity is the same independently of whether the changes are demand or supply driven. A 10% increase in oil prices over three years would imply that GDP is 0.3-0.4 percentage point lower than the baseline in Belgium, Germany, Greece and Italy, while the impact on GDP in Ireland, France, Luxembourg, Austria and Slovenia amounts to less than 0.1 percentage point. The other countries lie between these two groups.

Table 3 Effect of a 10% oil price rise on real GDP according to traditional structural models

(annual averages)

	Year 1	Year 2	Year 3
Belgium	-0.09	-0.30	-0.40
Germany	-0.16	-0.33	-0.37
Ireland	0.00	-0.03	-0.05
Greece	-0.03	-0.13	-0.34
Spain	-0.04	-0.21	-0.25
France	-0.01	-0.02	-0.05
Italy	-0.07	-0.25	-0.36
Cyprus	-0.03	-0.08	-0.15
Luxembourg	0.00	-0.03	-0.03
Malta	-0.27	-0.26	-0.16
Netherlands	-0.03	-0.08	-0.10
Austria	-0.07	-0.09	-0.07
Portugal	-0.05	-0.11	-0.20
Slovenia	0.01	-0.01	-0.06
Slovakia	-0.10	-0.14	-0.14
Euro area average	-0.08	-0.19	-0.24

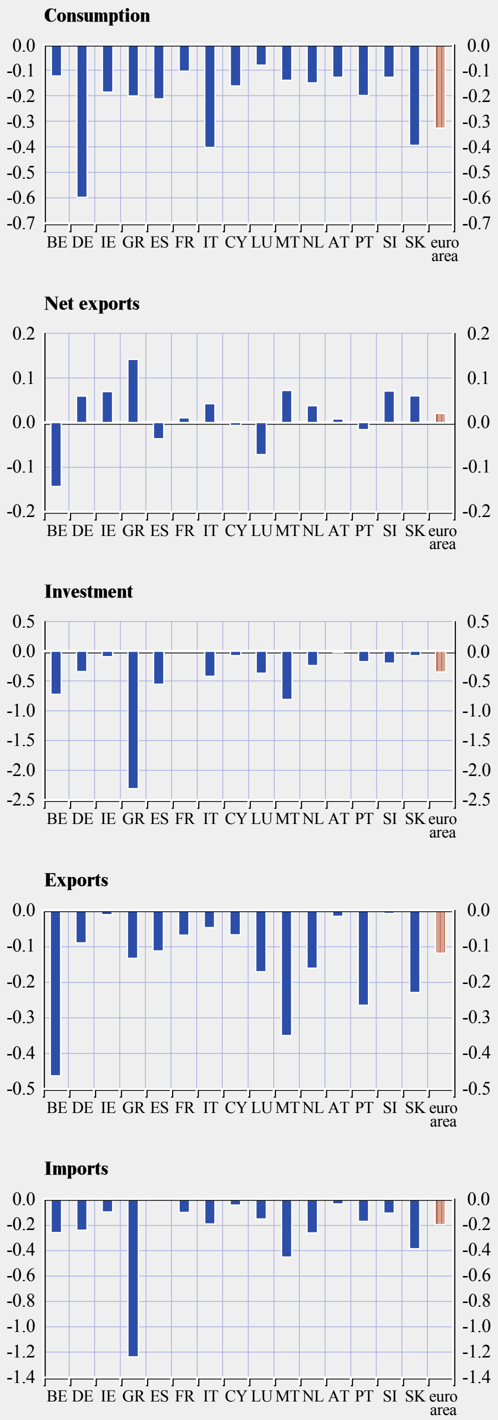
Source: Eurosystem staff calculations.
Notes: This table indicates the short-run effects of a permanent increase in the price of oil by 10% on real GDP in the euro area countries. The figures denote cumulated deviations in percent from the respective baseline simulation with unchanged oil prices. The estimations of the macroeconometric models are based on data samples going back to the 1980s for all countries with the exceptions of Cyprus and Malta (starting in 1995), Slovenia (starting in 1996) and Slovakia (starting in 2000).

Owing to their interactions, as also reflected in Chart 2, it is difficult to clearly disentangle demand and supply-side effects. However, a breakdown of GDP into its expenditure components can give insights into the source of differences in the reaction to changes in oil prices across countries.

30 The simulations were carried out on a largely harmonised basis, and under the assumption that monetary policy is exogenous (i.e. the nominal interest rate is kept constant, except for Greece), fiscal policy is exogenous and exchange rates are assumed not to be affected by the oil price change. Beyond this, the models are not harmonised and may differ with respect to their size, estimation period and theoretical underpinning. There could also be differences in the channels through which oil price changes affect the economy and in particular with respect to the inclusion of supply-side effects of a change in oil prices. In addition, the treatment of international spillover effects may differ across models. A detailed description of the models used is beyond the scope of this report, but a more comprehensive overview of many of them can be found in Fagan and Morgan 2005.

Chart 20 Effect of a 10% oil price increase according to traditional structural models (average effect in year three)

(percentage deviation from baseline (cumulated); percentage point deviations from baseline for net exports contribution)

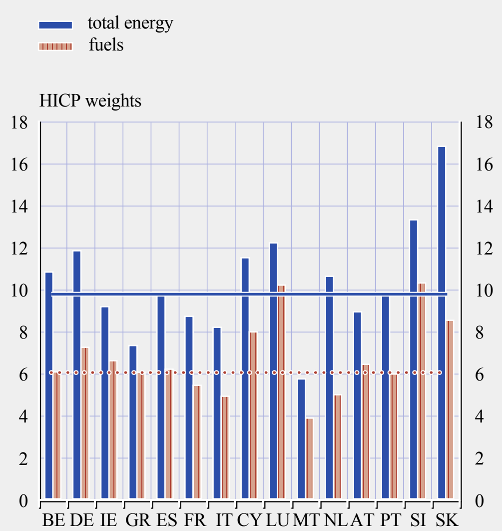


Source: Eurosystem staff calculations.

Looking at the expenditure breakdown of GDP, two of the countries with the strongest effects on *consumption* (Germany and Slovakia, see Chart 20) also have a relatively high energy content of consumer demand, as reflected in the HICP weights and input-output tables (see Charts 21 and 22). In addition, as real income is an important determinant of consumption, countries with a relatively large simulated negative effect on real income (for example Italy and Slovakia, see Chart 23) also tend to experience a larger impact on consumption, while those with a more muted reaction of real income (Belgium, France, Malta and Austria) have also relatively small consumption effects.

Interestingly, the relatively strong impact on wages for Belgium and Greece (see also Section 3.3.3) results in a relatively larger effect on employment, while countries with a smaller wage reaction (e.g. Ireland and Austria) tend to experience a smaller effect on employment (see Chart 23). However, this relationship between the size of the wage and employment reactions also depends on the flexibility of

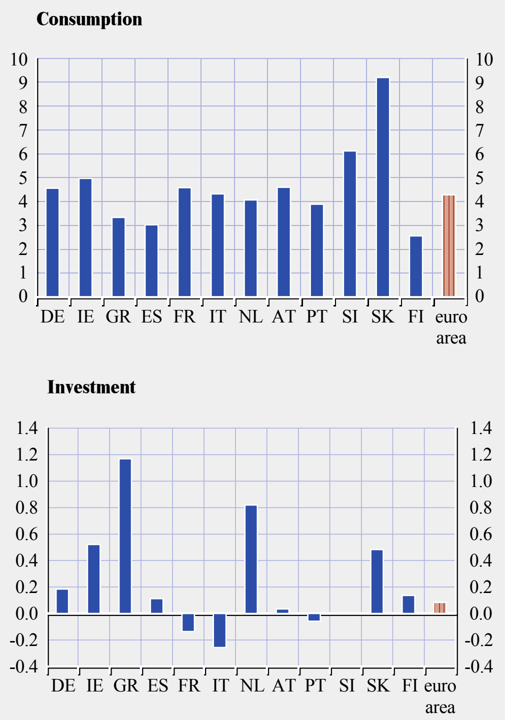
Chart 21 Weight of energy in the consumption basket



Source: Eurostat.
Note: The horizontal lines show the respective euro area average.

Chart 22 Energy content of final demand

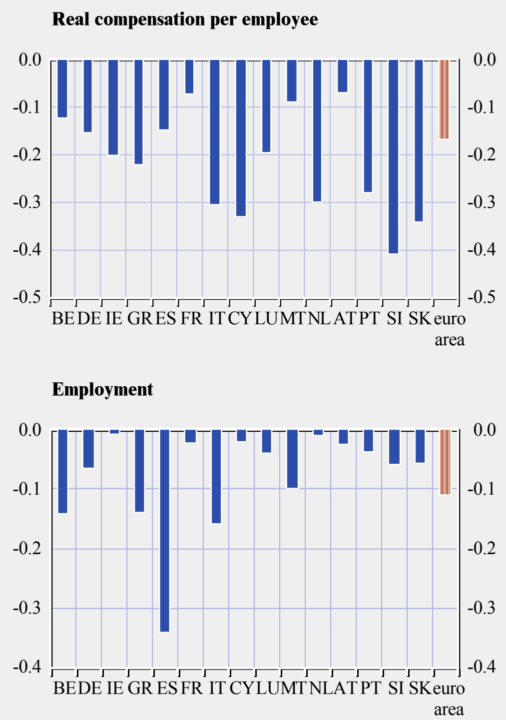
(2005; percentage of component of the final demand)



Source: Input-output tables from Eurostat.
Note: Negative figures for investment are due to inventories.

Chart 23 Effect of a 10% oil price increase according to traditional structural models (average effect in year three) – labour market

(percentage deviation from baseline (cumulated))



Source: Eurosystem staff calculations.

labour markets which influences the downward adjustment of both wages and employment. Overall, the strongest negative impact on employment can be observed in Spain, followed by Belgium, Greece and Italy, while the effect is very small for Ireland, France, Cyprus, Luxembourg, the Netherlands and Austria.

Regarding *investment* (see Chart 20), the simulation results indicate that the negative impact on this GDP component is substantial for Greece, which has a very high energy content of investment (see Chart 22). Note however that, contrary to the other models, the Greek model includes an interest rate reaction. Stronger than average negative effects on investment can also be observed for Belgium, Spain and Malta. The negative impact on investment is small for Ireland, France, Cyprus and Austria, where a rather small energy content of investment can be observed for France and Austria.[31] In addition, in France, the effect is small owing to a positive effect on housing investment, as the French model predicts a stronger impact stemming from a decline in real interest rates as a result of the increase in the HICP.

Finally, the simulations differ with respect to the impact on the contribution of *net exports* to GDP growth (see Chart 20). While some countries seem to react to an increase in oil prices with a decline in net exports (Belgium, Spain, Cyprus Luxembourg and Portugal), most countries' net exports increase, owing to a relatively stronger downward impact on imports than on exports.[32]

31 No input-output tables for 2005 are available for Belgium, Cyprus, Luxembourg and Malta.

32 Indeed the impact of oil prices on international trade flows outside the country under consideration is not explicitly modelled in most national simulations.

Regarding the time taken for a change in oil prices to manifest an effect on GDP, there are also differences across countries (see Table 3). Most countries experience negative impact fading relatively gradually to the full impact over the three years. Meanwhile, the impact is almost nil in Slovenia in the first year, mainly owing to a strong positive effect on investment which only becomes negative from the second year onwards. For Malta and Austria, the impact on GDP declines in year three compared with year two, owing to a diminishing investment and private consumption effect. The latter could be attributable to a relatively small downward impact on real wages (see Chart 23). A possible reason for the decline in the investment reaction is that it is assumed interest rates remain the same following the change in oil prices. Given that the HICP increases because of the increase in oil prices, real interest rates decline, thereby pushing investment up. This effect seems to be somewhat stronger in Malta and Austria than in the other countries. In the case of Malta, the positive contribution of net exports (reflecting a larger fall in imports) also has a significant impact, mainly because of the lagged effect on output growth of lower consumption, investment and exports, all of which have a high import content.

The large differences across countries in terms of trade can partly be explained by the *openness of the countries*, where in particular the effect on exports appears to be relatively strong for smaller countries (see Chart 20). Furthermore, different simulation results for exports can arise from differences in the degree of oil import dependence, price elasticity of oil demand, energy intensity of production and the sectoral and geographical decomposition of exports and imports. An additional element to be considered is that countries benefit to a different extent from the recycling of petrodollars (see Box 4), which is not explicitly included in the simulation results above.

Box 4

ENERGY PRICES AND EXTERNAL IMBALANCES

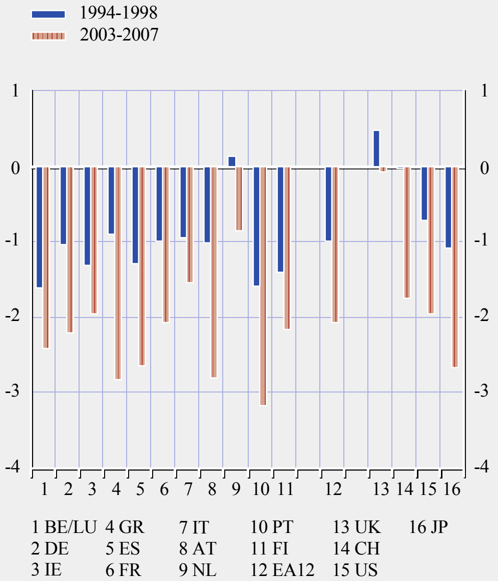
Energy products represent an important share of international trade. Chart A shows that in the period of rising energy prices between 2003 and 2007 the energy balance of the euro area countries, which are all net energy importers in nominal terms, deteriorated significantly as compared with the period between 1994 and 1998. In particular, the net external energy deficit of the euro area reached 2.1% of GDP. Chart B shows that the euro area energy external balance in the period 2003-07 almost entirely offset the surplus in the non-energy external balance.

In this box we focus on two channels through which oil price changes affect the external accounts of oil-importing countries in the short run. First, we consider the effects associated with *international trade*. A rise in oil prices directly increases the cost of imported oil, which constitutes an adverse shock to the terms of trade, thus decreasing the current account balance – the *direct trade effect*.[1] However, higher oil prices increase oil revenues and demand for goods and services by oil exporters, leading in principle to higher foreign demand of oil-importing countries and thus to increases in their current account balances – the *indirect trade effect*. Second, certain effects of oil price changes on the external balance are associated with *international financial markets*. As the domestic economies of oil exporters are heavily

1 The analysis and simulations exclude any trade volume and price changes owing to demand-side (real disposable income) or supply-side (production costs) effects of an oil price increase on the current accounts of oil importers. In addition, exchange rate and policy-induced changes are not accounted for.

Chart A Energy external balance

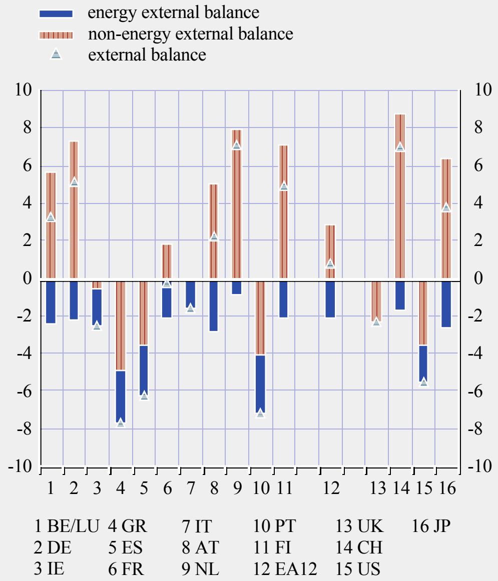
(as a percentage of GDP)



Source: Eurosystem staff calculations based on CHELEM data.
Note: The euro area is based on data for the composition of 12 countries (EA12).

Chart B Energy and non-energy external trade balances

(average 2003-2007; as a percentage of GDP)



Source: Eurosystem staff calculations based on CHELEM data.
Note: The euro area is based on data for the composition of 12 countries (EA12).

reliant on oil-producing industries, part of the additional oil revenues resulting from an increase in oil prices is usually channelled into international financial markets, either by purchasing foreign assets (in the form of the accumulation of foreign exchange reserves and other cross-border investments) or by repaying external debt.

The empirical evidence suggests that in past episodes, roughly half of the overall petrodollar windfall gain was spent on foreign goods, while the remainder was invested in foreign assets. Nevertheless, there are noticeable differences across countries. In the period between 2002 and 2006, estimates suggest that 41% of the increase in the euro area's oil deficit and 60% of the increase in China's oil bill were compensated for by higher purchases of domestically-produced goods in the oil-exporting countries, as against only 20% for the United States and 18% for Japan (Higgins et al. 2006). At the same time, OPEC countries have significantly increased net holdings of foreign assets as a percentage of GDP in recent years. Evidence suggests that the bulk was invested in the United States.

The table below shows the results of a simple benchmark calculation of the combined *direct and indirect trade channels* for two variants of an oil price increase[2]: an increase of roughly 40% (from 52 USD per barrel to 70 USD per barrel) and a stronger increase of 100%

2 The direct trade effect is simulated assuming inelastic oil demand in the short term (as documented in the literature, see for example Hamilton 2009) and a proportional response of oil balances to the change in oil prices. The indirect trade effect assumes that exports by oil-importing countries increase in line with the rising demand for imports by the oil-exporting countries (Norway, Russia and OPEC members excluding Iraq). We assume that the increase in imports by oil-exporting countries is distributed according to the shares of oil importers in those countries' total goods imports.

Combined effect on current account

(as a percentage of GDP; change in oil-exporters' import demand as a share of the increase in their oil export revenues (scenarios 1-4))

	Scenario 1 0%		Scenario 2 20%		Scenario 3 60%		Scenario 4 100%	
	70 $/bbl	100 $/bbl	70 $/bbl	100 $/bbl	70 $/bbl	100 $/bbl	70 $/bbl	100 $/bbl
Netherlands	-0.1	-0.2	0.1	0.3	0.4	1.1	0.8	2.0
Ireland	-0.2	-0.5	-0.1	-0.3	0.0	0.1	0.2	0.4
Italy	-0.5	-1.2	-0.3	-0.9	-0.1	-0.3	0.1	0.3
Germany	-0.7	-1.8	-0.5	-1.4	-0.3	-0.7	0.0	0.0
Finland	-1.2	-3.1	-0.9	-2.4	-0.3	-0.9	0.2	0.6
Spain	-0.5	-1.4	-0.5	-1.3	-0.4	-1.0	-0.3	-0.7
France	-0.8	-2.0	-0.7	-1.8	-0.5	-1.4	-0.4	-1.0
Austria	-0.8	-2.3	-0.7	-2.0	-0.5	-1.4	-0.3	-0.9
Slovakia	-1.2	-3.3	-1.0	-2.7	-0.6	-1.7	-0.2	-0.6
Belgium	-1.4	-3.7	-1.2	-3.2	-0.8	-2.2	-0.5	-1.3
Greece	-1.0	-2.7	-1.0	-2.7	-0.9	-2.5	-0.9	-2.4
Portugal	-1.4	-3.8	-1.3	-3.5	-1.1	-2.9	-0.9	-2.3
Cyprus	-1.2	-3.3	-1.2	-3.2	-1.1	-3.0	-1.0	-2.8
Luxembourg	-1.4	-3.7	-1.3	-3.6	-1.2	-3.3	-1.1	-3.0
Slovenia	-1.9	-5.2	-1.8	-4.7	-1.4	-3.7	-1.0	-2.7
Malta	-1.9	-5.1	-1.7	-4.6	-1.4	-3.8	-1.1	-2.9
Euro area	-0.7	-1.8	-0.6	-1.5	-0.3	-0.9	-0.1	-0.4
United States	-0.7	-1.8	-0.6	-1.7	-0.6	-1.6	-0.5	-1.4
China	-0.4	-1.1	-0.3	-0.8	-0.1	-0.3	0.1	0.3

Sources: Eurosystem staff estimates based on the IMF World Economic Outlook and Direction of Trade Statistics.
Note: Euro area countries are ranked in descending order based on the scenario of 70 USD/barrel and 60% change in oil-exporters' import demand as a share of the increase in oil-exporters' oil export revenues.

(to 100 USD per barrel) in 2009. Results are shown for four alternative scenarios regarding the extent to which petrodollars are recycled. These scenarios are 0%, 20%, 60% and 100%.[3]

The results of the simulations broadly confirm the findings of previous empirical research. First, as would be expected, the largest net oil importers, i.e. the euro area and the United States, experience the most pronounced deterioration in their oil balances in the short term (as illustrated by the first scenario in the table, which assumes no "oil bill recycling", and thus captures only the direct effect of higher oil prices). The deterioration ranges from 0.7% to 1.8% of GDP, depending on the size of the change in oil prices. Second, the economies with the largest export activity towards the oil-exporting countries, i.e. the euro area and China, significantly benefit from the indirect effect of increased import demand by the oil exporters, although in most cases it only partly offsets the negative direct effect. As long as the propensity of oil exporters to import does not change in favour of more saving, euro area countries should therefore benefit from higher exports to oil-exporting economies.[4] Geographical proximity to most major oil exporters and historical ties seem to partly explain the closer trade links between euro area countries and oil exporters and the relatively weaker export ties of the United States. Furthermore, the structure of import demand from oil-exporting countries, largely determined by an infrastructure and construction-led pattern of growth, seems to create a comparative advantage for those euro area countries that specialise in the production of capital goods, such as Germany in transport equipment and machinery. The euro area as a whole has been gaining import market shares in a number of oil-exporting countries

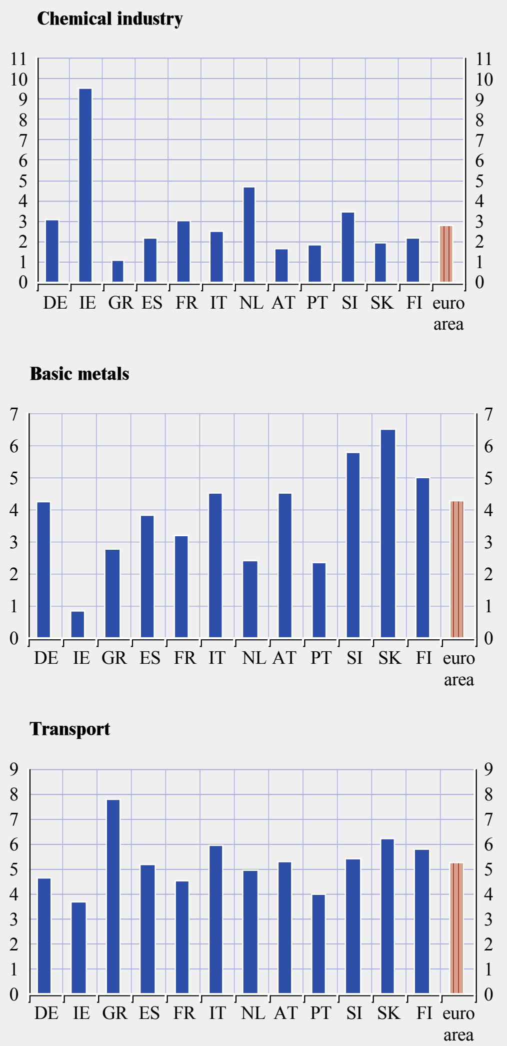
3 Exploratory estimates based on a panel of 12 oil-exporting countries over the period from 1980 to 2008 indicate that an increase in oil prices tends to result in an increase in the imports of oil exporters amounting to around 60% of additional oil revenues. Therefore, the scenario results are ordered according to the results based on this assumption.

4 The "marginal propensity to import out of oil revenues", defined as the change in imports net of non-oil exports, investment income, and transfers over the change in oil exports, seems to have decreased in most oil-exporting countries since the 1970s, but there is some evidence that it has started to rise again more recently (see Beck and Kamps 2009).

over the last decade, noticeably in Algeria, Saudi Arabia, the United Arab Emirates and Russia. In the scenario analysing the effect of an increase in the oil price to USD 70 per barrel – assuming that oil exporters spend 60% of the increase in oil revenues on additional import demand – the overall trade balances of countries such as Germany, Ireland, Italy, the Netherlands and Finland are likely to respond less negatively to the increase in oil price, while countries with weaker export ties with the oil exporters such as Cyprus, Luxembourg, Malta, Portugal and Slovenia would seem to bear the highest costs in terms of current account deterioration owing to an oil price hike. This finding differs from the simulation results described in the main text as the latter does not explicitly take into account the effect of petrodollar recycling.

Chart 24 Share of most energy-intensive sectors in gross output

(percentages)



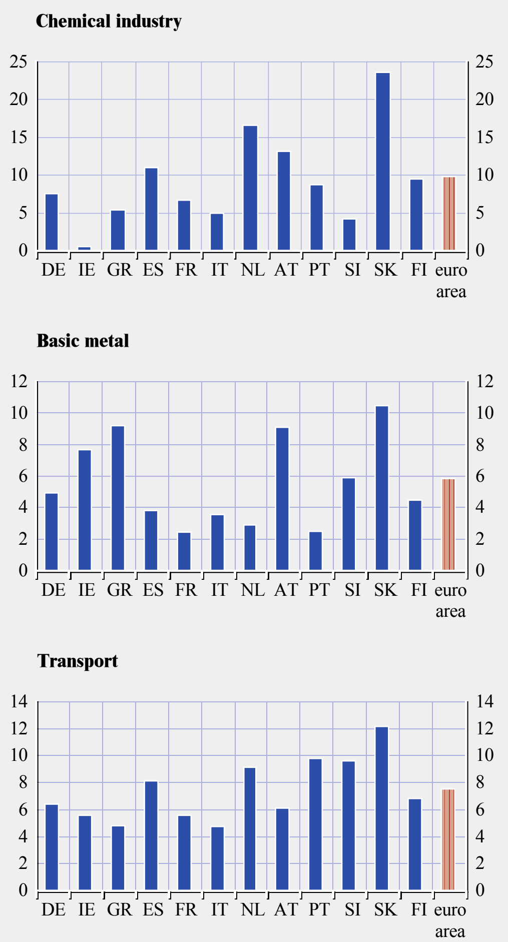
Sources: Input-output tables from Eurostat and Eurosystem staff calculations.

Country variations in the model results can, in addition to different model designs and openness of the individual countries, also stem from differences in the *sector structure*.[33] As shown in the input-output table analysis in Section 3.3.1, the most affected sectors were chemicals manufacturing and transport services (see also Knetsch and Molzahn 2009), which have different weights in the production of each country. Chart 24 shows that these most energy-intensive sectors have a relatively large share of gross output in the Netherlands and Slovenia for the chemicals industry, Slovenia and Slovakia, for basic metals, and Greece, Italy, Slovakia and Finland for transport services. At the same time, the chemicals sector has a high energy intensity in the Netherlands and Slovakia, while the energy intensity in the basic metal industry is particularly high for Greece, Austria and Slovakia, and in transport services for the Netherlands, Portugal, Slovenia and Slovakia (see Chart 25). In Greece, for example, the high energy intensity of the basic metal industry might partly explain the large impact of a change in oil prices on investment, while the impact on private consumption is below the euro area average. It is to be noted that the impact of energy prices on investment can also be quite different depending on whether the models differentiate between the

33 Berben et al. (2004) examine the reasons for differences in the estimated transmission mechanisms across countries; in particular the extent to which these are attributable to differences in the underlying economies or in the modelling strategies. They similarly find that the cross-country variation in results appears to be plausible in the sense that they correspond to other evidence or characteristics of the economies considered. Nevertheless modelling strategies are also likely to play a role.

Chart 25 Share of energy expenditures in total expenditures for most energy-intensive sectors

(percentages)



Sources: Input-output tables from Eurostat and Eurosystem staff calculations.

impact on energy investment (which should be positive), and other investment.[34]

Results from an *oil price scenario using dynamic stochastic general equilibrium models* available in the Eurosystem illustrate the role of expectation formation and monetary policy.[35] These models allow for the introduction of expectations which are not included in the traditional macro models described above. As a result, economic agents in these models react to expected future policy actions, so that the specification of the policy reaction, which was

Table 4 Effect of a 10% oil price increase on GDP (annual averages) according to DSGE models

(percentage deviation from baseline – cumulated)

	Year 1	Year 2	Year 3
DE	-0.89	-1.13	-0.55
ES	-0.20	-0.23	-0.18
FI	-0.53	-0.32	-0.23
Euro area	-0.01	-0.07	-0.11

Source: Eurosystem staff calculations.
Note: The results for Finland are based on a version of the Aino model including a Taylor rule.

assumed to be zero in the previous simulations, is crucial.[36] The GDP impact is negative everywhere (see Table 4) but the results are quite different from the results of the traditional macroeconometric models described above, in particular in the first year, where the interest rate reaction to stabilise inflation implies a larger reduction in output for all models, except the one for the euro area. However, the differences between the two types of models diminish over time.

None of the above-mentioned models have taken explicitly into account the possibility of *asymmetric effects of changes in oil prices* (i.e. where oil price increases have a bigger impact on the economy than oil price decreases). This is an issue which has been extensively discussed in the literature, although there is no clear agreement on its existence. For example,

34 For example, Kilian (2008a) estimates investment equations for these sub-sectors for the United States and finds a significant positive effect for the mining sector and a significant negative impact for residential investment. His results for total non-residential investment (including mining) are not significantly different from zero.

35 Results are present for the NAWM, the Aino model of Suomen Pankki – Finlands Bank, Banco de España's BEMOD model and a calibrated DSGE model of the Deutsche Bundesbank.

36 Furthermore, the exchange rate and world demand and prices (except in both cases for the Finnish model) also react to the shock. All models include a direct link between oil import prices and domestic demand prices, defining shares of oil in the demand components. Excise taxes also play a role in the models. All models except the NAWM include some supply-side effects, i.e. firms use oil in production. The elasticity of substitution is either calibrated to different values or imprecisely estimated, which may explain some of the differences in the results. Finally, the way the shocks are implemented also differs across models to some extent. The German model simulates a 10% increase on imports, generated by a shock to global oil demand, with a dampening down effect afterwards.

Mork (1989) and Balke et al. (2002) find evidence of a stronger impact of oil price increases than declines on economic output in the United States. Jiménez-Rodríguez and Sánchez (2005) report similar asymmetric effects for the euro area. For a comprehensive overview of the literature see Kilian (2008b). Kilian and Vigfusson (2009) attribute these results to the fact that most authors have introduced positive and negative oil price shocks separately into their estimation models which biases results in favour of asymmetries. Using alternative estimation methods not subject to this bias, they find that the impact of oil prices on activity in the United States does not yield any significant asymmetries. An application of this method to the euro area similarly does not suggest any asymmetry in oil price shocks. The evidence is somewhat more mixed for extreme oil price fluctuations over a longer horizon. However, this finding may also be driven by the nature of the underlying oil price shock.[37]

While the model results reported above assume that the impact of oil prices on GDP growth has not changed over time, other evidence suggests that it has become more muted since the 1990s compared with the 1970s. Blanchard and Gali (2007) find for Germany, France and Italy a negative effect of oil prices on output in the period 1970Q1 to 1983Q4, which becomes (close to) zero for France and Italy and positive for Germany in the period from 1984Q1 to 2005Q4. For the United States and the United Kingdom, they find that in the first period oil prices had a stronger negative effect on output than in the second period. Replicating a similar exercise for the euro area gives a similar result, i.e. the effect is larger in the first sub-sample than in the second (see Annex 2.2).

Different arguments have been put forward to explain this result. A key factor, as will be shown in Section 3.3.2, is that since the 1990s there seems to have been a decline in the pass-through of oil prices to the HICP compared with the 1970s and early 1980s. This decline is attributable to a combination of sources. First, labour markets and wage setting are more flexible today. Social partners have arguably learned their lessons and assume their responsibility to reduce second-round effects, even though some wage indexation mechanisms yielding second-round effects, are still in place in some countries. Second, an important factor is that monetary policy has focused more on anchoring inflation expectations. Third, the recent period of generally low levels of inflation has also been attributed to globalisation.

In addition to the lower pass-through into wages and prices, other factors may have contributed. The lack of other adverse shocks occurring at the same time as the oil price shock may also have played a role (see Blanchard and Gali 2007 and Nakov and Pescatori 2009). Furthermore, as discussed previously, the higher efficiency in the use of oil has dampened the impact of oil price increases on the economy. Kilian (2008a) finds evidence of a lower response of US consumption to an energy price shock since the end of the 1980s compared with the 1970s and the beginning of the 1980s. He attributes this mainly to the structure of the US automobile sector which has moved to more energy efficient cars and was thereby less vulnerable to energy price shocks over the second sample.

Finally, such results can also be related to the differences in the factors underlying oil price movements. While the oil price increases in the 1970s were caused by supply disruptions, the latest oil price increases have been, at least initially, a response to strong oil demand, particularly from emerging countries with high and more energy-intensive growth (see Hicks and Kilian 2009). As a result, the latest increases in oil prices should have a more muted effect on activity, as they are accompanied by stronger world activity. In fact, Kilian (2009) finds that supply shocks lead to a temporary decline in GDP growth in the United States. Aggregate demand shocks, i.e. higher oil

37 The evidence was kindly provided by Lutz Kilian in an unpublished research memorandum entitled "The effects of oil price shocks on euro area real GDP".

prices owing to higher aggregate activity, lead to a very small positive effect in the first four quarters, while the increase in oil prices owing to precautionary demand (increase in stocks) leads to a permanent negative effect on GDP growth. The different nature of oil price shocks may have been a further reason why the oil price increases observed in 2005 and 2007 were more gradual. However, it should be noted that this may have changed since the second half of 2007. Supply-side factors, such as heightened geopolitical uncertainty and spare capacity concerns played an increasing role in shaping the last oil price hike (see Box 1 on drivers of oil price developments). On this ground, oil prices have made a material contribution to the recent recession (see Hamilton 2009).

2.3 LONG-RUN IMPACT ON OUTPUT

This section discusses the macroeconomic impact of a higher energy price on euro area output in the long run. This issue is often also addressed with a view to assessing the potential output of the economy. It will be shown that the impact of energy prices on long-run or potential output depends very much on the substitutability of energy by other means of production inputs and on the energy efficiency of production. In economic models, these technological features are represented in the macroeconomic production function which, simply put, usually describes total output in the economy as an outcome of the combination of input factors, capital and labour, and total factor productivity.[38] In the model reported below, energy is included as a further production factor. The impact of a change in energy prices then depends on the flexibility of the production process and nominal rigidities. While nominal rigidities do not directly affect the level of potential output in the very long run, the extent to which prices and wages cannot adjust swiftly makes a substantial difference to the adjustment path of output after the energy supply shock over a protracted period of time and can impact on the overall functioning of the economy.

Different economic models conclude that energy price hikes have a negative impact on potential output. This result emerges in a more traditional production-function framework as well as in the context of a DSGE model.[39] The latter model-based approach is followed here, in line with that undertaken in Section 2.2, to analyse the short-term effects of energy price changes. Furthermore, this model-based approach enables a detailed analysis of the influence of rigidities in price adjustment on the economic adjustment process after an energy price increase. Potential output in the DSGE framework can be understood as the long-run level of output, after short-term adjustments to shocks have been absorbed – the so-called steady state of output. Similar to the other exercises, results are derived by introducing a permanent decrease in oil supply, which implies a permanent 10% increase in the relative price of energy, vis-à-vis the euro area GDP deflator. The long-run impact of the energy price increase depends greatly on available technology. Therefore, in order to illustrate the importance of technological progress, the same supply shock has been simulated with two variants first, allowing for a more flexible production process – captured technically by a higher elasticity of substitution between energy and other factors of production – and, second, where the energy intensity of production is 15% lower. This reflects developments in euro area industry between 1990 and 2005 (see Section 1.2.2).

38 "Total factor productivity" is a "residual" item, which is often referred to as the impact of technical progress on the production process. In fact, it captures the impact of all the factors which are not explicitly accounted for in the macroeconomic production function, such as varying degrees of capacity utilisation, structural changes in the institutional design of the economy, or changes in the scarcity of input factors other than capital and labour, and in many cases energy.

39 Estrada and Hernandez de Cos (2009) provide an example of the production function approach. The model analysis presented in the text is based on Jacquinot et al. 2009. The model is calibrated to represent three regions, the euro area, energy-producing countries and the rest of the world, as well as three sectors, labelled tradable, non-tradable and energy sector. The energy sector uses crude energy, capital and labour as inputs to deliver refined energy. Refined energy, capital, labour and imported goods are combined to produce tradable and non-tradable intermediate goods. The latter serve as inputs to final-goods firms who produce investment goods and who combine intermediate goods with refined energy to produce consumption and export goods.

After an energy supply shock resulting in a 10% increase in energy prices, steady-state output in the euro area falls by almost 0.1% compared with the baseline scenario (see Table 5). The size of the decline may appear insignificant at first sight. It should be considered, however, that the calibrated increase in the energy price by 10% is small by historical standards. Since the model is close to linear, the effect of a supply shock inducing an increase in the price of energy by 50% would inflate the macroeconomic impact by roughly a factor of five. Furthermore, while the impact of a supply shock on GDP calibrated to increase the price by 10% appears limited, this is not true for all the sub-components. Thus, the fall in output results from considerable drops in both the long-run capital stock (-0.3%) as well as in consumption (-0.4%). The energy share in the production cost increases by 0.1 percentage point, as energy can only be imperfectly substituted by other production inputs. The decline in consumption primarily reflects lower real wages. Despite lower real wages, hours worked increase compared with the baseline. This is attributable to the loss in real income which forces households not only to consume fewer goods, but also to spend less time in leisure activity and hence to increase their supply of labour services. In the new equilibrium, exports in the euro area are positively affected, mainly owing to the recycling of the proceeds from energy accruing to energy-producing countries, as well as considerable worsening in the terms of trade[40]. The higher price of energy passes through to an increase in the consumer price index of around 0.3%.

However, general equilibrium outcomes of demand-driven shocks differ substantially from those induced by a reduction of energy supply as considered in the current exercise. Simulations with the same DSGE model assessing the impact of a demand-driven increase in energy prices resulted, owing to the offsetting effects of the

40 The terms of trade is defined as the ratio of import to export prices, both expressed in domestic currency. An increase corresponds to a deterioration of the terms of trade.

Table 5 Long-term macroeconomic effects of an energy supply shock in the euro area

	Energy supply shock	Higher elasticity of substitution [1)]	Lower energy intensity [2)]
GDP	-0.09	-0.05	-0.06
Real consumption	-0.38	-0.19	-0.32
Capital	-0.29	-0.14	-0.24
Energy cost share [3)]	0.12	0.00	-0.04
Hours worked	0.10	0.06	0.09
Real wage	-0.53	-0.26	-0.45
Real exports	0.96	0.41	0.85
Real imports	-0.57	-0.33	-0.51
Price of energy	10.00	6.23	10.08
Price of output (GDP deflator)	0.31	0.10	0.27
HICP	0.31	0.15	0.28
HICP ex-energy	0.09	0.04	0.08
Import prices	1.77	0.85	1.56
Imports ex-energy	0.19	0.09	0.17
Export prices	0.24	0.11	0.21
Terms of trade	1.53	0.74	1.36

Source: DSGE model simulation by Eurosystem staff.
Note: This table indicates the steady-state effects on selected macroeconomic variables in the euro area of a permanent reduction in worldwide energy supply of around 2%. All effects are reported as percentage changes relative to the initial steady state. The details of the model are discussed in Jacquinot et al. 2009.
1) Combined effects of a permanent reduction in energy supply of 2% and an increase in the elasticity of substitution from 0.2 to 1 between energy and other inputs to production.
2) Combined effects of a permanent reduction in energy supply of 2% and an increase in the energy efficiency of production. The increase in energy efficiency has been calibrated consistent with a decline in energy intensity in the production of tradable and non-tradable goods of 15%.
3) Change of the cost share of refined energy in intermediate production in percentage points. The cost share is calculated as a weighted average of nominal outputs in the tradable and non-tradable goods production sectors.

related higher world demand, in a reduction of output in the euro area. This reduction was only around one-quarter of the size of the reduction after a similar supply-driven increase in energy prices. In more detail, the latter simulations assumed a permanent increase in the productivity of labour outside the euro area, which resulted in higher global energy demand and, thus, higher energy prices.[41]

The results illustrate the importance of technological parameters, such as the ease with which energy can be substituted by other means of production and the energy intensity of production.[42] If the *substitution of energy* with respect to other factors of production is higher the adverse impact of the energy supply shock on long-run output would be more limited. For instance, increasing the elasticity of substitution of energy to a value of one[43] would approximately halve the impact on real macroeconomics variables. With such a high elasticity of substitution, the energy cost share in production would not change as energy can be substituted relatively easily by other production inputs in proportion to the increase in the price of energy. A higher degree of efficiency in the use of energy in production would also mitigate the adverse effects of higher oil prices, albeit to a lesser extent. With energy costs in production lowered by 15%, corresponding broadly to the decline in energy intensity over the period 1985-2005 in the euro area, the impact of a decline in energy supply reduces the impact of the energy supply shock on real GDP by a factor of two-thirds.

The above analysis shows that substitutability of energy is a key element in the assessment of the long-run impact of energy prices on output. The elasticity of substitution between production factors – especially between capital and energy – has been discussed for a long time. Reported elasticities in past studies are highly variable and reveal an apparent dichotomy between cross-sectional and time-series studies. While the former suggests that capital and energy are complements, the latter typically estimate them to be substitutes.[44] The now commonly held view is that energy is not easily substitutable. Results from a range of empirical studies (see, for example, Van der Werf 2008, Kemfert 1998, and Thompson and Taylor 1995) suggest that the elasticity of substitution of energy with respect to the other factors of production is significantly below 1.[45] Since it is hard to substitute away from energy, it is important to advance technological change and increase productivity in the long term to mitigate the adverse impact of higher energy prices.

The dynamic adjustment of the economy to the long-run steady state can be associated with significantly higher output losses owing to real and nominal rigidities. In the model used in the present analysis, prices and nominal wages are assumed to adjust sluggishly owing to staggered price setting and wage contracts. These realistic model features can be used to assess the role

41 The five-year average of the world market price index of raw energy in the euro area between the years 2004-09 increased by almost 220% compared with the average over the years 1995-99. According to the simulation results above, such an increase in the energy price – if fully supply driven – would imply a reduction of output of 2.0%. However, it should be kept in mind that, first, the increase in the price of energy took place over a period of ten years and, second and more importantly, the upward trend in energy prices observed in the recent past has not only been supply driven. In particular, it reflects to a substantial extent the increase in world demand for energy in the wake of the considerable expansion in economic activity in emerging market economies. For an analysis of the impact of a temporary demand-driven energy price shock see, e.g. Jacquinot et al. 2009.

42 Note that in all three scenarios it is the size of the energy supply shock of -2% that is held constant whereas the price of energy increases endogenously as a response to the supply shock in all three scenarios. Compared with the first scenario, the increase in the steady state price of energy is lower in scenario two which, in addition to the supply shock, assumes that energy can be substituted more easily. Scenario three which, in addition to the supply shock assumes a lower energy intensity of production, yields an increase in the steady state price of energy broadly in line with that in the first scenario.

43 The elasticity of substitution measures the impact of a change in the relative price of two factors of production on their ratio in production – a value of one implies that energy can be well substituted.

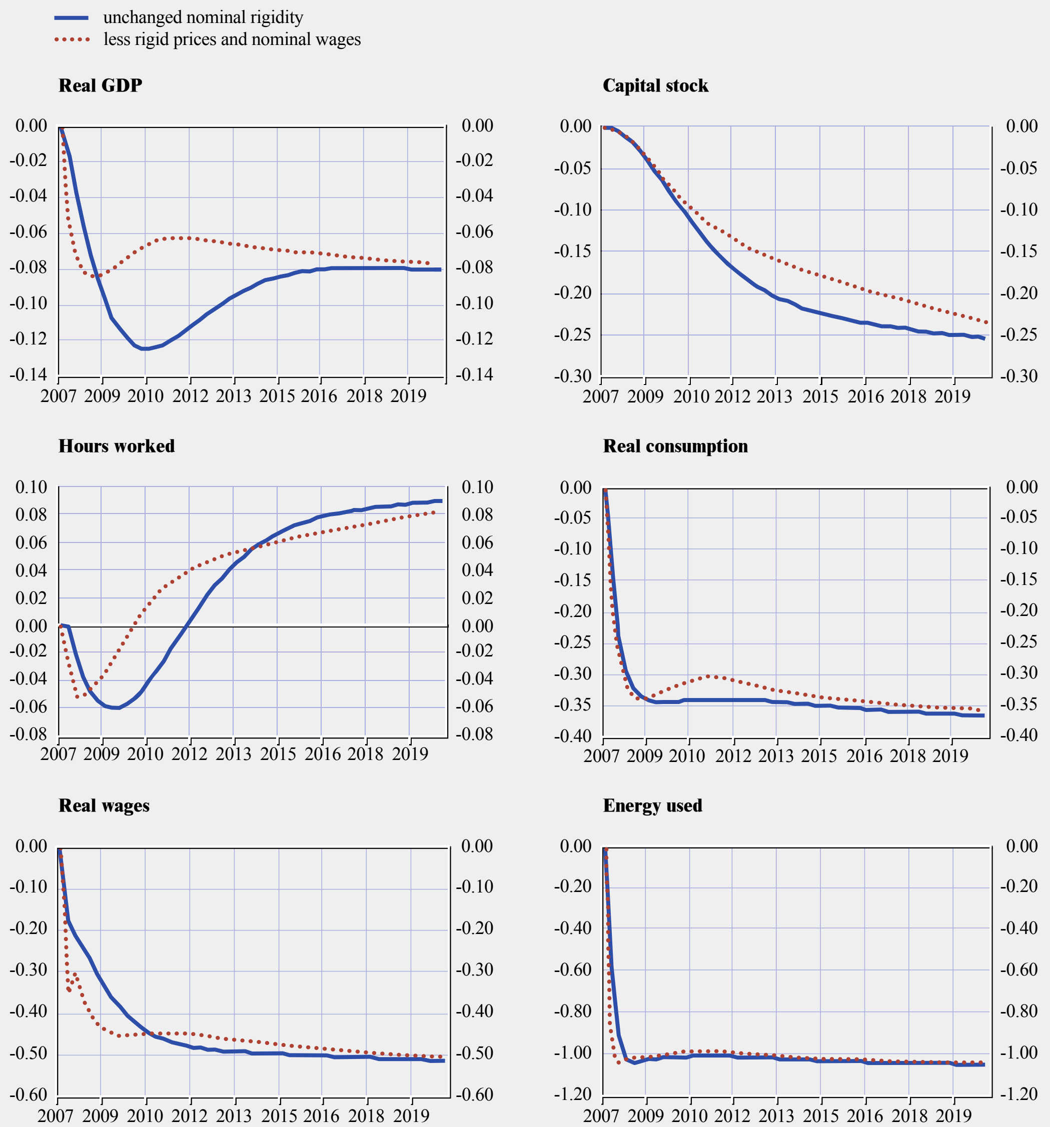
44 In a review of several studies, Thompson and Taylor (1995) show that the dichotomy primarily derives from the different approaches to measuring the elasticity of substitution.

45 Empirical evidence based on correlation analysis for a cross-section of countries of a negative link between oil prices and investment is also provided in Estrada and Hernandez de Cos (2009). However, they find that this link weakened after the mid-1980s, which might suggest some variation in the elasticity of substitution, but can also be linked to other factors, such as the type of oil price shock.

of nominal rigidities on the adjustment of the economy after an adverse shock in energy supply. Chart 26 depicts the adjustment dynamics of selected macroeconomic variables in the euro area following a permanent decrease in the energy supply in the rest of the world under a regime of high and low flexibility of wages and prices in the euro area. If prices and nominal wages can be adjusted more easily, the adjustment of output to the new steady state after the energy supply shock would be smoother. In particular, the undershooting of output under its new equilibrium value in the initial phase would be avoided as real wages

Chart 26 The short-run domestic effect of less nominal wage rigidity in the euro area on the transmission of a permanent, exogenous negative shock to energy supply

(percentages)



Source: Eurosystem staff calculations.
Notes: This chart depicts the adjustment dynamics of selected variables in the euro area following a permanent decrease in the energy supply in the rest of the world for high and low flexibility of wages and prices in the euro area. With high flexibility, a larger fraction of wages and prices can be adjusted optimally at a certain point of time. All dynamic effects are reported as percentage deviations from the initial steady state.

would fall almost immediately and labour supply – as a consequence of the negative income effect − would rise faster. Furthermore, the capital stock would be cut back in a more gradual manner.

2.4 SUMMARY OF IMPACT ON OUTPUT

The impact of energy price changes on economic activity depends on a number of factors, including the nature of the shock, the functioning of energy markets, the time frame considered and the structure of the economy. Shocks to energy supply may have a stronger impact on output, and permanent shocks may have a larger effect. In the short run, as the scope for adjustment is limited, an increase in energy costs increases firms' costs and reduces households' disposable income. In the long run, changes in the relative price of energy will lead to a substitution away from energy products (either via a shift towards other, less expensive, factors of production or via technological change leading to reduced energy intensity of production and consumption).

The empirical evidence from macroeconometric models suggests that the overall impact on euro area activity of a 10% increase in energy prices is estimated to be -0.25% after three years, but shows considerable heterogeneity across countries (ranging from close to zero to 0.4%). These differing effects are partly attributable to structural differences in the countries, such as the energy intensity of production or consumption, the degree of nominal rigidities in the economy, the sector structure, and their openness. Some countries also benefit more than others from the recycling of petrodollars, thereby showing a smaller deterioration in their external balance. The impact of energy prices on activity may have attenuated relative to that observed in the 1970s and early 1980s. This attenuation may be attributable to the complex interaction of a number of factors including the nature of the underlying energy shocks, the lower energy intensity of developed economies, changes in wage-setting behaviour and the role of monetary policy in stabilising inflation expectations.

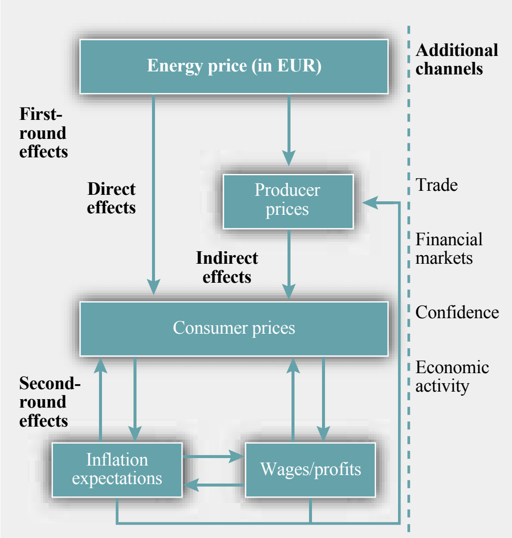
In addition to the short and medium-term effects, energy price developments may also impact output in the long run. Model estimates suggest an impact of approximately 0.1% on output in the long run. Such losses are higher for the long-term level of consumption and investment. A key element affecting the long-run vulnerability of the economy to energy prices is the substitutability of energy. The more flexible the economy in terms of substituting relatively expensive energy sources, the less vulnerable it is to energy price fluctuations. Moreover, wage and price rigidities exacerbate the adjustment costs following an energy price shock. In particular, the losses of output and labour input into the production process will be less pronounced if nominal changes allow for a more speedy adjustment process.

When considering model-based estimates of the impact of energy prices on economic activity, it is important to bear in mind that macroeconometric models are, by necessity, simplifications of the underlying economic structure. Even if model builders incorporate expectations formation and (monetary or fiscal) policy responses into their toolkit, these are impossible to capture in their entirety and may change over time. Thus the estimates reported here should be considered as indicative rather than precise results.

3 THE IMPACT OF ENERGY PRICES ON INFLATION

This chapter considers the economic impact of energy prices on inflation, with the aim of identifying the determinants of the pass-through of energy prices and drawing policy conclusions on the structural determinants of inflationary pressures stemming from energy price movements. The first section provides a conceptual framework for guidance throughout the chapter. Then the direct pass-through of energy prices into liquid fuel and non-liquid fuel consumer prices and price level differences are assessed. Subsequently, the analysis elaborates on indirect and second-round effects. In this context, particular attention is paid to the role of inflation expectation formation, which is discussed in more detail in a box.

Chart 27 Stylised overview of energy price pass-through channels



Source: Drawn from European Central Bank (2004).

3.1 CONCEPTUAL FRAMEWORK

A stylised overview of the main transmission mechanisms through which oil prices impact on consumer price developments is presented in Chart 27. In terms of price effects, the impact of energy price changes is often broken down into direct and indirect first and second-round effects.[46] The *direct first-round effects* refer to the impact of changes in primary energy prices (e.g. oil and gas) on consumer energy prices. The *indirect first-round effects* refer to the impact of changes in consumer prices that occur as energy prices impact on producer and distribution costs. An oil price increase can, for example, affect through higher producer costs the prices of goods which may include an energy-based input (such as chemical goods) or of transport services (such as aviation which have a significant oil input). Higher distribution costs can affect more broadly other consumer prices. First-round effects, either direct or indirect, of a one-off increase in oil prices only generate a rise in the price level, but no lasting inflationary effects.

So-called *second-round effects* capture reactions of wage and price-setters to the first-round effects (direct and indirect) of a price shock, in an attempt to keep their real wages and profits, respectively, unchanged. Second-round effects magnify and extend the impact of energy price movements. The impact on wages may be further reinforced by additional upward pressure on the price level. Employers, being price-setters, will seek to pass rising labour costs on to consumer prices to try to maintain the real value of their profits, which are already penalised by the higher input prices. These dynamics can cause higher inflation expectations to become embedded in the economy's wage and price-setting processes, eventually endangering price stability. This dynamic makes indirect first and second-round effects interdependent and often difficult to disentangle empirically, but they remain conceptually different.

46 This taxonomy of the breakdown of the pass-through of oil prices into different effects is drawn from ECB (2004). The terminology is not uniform in the literature. For example, the Reserve Bank of New Zealand (2005) refers to the impact of oil prices via the impact on activity as a third-round effect. Esteves and Neves (2004) refer to terms-of-trade effects, whilst Bernanke (2006) includes indirect effects as part of second-round effects.

The following sections first consider the direct effect of consumer liquid fuel prices (i.e. transport – petrol and diesel – and heating fuels), which generally are the most rapidly affected by changes in global energy commodity prices, and consumer prices of other energy products (primarily gas and electricity). The indirect and second-round effects are assessed in subsequent sections. Given the numerous ways that energy prices may work their way through the production chain, three alternative approaches (input-output tables, small-scale econometric models, and large-scale macroeconometric models) are considered in order to cross-check the information from each approach.

3.2 DIRECT FIRST-ROUND EFFECTS

3.2.1 CONSUMER LIQUID FUEL PRICES

Liquid fuel prices enter the HICP in two main components – transport fuel and home heating fuel. In 2009 liquid fuels accounted for a substantial proportion (4.7%) of the overall HICP in the euro area, with considerable variation across countries (see Table A3 in Annex 1). As HICP weights are based on total expenditure, and are thus a function of both volume and price, variations in the weight of liquid fuel prices may reflect a combination of factors, including living standards, the degree of car ownership and intensity of use, climatic conditions and fuel tourism, as well as the impact of taxes on final consumer prices.

Given the strong increase in oil prices observed over the last decade, unsurprisingly, the average annual rate of change in HICP liquid fuel prices since 1996, at 4.6%, was considerably higher than the average overall HICP inflation rate (2.0%) (see Table 6). The average rate of increase in home heating fuel, at 8.5%, was even larger than that for transport fuel (3.9%). Much of this difference, as well as the large cross-country differences, is attributable to differences in excise taxes. As excise taxes are set as a value rather than as a percentage of the price (as is the case with VAT), a higher level of excise tax, whilst increasing the price level, dampens the elasticity (percentage response) to changes in oil prices.

HICP liquid fuel prices are among the most volatile and variable items in the HICP basket. The average standard deviations of month-on-month changes in transport and home heating fuels, at 2.4 and 4.9 percentage points respectively, are substantially above that of the overall HICP (0.3 percentage point non-seasonally adjusted, and 0.2 percentage point seasonally adjusted). Liquid fuel prices tend to change more frequently with respect to other sub-components of the HICP. Table A6 in Annex 1 illustrates that, even when using the

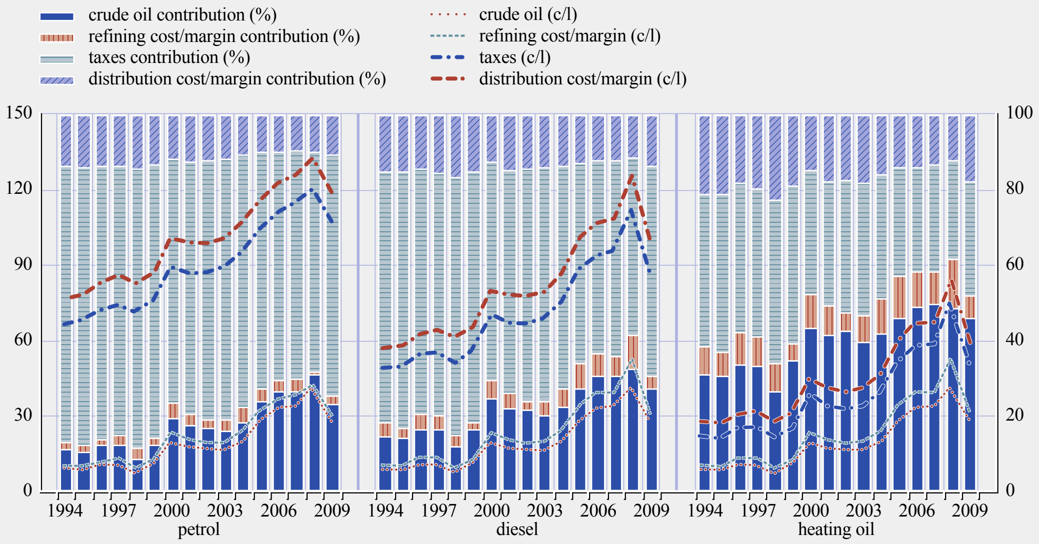
Table 6 HICP liquid fuel components, weight, inflation and volatility

	Weight (2009)				Average year-on-year rate of change (1996-2009)				Standard deviation (month-on-month, non-seasonally adjusted)			
	euro area	Min.	Med.	Max.	euro area	Min.	Med.	Max.	euro area	Min.	Med.	Max.
HICP	100.0	100.0	100.0	100.0	2.0	1.5	2.5	6.0	0.3	0.3	0.5	1.4
HICP excl. energy	90.4	83.7	89.7	93.5	1.8	1.2	2.3	4.8	0.3	0.2	0.5	1.4
Energy	9.6	6.5	10.3	16.3	3.9	3.1	4.6	13.8	1.5	1.2	2.0	3.7
Liquid fuels	4.7	2.4	4.8	8.5	4.6	3.2	4.8	7.2	2.7	2.0	3.1	3.8
Transport	4.0	2.4	3.9	7.7	3.9	2.9	4.4	6.8	2.4	2.0	2.9	3.5
Home heating	0.7	0.0	0.7	2.1	8.5	4.4	8.8	12.6	4.9	2.2	5.8	7.1

Sources: Eurostat and Eurosystem staff calculations.
Notes: For detailed country data see Tables A3 to A6 in Annex 1. Euro area denotes the euro area average; min. denotes the minimum, med. the median and max. the maximum across the euro area countries.

Chart 28 Breakdown of consumer liquid fuel prices

(euro cent/litre, left-hand scale; percentages, right-hand scale)



Sources: Eurostat and Eurosystem staff calculations.
Note: Series in chart are cumulated starting with crude oil, then refining costs/margins, taxes and lastly distribution costs/margins.

relatively aggregated HICP data, liquid fuel prices changed almost every month in most euro area countries over the period 1996-2009.[47]

In this section, data from the European Commission's (DG-TREN) weekly Oil Bulletin are used to consider the pass-through of oil prices to consumer liquid fuel prices and compare their price levels across countries.[48] Combining the Oil Bulletin data with international market data on crude and refined oil prices allows us to decompose the wedge between crude oil prices and final consumer prices into three components: refining margins and costs, distribution and retail margins and costs, and taxes.

Looking at the evolution of the components of liquid fuel prices between 1996 and 2008 (Chart 28) it can be seen that: (i) most of the increase in liquid fuel prices observed in the past decade can be attributed to crude oil prices, which rose from 10 cent per litre in 1996 to 41 cent per litre in 2008, (ii) although refining costs and margins have been relatively volatile in recent years, increases have not persisted, (iii) the contribution of distribution costs and margins has not changed much over time and (iv) taxes, which generally represent the largest portion of final prices (with the exception of heating fuels), have risen by 18 cent in the case of petrol and diesel prices and by 12 cent

47 The main exceptions being Greece (heating fuel), Cyprus, Malta and Portugal. In the case of Cyprus and Portugal the low frequency of price changes is attributable to previous pricing regimes and the frequency of price changes in the more recent period is in line with the euro area pattern. The relatively high frequency of price changes of oil energy products has also been noted by Dhyne et al. (2006) using micro-level price data as part of the Eurosystem Inflation Persistence Network (IPN) research project. They find that the frequency of price changes of oil energy products is 78% (i.e. 78% of prices for oil energy products change every month), which compares to a frequency of 28% for unprocessed food, 14% for processed food, 9% for non-energy industrial goods and 6% for services items.

48 The Oil Bulletin data have features that make them suited to this purpose: they are available for all euro area countries, at a weekly frequency, with data on actual prices including and excluding taxes. Importantly, although the Oil Bulletin data are not collected to the same high standards as the HICP data, they co-move quite closely (see Annex 2.3) suggesting that they could be used for a deeper analysis of liquid fuel price developments. Furthermore, the availability of both petrol and diesel prices from the Oil Bulletin is particularly useful, especially in view of the growing penetration of diesel cars in the overall passenger car stock in Europe and in view of the strongly differing evolution of gasoline/petrol and gasoil/diesel refining margins in recent years.

in the case of heating oil. Around half of these increases were attributable to explicit changes in excise duties, and the other half to automatic changes in the VAT component in the face of broadly unchanged VAT rates.[49]

ANALYSIS OF OIL PRICE PASS-THROUGH INTO CONSUMER LIQUID FUEL PRICES

The following analysis focuses on developments between refined prices and consumer prices excluding taxes. It does not explicitly consider developments in refining costs and margins because first, one may observe refined and crude oil prices simultaneously in real time, and second, as petroleum markets are global, refining margins are most likely to be driven by global factors rather than euro area or specific country ones. Furthermore, the gap between pre-tax and post-tax prices is not considered, as it is fully determined by excise and VAT rates.[50]

The relative stability of distribution costs and margins suggests that the pass-through should be modelled in terms of absolute levels. Table 7 shows the amount and speed of pass-through from refined oil prices to consumer prices (excluding tax) for petrol in each country.[51] At the euro area level, the amount of pass-through is generally 100% (i.e. a 10 cent per litre increase in refined oil prices results in more or less a 10 cent per litre increase in consumer prices before taxes). Furthermore, the speed of pass-through is generally quite rapid, with 50% being passed through within two weeks, and 90% within three to six-weeks.[52] For example, given a 10 cent increase in refined oil prices, consumer petrol prices increase by 6.0 cent within two weeks, and by 9.3 cent within five weeks. The results on the pass-through for heating fuel are broadly of the same pattern as those for consumer petrol prices (see Table A12). The pass-through for diesel prices, if anything, appears even more rapid.

Considering individual country developments, it is clear that this pattern is generally shared by most countries.[53] The pass-through to petrol prices seems to be the quickest in Belgium, Germany, Luxembourg and the Netherlands, possibly reflecting the fact that the refined prices considered in the analysis above include delivery to Rotterdam (i.e. the north-west Europe region).[54] Using Mediterranean prices would perhaps provide a faster pass-through for the Mediterranean countries.[55]

Regarding the question of whether the pass-through has changed over time, estimates over the entire time period for which data are available, 1994-2008, as well as for a number of different sub-samples (1994-99, 2000-08 and 2005-08) confirm that the results are largely unchanged regardless of the estimation period.

With respect to the issue of whether there is asymmetry in the response of pre-tax prices to refined oil price changes (i.e. whether consumer prices change by more or more quickly when refined prices rise than when they fall), there is little in the way of economically meaningful asymmetry between the pass-through of upstream price increases and decreases for the euro area as an aggregate (see Table A17 in Annex 2.4).[56] Recent evidence provided by Venditti (2010) on the four largest euro area countries also suggests that the role of

49 As VAT is levied as a percentage of the selling price, an increase in the pre-VAT selling price results in an increase in the amount of VAT charged even if the VAT rate remains unchanged.
50 Although taxes are an important component of final prices, they are not modelled in the econometric analysis of the pass-through as they are likely to be driven by government policies.
51 For a description of the methodology employed, see Annex 2.4.
52 One feature of the weekly Oil Bulletin data may mean that the estimated speed of pass-through is slightly understated. This is because most, although not all, countries collect the data on a Monday. However, Asplund et al (2000) find that fewer price changes are made on Mondays. Their explanation is that the Rotterdam markets are closed over the weekend and thus any new information that may have arrived up to the Monday is not normally implemented until the following day.
53 The results for Ireland are affected by the fact that only monthly average data are provided.
54 Rotterdam (north-west Europe or Amsterdam, Rotterdam and Antwerp – ARA) prices are considered to be the benchmark for Europe. Rotterdam is by far the biggest liquid bulk port in Europe (see European Sea Ports Organisation – ESPO 2008).
55 The relatively low pass-through for Portugal may reflect the fact that full liberalisation of the liquid fuel market occurred only in 2004.
56 In a small number of instances, statistically significant evidence of asymmetry is found; when it is quantified the asymmetry effect is marginal.

Table 7 Pass-through rates by product and country

(euro cent)

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Euro area	**1.9 (1.5;2.3)**	***<u>6.0</u>* (5.5;6.4)**	**7.5 (7.0;8.0)**	**8.4 (7.9;8.4)**	**<u>9.3</u> (8.8;9.7)**	**9.3 (8.8;9.8)**	**9.5 (9.1;10.0)**	**9.7 (9.2;10.2)**	**9.9 (9.4;10.4)**	**9.9 (9.4;10.4)**	**9.9 (9.4;10.4)**	**9.9 (9.5;10.3)**
BE	1.8 (0.9;2.8)	*<u>7.6</u>* (6.7;8.7)	8.7 (7.8;9.7)	<u>9.5</u> (8.5;10.6)	9.8 (8.8;10.8)	9.8 (8.8;10.8)	10.6 (9.6;11.7)	9.9 (8.9;10.9)	9.3 (8.3;10.4)	9.5 (8.8;10.3)	9.9 (9.3;10.6)	10.0 (9.4;10.5)
DE	1.9 (1.0;2.7)	*<u>7.4</u>* (6.4;8.3)	8.8 (7.9;9.8)	<u>9.7</u> (8.8;10.6)	10.6 (9.7;11.6)	10.0 (9.1;10.9)	9.8 (8.9;10.7)	10.2 (9.2;11.2)	10.3 (9.3;11.3)	10.2 (9.4;11.0)	10.1 (9.4;10.7)	10.1 (9.5;10.6)
IE	1.2 (0.1;2.1)	0.7 (-0.6;1.8)	1.5 (0.1;2.7)	1.9 (0.5;3.2)	2.2 (0.9;3.5)	2.7 (1.3;4.1)	3.2 (1.7;4.6)	4.2 (2.7;5.7)	<u>5.3</u> (3.9;6.7)	6.2 (4.9;7.5)	6.9 (5.8;8.1)	7.6 (6.5;8.9)
GR	1.2 (0.6;1.7)	*<u>6.2</u>* (5.6;6.9)	8.6 (7.9;9.3)	<u>9.7</u> (9.0;10.3)	10.0 (9.4;10.7)	10.2 (9.6;10.9)	10.3 (9.6;11.0)	10.3 (9.6;11.0)	10.4 (9.7;11.1)	9.9 (9.3;10.6)	9.8 (9.2;10.4)	9.9 (9.4;10.4)
ES	1.6 (1.3;2.0)	4.5 (4.0;4.9)	*<u>6.2</u>* (5.7;6.7)	7.7 (7.1;8.2)	8.6 (8.0;9.2)	<u>9.1</u> (8.5;9.7)	9.3 (8.6;9.9)	9.6 (9.0;10.2)	9.7 (9.1;10.3)	9.8 (9.2;10.4)	9.8 (9.2;10.4)	9.8 (9.2;10.4)
FR	1.6 (1.2;2.0)	*<u>6.1</u>* (5.6;6.6)	8.0 (7.5;8.6)	8.9 (8.4;9.5)	<u>9.6</u> (9.0;10.2)	9.6 (8.9;10.2)	9.6 (8.9;10.2)	9.7 (9.1;10.3)	10.1 (9.4;10.7)	10.0 (9.3;10.8)	9.9 (9.2;10.7)	9.9 (9.3;10.7)
IT	1.4 (1.0;1.8)	4.7 (4.1;5.2)	*<u>6.5</u>* (5.9;7.0)	7.5 (6.8;8.1)	8.6 (7.9;9.2)	8.9 (8.1;9.6)	<u>9.7</u> (9.0;10.3)	9.5 (8.8;10.2)	9.8 (9.0;10.5)	9.6 (9.0;10.3)	9.7 (9.1;10.4)	9.7 (9.2;10.4)
LU	2.5 (1.8;3.1)	*<u>8.5</u>* (7.9;9.0)	<u>9.5</u> (8.9;10.1)	9.8 (9.2;10.5)	10.7 (10.1;11.3)	10.4 (9.8;11.1)	10.3 (9.7;10.9)	10.0 (9.4;10.6)	10.4 (9.8;11.0)	10.4 (9.9;10.8)	10.3 (10.0;10.6)	10.3 (10.0;10.5)
NL	*<u>5.8</u>* (5.2;6.5)	<u>9.9</u> (9.2;10.6)	10.6 (9.9;11.3)	10.5 (9.7;11.2)	11.0 (10.3;11.7)	10.3 (9.6;11.0)	10.1 (9.4;10.9)	10.6 (9.9;11.4)	10.4 (9.6;11.2)	10.7 (10.0;11.4)	10.6 (10.1;11.2)	10.6 (10.1;11.1)
AT	1.2 (0.6;1.8)	*<u>5.0</u>* (4.3;5.8)	6.4 (5.6;7.3)	7.5 (6.6;8.4)	8.3 (7.3;9.1)	8.6 (7.8;9.5)	8.9 (8.1;9.8)	<u>9.1</u> (8.3;10.0)	9.3 (8.4;10.2)	9.5 (8.6;10.3)	9.4 (8.5;10.2)	9.3 (8.5;10.1)
PT	0.3 (-0.6;1.2)	1.3 (0.2;2.4)	2.7 (1.4;4.1)	4.5 (3.1;6.0)	*<u>6.2</u>* (4.7;7.8)	7.5 (5.9;9.1)	7.4 (5.6;9.1)	7.7 (5.8;9.7)	8.3 (6.3;10.4)	8.7 (6.6;10.8)	<u>9.0</u> (6.9;11.3)	9.1 (7.0;11.5)
FI	3.3 (2.1;4.6)	*<u>5.6</u>* (4.2;7.2)	5.0 (3.4;6.4)	4.8 (3.2;6.5)	6.2 (4.7;7.7)	7.1 (5.4;8.6)	<u>9.0</u> (7.3;10.5)	10.6 (9.1;12.3)	10.1 (8.5;11.7)	9.6 (8.3;10.8)	9.5 (8.3;10.8)	9.2 (8.0;10.6)

Source: Eurosystem staff calculations.
Notes: Figures underlined and in italics denote 50% pass-through reached. Figures underlined denote 90% pass-through reached. Figures in parenthesis represent the 99% confidence intervals calculated using bootstrap techniques (10,000 iterations). Results on pass-through for the latest members of the euro area (Cyprus, Malta, Slovenia and Slovakia) were not estimated as data are only available from 2005.

non-linearity in the adjustment of gasoline prices is negligible. The results and analysis here are also broadly consistent with Rodrigues (2009), who finds evidence of asymmetry in the "international" channel (i.e. the refining stage in our analysis), but only sporadic instances in the "domestic" channel (i.e. the distribution and retailing stage in our analysis).

In summary, the pass-through of oil prices into consumer liquid fuel prices appears to be complete and relatively quick, with little evidence of substantial asymmetries – these results hold generally across most euro area countries.

ANALYSIS OF CONSUMER LIQUID FUEL PRICE LEVELS

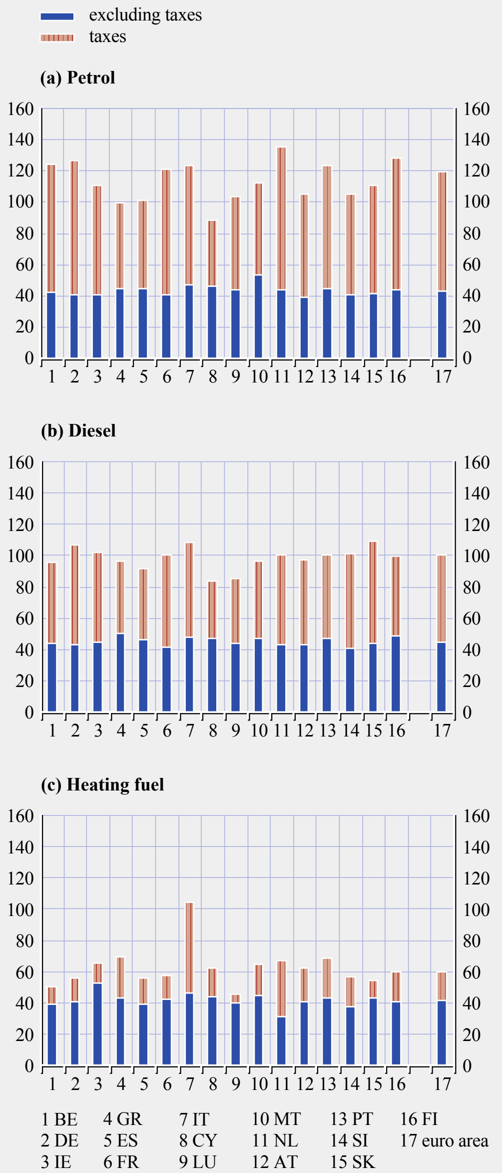
Although liquid fuels are relatively homogeneous and tradable goods, the levels of their consumer prices appear to differ somewhat across euro area economies. Chart 29 reports prices, including and excluding taxes, for petrol, diesel and heating fuel across the euro area countries on average in 2009.[57] According to these data, consumers in Cyprus, Greece and Spain paid the least for one litre of petrol in 2009 (€0.88, €1.00 and €1.01 respectively). By contrast, Dutch, Finnish and German consumers paid the highest prices (€1.35, €1.28 and €1.27 respectively). Price level differences across countries can arise from tax differences as well as from differences in costs and margins which, in turn, may be related to the degree of market concentration.

By far, the largest part of the discrepancies in levels can be attributed to *indirect taxes*: the

57 A possible caveat to using Oil Bulletin data from the European Commission is that data compilation methods have not been unified. As the discrepancies in pre-tax price levels across countries are small (especially in proportion to price volatility), this could also be a relevant factor in explaining the differences in level observed.

Chart 29 Cross-country comparison of liquid fuel prices in 2009

(in euro cent/litre)



Sources: European Commission (DG-TREN) and Eurosystem staff calculations.

unweighted standard deviation of consumer prices excluding taxes was €0.03 in 2009, compared with a standard deviation of €0.13 including taxes.[58] An interesting feature of euro area prices across countries is that, despite VAT rates of around 20% on average levied on the pre-tax price plus excise, there is no correlation between prices including and excluding taxes. An additional feature of cross-country price differences is their relative stability in that the ranking of price levels has varied little since the mid-1990s. The lack of correlation is attributable to the fact that countries with lower pre-tax prices have higher indirect taxes (both VAT and excise). Rietveld and Van Woudenberg (2005), for example, find the pattern that small countries tend to be more aggressive with indirect taxes. However, they do not address other sources of differences in pre-tax prices.

The literature on energy markets mentions a number of factors that shape the *costs* of companies operating in liquid fuel markets. Differences among these could therefore lead to price differentials.[59] Costs can be expected to lower with: (i) the size and density of the market, (ii) the availability of a pipeline infrastructure for transporting oil as the marginal cost of transporting liquid fuels by pipeline is much lower than by road, rail or water, (iii) the country refining capacity and (iv) the efficiency of the distribution sector (measured either in terms of turnover per station, or use of self-service vs. manned pumps and the prevalence of cross-selling other non-petroleum products). In turn, costs tend to increase with: (i) the distance from Rotterdam, the most important port for the shipping of crude and refined petroleum products and (ii) the level of income or the general price level as final liquid fuel prices also incorporate costs of non-tradable services, such as rents or labour costs.

58 See also Arpa et al. 2006 for an overview of cross-country price differences. It should be noted that the differences across country averages may be much lower than differences within countries. For example, in a study of Irish transport fuel prices, the National Consumer Agency (2008) found differences of up to 15 cent per litre between the maximum and minimum prices of petrol and diesel.

59 See, for example, the Australian Competition and Consumer Commission – ACCC 2007, Bello and Cavero 2008, Contín-Pilart et al. 2001, Nomisma Energy 2007, and Van Meerbeeck 2003. Bello and Cavero (2008) consider a number of these indicators in their detailed study of the Spanish gasoline market. More specifically, they find significant relationships between prices and market power, station density, distance from refineries, income levels and the degree of cross-selling.

Margins depend on the level of competition, price regulation and scale effects. As already mentioned (see Section 1.3.2) understanding effective competition in the liquid fuel market is complicated by the fact that, although there is a very large number of individual stations, there is a relatively small number of large-scale retailer chains, who tend to be vertically integrated. On this point, some of the indicators mentioned before capture how competition impacts on price levels, such as: (i) the degree of market concentration, as measured by the market share of the three largest companies and (ii) competition from supermarkets

Chart 30 Bivariate charts of petrol prices (excluding taxes) with various indicators

Sources: European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer petrol prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

which can rely either on scale economies or loss-leading on a "known-value item", such as petrol, to attract customers. In addition, other elements capturing competition and economies of scale effects include: (i) whether fuel tourism is an issue, (ii) density either in terms of petrol stations per capita or population density and (iii) the intensity of car use, which could increase price monitoring efforts.

Euro area markets are extremely heterogeneous in terms of market characteristics, not only with regard to competition structures as shown in Section 1.3.2, but also cost factors and economies of scale. Table A11 presents some of these structural indicators. Countries characterised by relatively low pre-tax petrol prices, such as Germany and France, have a higher percentage of self-service stations, fewer service stations per capita (and consequently a higher sales volume per petrol station), a high number of refineries, and either a high degree of cross-selling (as in Germany) or heavy competition from supermarkets (as in France). Countries where pre-tax prices are relatively high, such as Italy [60] and Greece, show a much more fragmented distribution sector (with a consequently lower sales volume per petrol station), as well as a percentage of self-service stations and a degree of cross-selling well below the average.

An illustration of the relationship between structural indicators and liquid fuel prices is provided by bivariate charts (see Charts A9 – A11 in Annex 1 for an overview). The limited number of observations (a maximum of sixteen) does not allow for more precise methods although the link between market structure and prices is obviously complex and multi-dimensional. Many of these relationships have the expected sign for indicators of efficiency (such as sales per petrol station or the number of petrol stations per capita) and competition from supermarkets, as well as for indicators of self-service pumps and cross-selling, for which the link seems to be fairly strong. The distance from Rotterdam also has a strong and positive relationship with liquid fuel prices (see Chart 30). Thus, although differences in pre-tax transport fuel prices across the euro area are relatively small, they do appear to be linked to some degree to structural features of individual country markets. The results for petrol and diesel prices are broadly similar. Those for heating fuel are quite distinct. However, this market is substantially different in nature from the transport fuel market.

60 Nomisma (2007) analyses Italian liquid fuel prices, which have tended to be above the EU average, and ascribes this to a combination of factors including the high degree of manned petrol stations, relatively limited cross-selling of non-fuel products, road density and limited competition, in particular from supermarket retailers.

Box 5

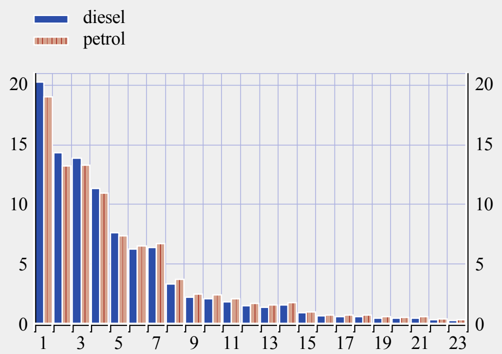
MICRO EVIDENCE ON TRANSPORT FUEL PRICES IN FRANCE

Here we consider detailed micro data on transport fuel prices in France, using a unique dataset comprising 8.5 million daily individual price quotes from 1 January 2007 to 31 May 2009 drawn from over 10,000 retail stations.[1] To assess the degree of price rigidity, some basic indicators are calculated, such as the duration of prices and the frequency of price changes. Each day around 20% of gasoline prices are modified (19.2% for diesel and 17.9% for petrol) with implied average price durations ranging from five to six days. Chart A plots the price duration distributions for diesel and petrol. About one-fifth of prices last exactly one day, with less than 20% of prices lasting more than one week. Price duration distributions are very similar for petrol and diesel. Chart B shows the hazard rate of diesel and petrol prices (i.e. the proportion of prices which are

1 The dataset consists of individual prices collected by the French Ministry of the Economy, Industry and Employment in petrol stations selling more than 500 m3 of gasoline per year (see Gautier and Le Saout 2009).

Chart A Distribution of price durations

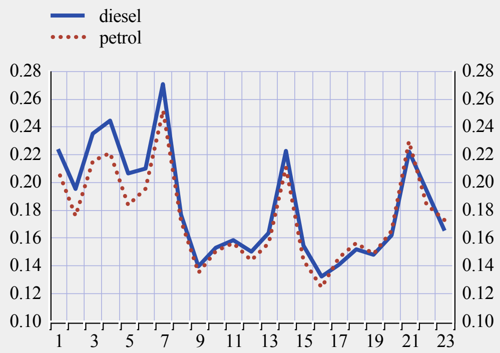
(in days; percentages)



Source: Eurosystem staff calculations.

Chart B Hazard rates of gasoline prices

(in days; percentages)



Source: Eurosystem staff calculations.

modified against those which have not been changed for X days). Peaks at seven, 14 and 21 days reveal strong, time-dependent patterns in gasoline price re-settings.

Price durations display some heterogeneity along three dimensions. First, price durations are shorter in stations where prices are low (on average every five days) and longer in stations where prices are higher than the median price (on average every six days).[2] Second, price durations were much shorter during the sharp decrease in oil prices (end-2008): on average around 4.5 days between July and December 2008 compared with 5.5 days outside this period. Third, prices are more likely to be modified on a Friday (around 21% of all price changes) and Tuesday (19% of all price changes) and are less likely to be changed during the weekend (12.5% on Saturdays and less than 1% on Sundays). Lastly, there is some evidence that the probability of price changes increases the further away the actual prices are from their reference prices (generally refined products sold in Rotterdam).

Overall, the results from these French micro data are consistent with and complement the more aggregated, but cross-country, data presented earlier – in particular the findings on the high frequency of price changes, the lack of substantial asymmetry, and the competitive impact of independent (supermarket) retailers.

2 This may reflect some differences in the number of opening days per week.

3.2.2 CONSUMER NON-OIL ENERGY PRICES

Non-oil energy prices enter the HICP in four sub-components – electricity, gas, heat energy and solid fuels.[61] These items are used primarily for home heating and other domestic purposes such as cooking and appliances. Gas and solid fuels are generally consumed in their primary state without secondary production, whereas electricity and heat energy are usually derived from a primary source of energy which is then transformed.

Non-oil energy prices accounted for 4.8% of the overall HICP in the euro area in 2009 (see Table 8). However, the range across euro area countries is quite large, from 1.5% in Greece to 13.9% in Slovakia (see Table A7

61 Heat energy is mainly hot water and steam purchased from district heating plants, but also includes associated expenditure such as the hire of meters, reading of meters, standing charges, as well as ice used for cooling and refrigeration purposes. Solid fuels include coal, coke, briquettes, firewood, charcoal and peat.

Table 8 HICP non-oil energy components, weight, inflation and volatility

	Weight (2009)				Year-on-year rate of change (1996-2009)				Standard deviation; month on month; non-seasonally adjusted			
	euro area	Min.	Med.	Max.	euro area	Min.	Med.	Max.	euro area	Min.	Med.	Max.
HICP	100.0	100.0	100.0	100.0	2.0	1.5	2.5	6.0	0.3	0.3	0.5	1.4
HICP excl. energy	90.4	83.7	89.7	93.5	1.8	1.2	2.3	4.8	0.3	0.2	0.5	1.4
Energy	9.6	6.5	10.3	16.3	3.9	3.1	4.6	13.8	1.5	1.2	2.0	3.7
Oil	*4.7*	*2.4*	*4.8*	*8.5*	*4.6*	*3.2*	*4.8*	*7.2*	*2.7*	*2.0*	*3.1*	*3.8*
Non-oil	4.8	1.5	3.9	13.9	3.5	1.7	3.8	16.5	0.7	0.7	1.1	4.6
Gas	1.8	0.0	1.2	4.1	5.5	4.1	6.1	18.1	1.3	0.8	2.4	6.6
Electricity	2.3	1.2	2.2	4.5	1.8	-0.3	2.6	16.5	0.6	0.4	1.3	6.0
Heat energy	0.6	0.0	0.0	4.9	5.8	2.3	5.8	15.9	0.9	0.6	1.7	7.8
Solid fuels	0.1	0.0	0.1	1.0	2.5	0.5	2.4	8.9	0.5	0.3	1.0	5.1

Sources: Eurostat and Eurosystem staff calculations.
Notes: For detailed country data see Tables A7-A10 in Annex 1. Euro area denotes the euro area average; min. denotes the minimum, med. the median and max. the maximum across the euro area countries.

in Annex 1). Electricity and gas are by far the most important components, with average weights of 2.3% and 1.8% respectively. The average euro area weights of heat energy and solid fuels are much lower at 0.6% and 0.1% respectively.

Like liquid fuel prices, non-oil energy prices have also risen by more than the overall average inflation rate over the period 1996 2009 – by 3.5% vs. 2.0%. Gas and heat energy prices experienced the strongest increases at 5.5% and 5.8% respectively, whereas electricity prices have risen on average by the same amount as the HICP excluding energy (i.e. 1.8% per annum). The cross-country range of average price increases was much larger for non-oil energy than for liquid fuel prices. By far the strongest average annual rate of increase was in Slovakia, at 16.5%, with the lowest average increase recorded in France at 1.7% – see Table A8 in Annex 1. The relatively low average rate of increase in France primarily reflects relatively subdued electricity prices.

Relative to liquid fuel prices, non-oil energy prices tend to be much less volatile and change less frequently. The average standard deviation of month-on-month changes in non-oil energy prices, at 0.7 percentage point, was substantially lower than for liquid fuels (2.7 percentage points). Electricity prices change, on average, every four months, against an average of one and a half months for gas prices.

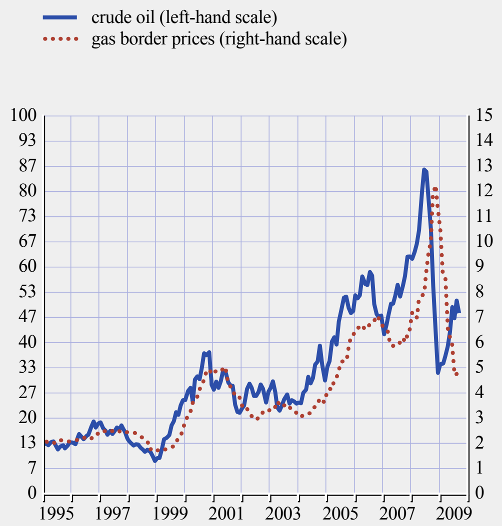
ANALYSIS OF PASS-THROUGH INTO CONSUMER GAS AND ELECTRICITY PRICES [62]

A key and well-known feature of *natural gas prices* is their strong co-movement with crude oil prices (see, for example, Brown and Yücel 2009 and 2007, Bachmeier and Griffin 2006 and Villar and Joutz 2006). This mainly reflects: (i) the substitutability of, and competition between, gas and oil for certain purposes such as electricity generation and (ii) institutional arrangements whereby many long-term gas supply contracts are explicitly linked to oil prices.[63] The latter is a crucial determinant of co-movements in gas prices since gas, being less storable and shippable than oil, is still transmitted by pipeline.[64] Thus, in the absence of explicit indexing on oil prices, regional supply and demand developments will have more impact on gas price movements. Chart 31 shows the evolution of crude oil prices and border prices

62 The analysis is based on Eurostat price level data. A detailed discussion of this data source is presented in Annex 2.5.
63 For an economic analysis of the oil price indexing of natural gas see, for example, Bartholomae and Morasch 2007.
64 The emergence of liquefied natural gas may diminish somewhat the regional nature of gas markets. However, the costs of transport mean that regional markets may remain rather fragmented, particularly in comparison with liquid fuel markets. See Neumann 2009 for a discussion on the impact of LNG on the linking of natural gas markets.

Chart 31 Crude oil prices and euro area border gas prices – levels

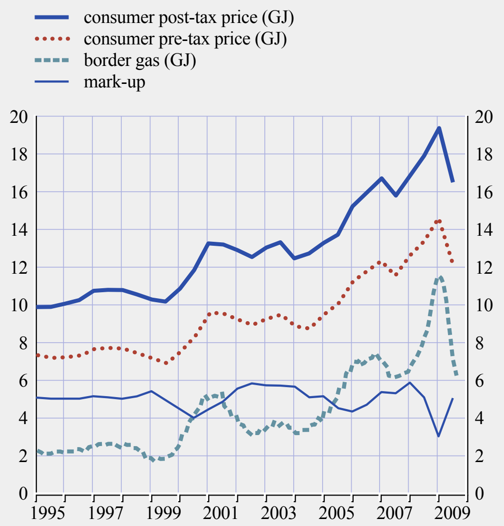
(euro/barrel; euro/MMBtu)



Sources: Datastream, Haver Analytics, Gas International Weekly and Eurosystem staff calculations.
Note: Based on border prices for Belgium, Germany, Spain, France, Italy and the Netherlands.

Chart 32 Euro area consumer gas price developments and the pass-through from border prices

(euro/GJ)



Sources: Datastream, Haver Analytics, Gas International Weekly and Eurosystem staff calculations.
Note: Based on border prices for Belgium, Germany, Spain, France, Italy and the Netherlands.

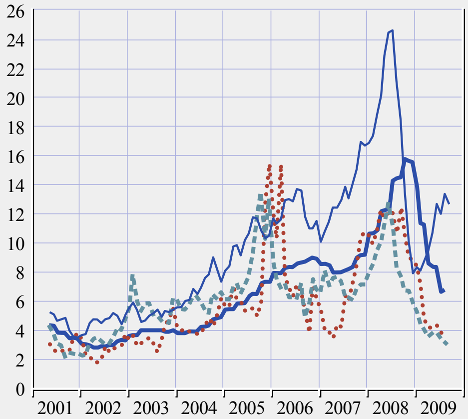
for gas (i.e. mainly cross-border pipeline prices, but also LNG), highlighting this strong co-movement as well as the slight lag in gas prices.

Consumer gas prices tend to lag both crude oil prices and gas border prices somewhat. For the euro area as a whole, the peak correlation between consumer gas prices and crude oil prices is at a lag of eight months in level (0.97) and year-on-year (0.79) terms and six months in terms of month-on-month changes (0.35). The peak correlation between consumer gas prices and gas border prices is at three months in level (0.95), year-on-year (0.88) and month-on-month (0.69) terms. This correlation structure is broadly shared across euro area countries. The gap between the border and the pre-tax consumer price (called the mark-up below) reflects the *costs* of processing, transmitting, storing and distributing gas to consumers, as well as the *margins* of the various operators along the gas chain.

Chart 32 shows that movements in consumer gas prices mainly reflect developments in border gas prices. Overall, the "mark-up" has remained relatively stable, at around €5/GJ, over the period since 1995. This suggests that movements in gas border prices are passed through fully into consumer prices, albeit with some lag, and that as international gas prices have increased, the share of consumer prices accounted for by raw inputs has also increased. One implication of this is that as the price level increases, the percentage pass-through (i.e. elasticity) increases, although the absolute pass-through remains the same (i.e. complete).

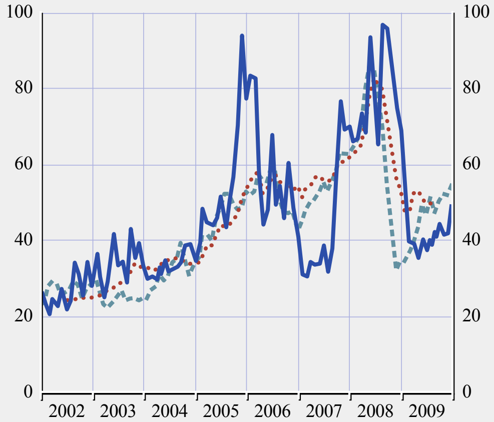
The role of national arrangements in contracts and the role of spot markets become more apparent in these results when comparing gas prices in all the main gas markets (euro area, Japan and the United States). Although they all co-move with oil prices, euro area and Japanese gas prices appear much smoother and more formally linked to oil prices. Prices in the United States, besides being more volatile, also tend to lead slightly those in the euro area. A key difference between US markets on the one hand, and euro area markets on the other, is the extent to which

Chart 33 International gas prices



Sources: Haver Analytics and Eurosystem staff calculations.

Chart 34 Crude oil and electricity exchange (spot and future) prices



Sources: Reuters/Bloomberg, EEX, Haver Analytics and Eurosystem staff calculations.

prices are determined by long-term contracts with explicit indexation on oil prices[65] or in spot markets where they are determined by local supply and demand conditions. Spot markets play a key function in the United States but still play a small role in the euro area, though this is growing rapidly relative to contracted gas.[66] Chart 33, using data from 2001 onwards, shows that the co-movement of spot market prices in the euro area and in the United States is very strong[67] so that if the weight of long-term contracts in the euro area market was to diminish over time, regional gas price dynamics could become much more synchronised. However, transport costs may mean that gas markets remain regional, at least to some extent.

Turning to *electricity prices*, the reaction of consumer prices to energy commodity price changes is much less clear. However, there are notable differences between wholesale and consumer electricity price developments. Chart 34 shows that there is a considerable degree of co-movement between crude oil and exchange-based (spot and one-year-ahead futures) wholesale electricity prices. This co-movement stems from the co-movement of gas and oil prices and the key role of gas power plants as the "swing" or marginal generator. Notwithstanding the link between crude oil and exchange-based wholesale electricity prices,

65 Japanese gas prices (generally LNG) are also linked by formula to oil prices, but the formula is generally non-linear (the so-called "S-curve"). This may help explain why Japanese gas import prices, which were historically higher than euro area and US prices as Japan imported LNG, have not risen by as much in recent years.

66 Contracted border prices tend to be smoother than spot market prices. On the other hand, although spot prices were more volatile over the period 2001-09, they were also somewhat lower on average by approximately USD 1/MMBtu. There have been various arguments put forward in favour and against longer-term contracting and indexing of natural gas prices. Those in favour argue that given the large capital costs involved in building gas infrastructure, longer-term contracts help reduce uncertainty. On the other hand, those against argue that indexing on oil prices dulls the signal coming from relative supply and demand in gas markets. Ultimately, both sets of prices should broadly co-move. However, this co-movement may vary over time reflecting market-specific factors in both oil and gas markets (for a more detailed discussion, see for example, IEA 2009, Onour 2009 or Hartley et al. 2007).

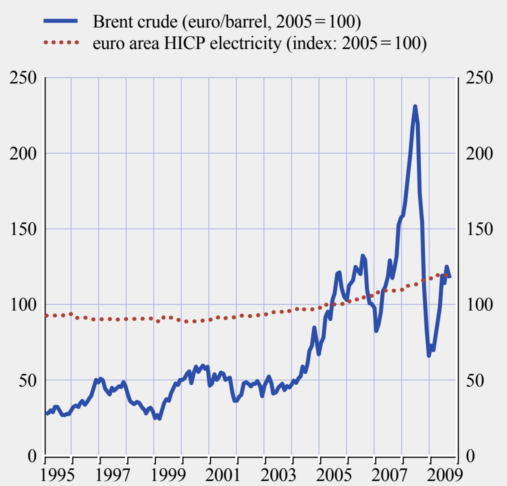
67 The chart shows gas prices at the Zeebrugge Hub (Belgium). The picture remains the same for the Title Transfer Facility (TTF, the Netherlands) and the National Balancing Point (NBP, the United Kingdom) hubs.

the link between electricity and oil prices at the consumer level is very weak – see Chart 35. This is owing to a variety of factors including taxes, different fuel mixes, and network costs but may also in part reflect price regulation.

When consumer electricity prices are administered in nature, revisions in regulated tariffs usually take place after a set interval of either a quarter or one year, and the pass-through of commodity price shocks will naturally be protracted and cumulated. Regulation may also place a limit on the price changes granted which is likely to be much lower than the increase in input prices. Overall this suggests that profit margins in some countries buffer, at least in the short run, changes in commodity prices. The high volatility of energy commodity prices and the problem of disentangling transitory and persistent price shocks may also help explain the long lags observed.

Following liberalisation there appear to have been changes in pricing behaviour, at least in some countries, with a move away from infrequent adjustments towards more frequent ones while the importance of traditional long-term contracts declines.[68] However, higher and more volatile energy prices in the recent period might also have played a role. With the opening of electricity exchanges throughout the euro area in the wake of liberalisation, market-based instruments to procure electricity are beginning to replace traditional (long-term) bilateral contracts. Some Member States report a correlation between spot or future and consumer prices, although the impact is hard to quantify as trading on electricity exchanges is still in its infancy and generally makes up only a small proportion of a country's total electricity consumption.[69] However, with the trading volume fast increasing, the impact will probably become stronger and more discernable.[70]

Chart 35 Crude oil and consumer electricity prices



Sources: Eurostat, Reuters/Bloomberg and Eurosystem staff calculations.

ANALYSIS OF CONSUMER GAS AND ELECTRICITY PRICE LEVELS

Consumer gas price levels differ markedly across countries and, with the exception of Slovakia, are generally higher than in the United Kingdom, a country often taken as a benchmark because of its early liberalised and well-developed gas market (see Chart 36). Despite tentative evidence of price convergence, signalled by a decline in price dispersion between 2001 and 2006, price differentials were still relatively high in 2009, resulting in a coefficient of variation of between 12% and 16% in 2009. Considering electricity prices for households across the euro

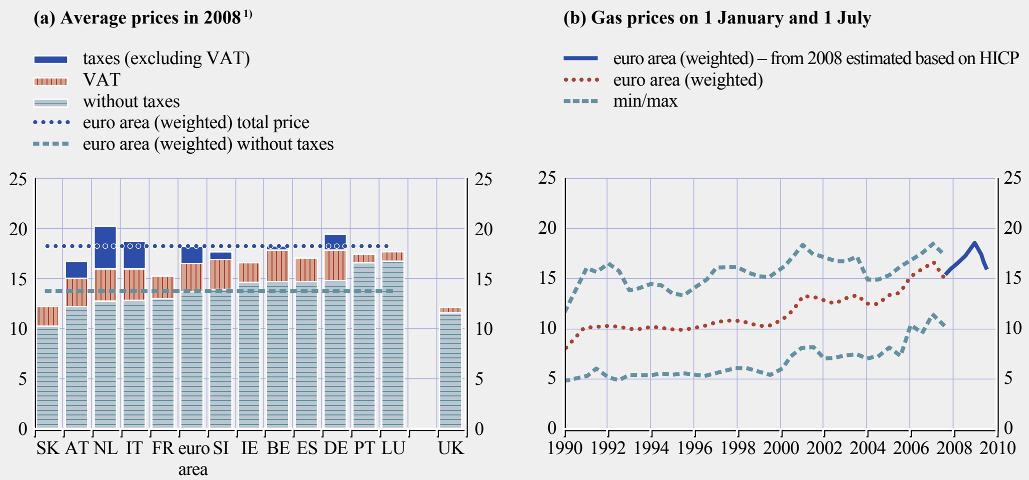
68 Monthly HICP data on electricity from January 1995 to July 2009 for Austria and Germany show that the frequency of non-zero price changes per year is two-thirds higher after deregulation than before.

69 According to NCB information: in Belgium some suppliers use spot electricity market prices to adjust their prices (see Nationale Bank van België/Banque Nationale de Belgique 2008); for Germany and the Netherlands there is tentative evidence that future electricity market prices are a good predictor of consumer prices; in Finland an asymmetric pass-through of electricity market prices into consumer ones is observed, with increasing prices having a stronger impact than decreasing ones.

70 Fuel prices have been identified as an important factor amongst others influencing prices on electricity exchanges. Bosco et al. (2007) find evidence of long-term dynamics between prices on a number of euro area electricity exchanges and gas prices. Zachmann and von Hirschhausen (2008) confirm this finding and also identify the prices of CO_2 certificates as a determining factor of future prices. The "Quarterly Report on European Electricity Markets" by the European Commission (2008-2009) reports that industrial and household demand, capacity constraints and weather conditions also play a role.

Chart 36 Euro area gas prices for medium-sized households

(euro/GJ)



Sources: Eurostat and Eurosystem staff calculations.
Notes: Post-2007 prices are computed as average prices for the period January to June (semester 1) or July to December (semester 2). The euro area is weighted according to 2009 HICP countries and item weights.
1) Average of the first and second semesters of 2008.

area, price dispersion is even larger than for gas (see Chart 37) and does not show clear signs of convergence.[71]

The considerable cross-country heterogeneity in consumer gas and electricity prices, especially in comparison with liquid fuel prices, can again be explained by three main factors: (i) taxes, (ii) costs and (iii) competition and margins.[72] Considering the differences in consumer gas price levels across countries, it is clear from Charts 38 and 39 that taxes and levies play an important role in both gas and electricity prices – as substantial and positive correlations are evident. However, taxes and levies still play a more predominant role in liquid fuel prices.

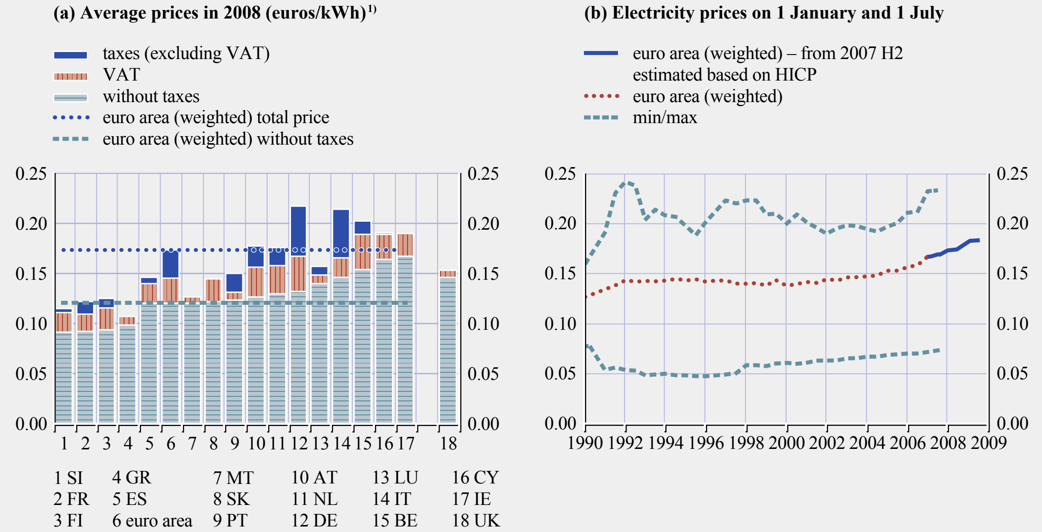
Gas and electricity are industries for which a substantial portion of costs derive from the construction and maintenance of networks to deliver the end product to consumers.[73] In the second half of 2008, in the euro area, energy and supply costs accounted for around 45% of the consumer electricity price[74], and, of those costs, "network" costs represented around 25%. On the other hand, taxes and levies accounted for around 35%. In terms of prices excluding taxes and levies, the ratio of energy and supply costs to network costs was around two-thirds (63%) to one-third (37%).[75] These differences may stem from structural factors such as population density and the investment required for maintaining and upgrading the network. Alternatively, given that some of these network activities are natural monopolies, they could represent rent extraction.

The link between network costs and price differentials seems, however, to be weaker for

71 For more formal tests of convergence in European gas and electricity prices, see Robinson (2007a, b).
72 These factors may not be independent. For example, Brunekreeft and Keller (2000) report that vertically integrated firms concentrate on excessive network access charges.
73 The "energy and supply" price includes the costs and margins of generation and of trade and customer services. "Network" costs include transmission and distribution tariffs, distribution losses, system operation, ancillary services costs and meter rental. Taxes include VAT but also other levies such as environmental taxes. For a breakdown across the euro area, see Table A13 in Annex 1.
74 This figure is likely to overstate the portion accounted for by fuel costs as data from France are not available. Given the large share of nuclear power in that country, fuel costs are likely to be substantially lower, as is suggested by the low selling price (€12.3/100kWh).
75 Correspondingly, typical two-tier consumer tariffs differentiate between a fixed basic fee and rates for volumes consumed. They are also reflected in the HICP.

Chart 37 Euro area electricity prices for medium-sized households

(euro/kWh)

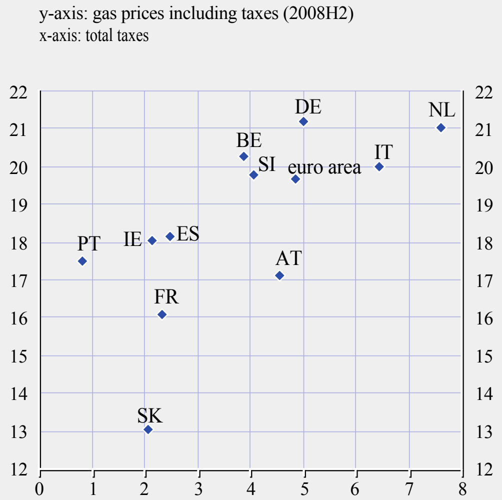


Sources: Eurostat and Eurosystem staff calculations.
Notes: Post-2007 prices are computed as average prices for the period January to June (semester 1) or July to December (semester 2). The euro area is weighted according to 2009 HICP countries and item weights.
1) Average of the first and second semesters of 2008.

gas than for electricity. Charts 40 and 41 show the relationship between consumer prices excluding taxes and network charges/costs for gas and electricity respectively. Generally, the network access tariffs/costs are lower for gas than for electricity. No clear relationship is evident concerning gas prices, although there appears to be a clearer positive relationship in the case of electricity, with Italy and Malta as outliers.[76]

Chart 38 Consumer gas prices (including taxes/levies) 2008H2 and taxes/levies

(euro/GJ)



Sources: Eurostat and Eurosystem staff calculations.

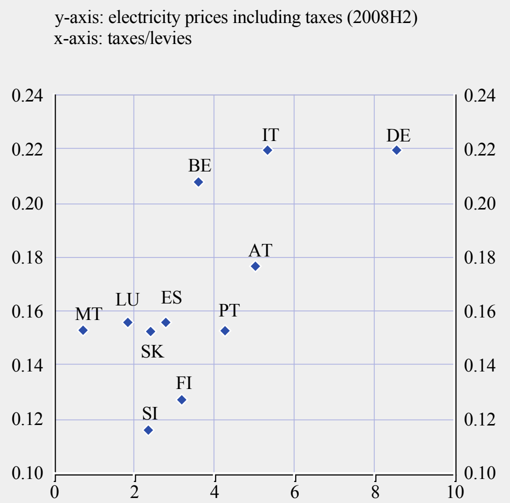
An additional element as regards electricity is that it may be generated using a wide range of inputs.[77] The decomposition of euro area electricity generation by fuel type (Chart 42) was discussed in Chapter 1. One key feature was the heterogeneity in the fuel mix used to generate electricity. In particular, some countries were

76 There is some evidence that network access tariffs/costs are affected to some extent by scale effects, as there is a negative relationship between network access tariffs on the one hand, and market size and population density on the other.

77 ICF International (2007) provides an overview of electricity price drivers. Although its report is structured along the lines of demand, supply and other factors, the main issues covered are the same: fuel input mix, the load duration curve and marginal vs. average pricing, transmission and distribution, competition, as well as environmental and more general regulations. See also KEMA Consulting 2005 for an overview of European electricity prices.

Chart 39 Consumer electricity prices (including taxes/levies) 2008H2 (euro cent/kWh) and taxes/levies

(euro/100kWh)

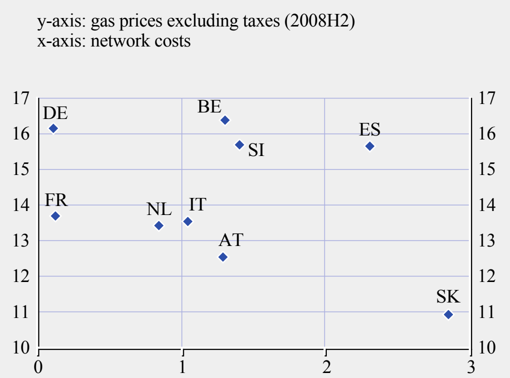


Sources: Eurostat and Eurosystem staff calculations.

more reliant than others on fossil fuels to produce electricity. As prices of fossil fuels have risen sharply over the last decade, these countries may have experienced above average increases in costs – especially as, in the short run, it is not easy to substitute different fuel types. Chart 43, which shows the relationship between consumer electricity prices excluding taxes and the share of electricity generated using natural gas or oil, provides some evidence for this hypothesis.

Chart 40 Consumer gas prices (excluding taxes/levies) 2008H2 and network access tariffs

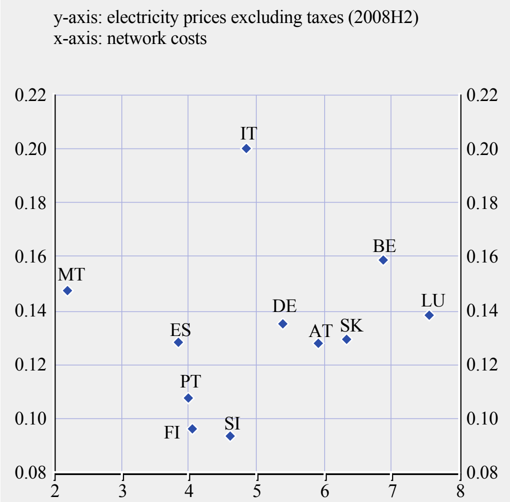
(euro/GJ)



Sources: DG-TREN, Eurostat and Eurosystem staff calculations

Chart 41 Consumer electricity prices (excluding taxes/levies) 2008H2 (euro cent/kWh) and network costs

(euro/100kWh)



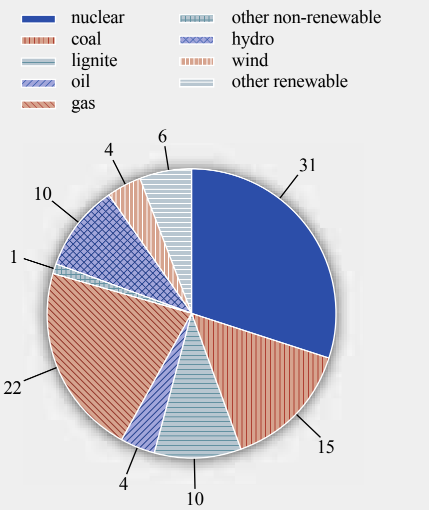
Sources: DG-TREN, Eurostat and Eurosystem staff calculations.

However, it should be noted that this relationship may not always hold true. Indeed, around the late 1990s, gas and oil may have been relatively cheap to use compared with other fuel types. Indeed the results of the econometric panel analysis of electricity prices below and in Annex 2.6 suggest this.

Turning to the impact of competition and deregulation on price level differences, it should be recalled that both gas and electricity markets in Europe have undergone a sustained process of deregulation dating back to the mid-1990s. However, much of this period was also characterised by high and volatile energy prices. Therefore, disentangling the impact of competition and deregulation is challenging. Nonetheless, in the empirical literature there is some evidence in support of a largely beneficial impact from deregulation. Martin et al. (2005) provide an overview of earlier studies supporting the downward impact of liberalisation, in particular third-party-access and unbundling, on prices in the electricity and gas sector. Their own estimates suggest that a reduction in public ownership leads to lower electricity and gas prices. Polo and Scarpa (2003) also find a negative association between electricity price levels

Chart 42 Decomposition of euro area electricity generation by fuel type

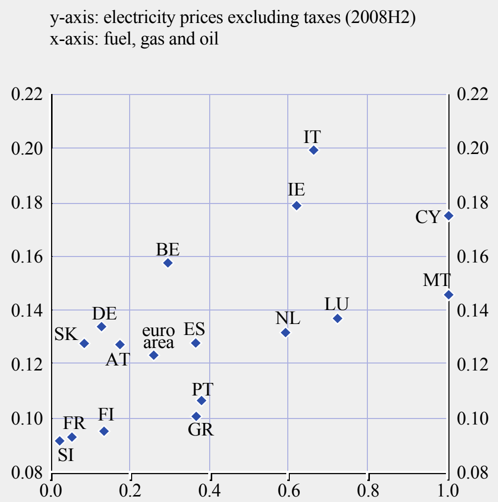
(2007; percentages)



Sources: Eurostat and Eurosystem staff calculations.

Chart 43 Consumer electricity prices (excluding taxes/levies) 2008H2 (euro cent/kWh) and share of electricity generated using natural gas or oil

(percentages)

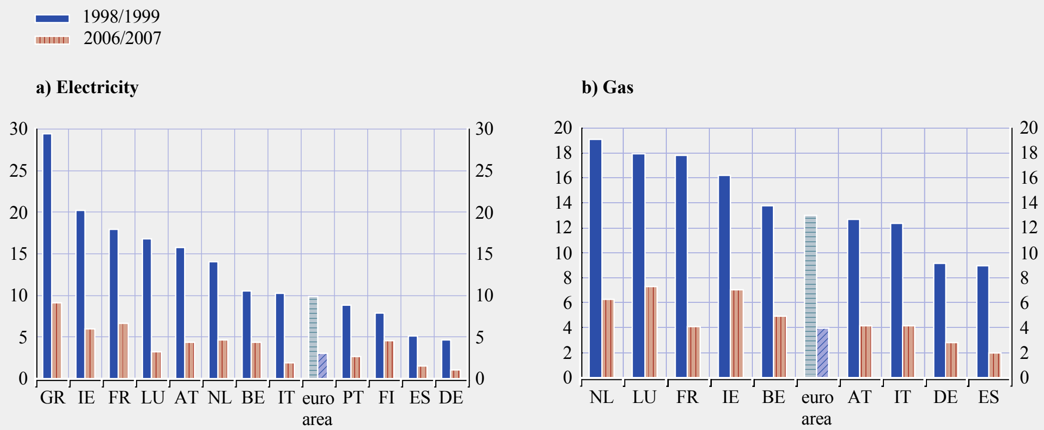


Sources: Eurostat and Eurosystem staff calculations.

and liberalisation policies: according to their estimates liberalisation would reduce electricity prices by 10%. Copenhagen Economics (2007) estimates that in EU15 networks liberalisation stimulated a 3% growth in electricity and gas output, with a drop in electricity prices and a slight increase in gas prices. Finn Roar et al. (2008) measure the effect of removing barriers to competition in gas and electricity in western European markets using a computable general equilibrium (CGE) model, and find beneficial effects for the electricity market.

Chart 44 OECD regulation/competition aggregate indicator: contribution to price levels

(percentage of price level net of taxes)



Sources: OECD and Eurosystem staff calculations.
Note: Results are based on panel estimations across the euro area countries. The OECD regulation/competition aggregate indicator for the electricity market includes three indicators, namely an indicator for entry barriers, an indicator for public ownership and an indicator for vertical integration. The OECD regulation/competition aggregate indicator for the gas market includes four indicators, namely an indicator for entry barriers, an indicator for public ownership, an indicator for vertical integration and an indicator for C1.

To confirm and update these findings, a panel model of (pre-tax) electricity and gas prices on the OECD regulation/competition indicators (covering barriers to entry, the degree of vertical integration and public ownership in both sectors, and market structure in the gas market, as mentioned in Section 1.3.2) was estimated.[78] The empirical findings further confirm that barriers to entry in the electricity and gas sectors, as well as vertical integration in the electricity sector and public or concentrated ownership in the gas sector are associated with higher price levels. For the sample of countries, contrary to other studies, vertical integration in the gas sector is found to have a negative impact on prices. According to these estimates, the impact of regulation on prices seemed to be more diverse for electricity than for gas in the early 1990s before liberalisation took place (see Chart 44). For the euro area aggregate they would account for 10% of the electricity price level, but the estimated contribution is substantially higher in some countries for which institutional indicators are available. In addition, liberalisation has made a substantial contribution to lower price levels. For both sectors, the euro area average contribution of regulation to the price level in recent years is less than one-third of the contribution in the early 1990s.

3.2.3 SUMMARY OF THE DIRECT FIRST-ROUND EFFECTS OF A CHANGE IN OIL PRICES ON HICP ENERGY

Table 9 summarises the results of the findings on the direct pass-through of crude oil prices into consumer energy prices. The highest elasticity is for heating fuel owing to the relatively low share of taxes in final consumer prices. The level of excise taxes impacts on the elasticity – i.e. the percentage response to a given percentage change in crude oil prices – of consumer oil prices. Other things being equal, a higher level of excise taxes increases the level of consumer energy prices, but dampens their elasticity and vice versa. The elasticities for petrol and diesel are broadly similar – although slightly lower for the former owing to somewhat higher excise taxes on petrol compared with diesel on average. The elasticity of natural gas (and heat energy, which generally co-moves with natural gas) lies between that of transport and heating liquid fuels.

In each case, owing to the, on average, relatively constant refining and distribution costs and margins, the elasticity is a function of the crude oil price level. The elasticity of overall HICP energy doubles from around 15% when crude oil prices are €20 per barrel to around 30% when crude oil prices rise to €50 per barrel. If crude oil prices were to reach a level of €100 per barrel, under the assumptions of broadly constant refining and distribution costs and margins and excise taxes, the elasticity would be slightly over 40%.

78 For a more detailed technical discussion and presentation of the results, see Annex 2.6.

Table 9 Crude oil price pass-through into HICP energy components

(summary of direct elasticity rates)

Crude oil (euro per barrel)	Weighted average pass-through 1)	Petrol (2.6%) 2)	Diesel (1.4%) 2)	Heating fuel (0.7%) 2)	Natural gas (1.8%) 2)
20	16%	15%	19%	39%	24%
50	30%	31%	37%	62%	44%
100	42%	47%	54%	76%	61%

Source: Eurosystem staff calculations.
Notes: Based on taxes (VAT, excise and other) as at 19 October 2009 and median refining and distribution costs and margins since 1999. Assumes HICP heat energy (0.6% weight) co-moves with natural gas.
1) Weighted average probably slightly underestimates extent of elasticity as it assumes zero pass-through for electricity and solid fuels.
2) Denotes weight in overall HICP.

3.3 INDIRECT EFFECTS VIA THE PRODUCTION CHAIN

The indirect effects of energy prices through the production chain originate from the change in the production cost of a consumption good or service that uses energy in its own production process. This use could be either direct or via other intermediate goods or services that are used as inputs, as well as distribution costs, and indirectly capture the effect of changes in energy prices. Indirect price effects arise when firms pass changes in energy costs on to their selling prices in order to maintain or restore their profit margin, resulting eventually in rising non-energy consumer prices. The degree to which costs are passed on to subsequent price stages is affected by factors such as the business cycle situation and the competitive pressures in the respective market. As the transmission of a cost increase on prices along the supply chain is not immediate, the indirect impact of an oil price shock on consumer prices is delayed more and takes longer compared with the direct effect. As indirect effects can appear along the whole production chain from import to final demand prices, it is necessary to disentangle the impact on both producer prices and non-energy consumer prices, taking account of the different degrees of energy input into production.

A particular caveat to the analysis of indirect effects is that it is rather difficult to distinguish them empirically from second-round effects, as an adjustment in non-energy consumer prices following an energy shock can either stem from pass-through (cost) effects or the reaction of wages, profit margins and inflation expectations to the first-round effects of the shock. A number of factors, in particular labour market features and wage-setting institutions, can facilitate the appearance of second-round effects. However, as these are generally not a function of energy markets themselves, these institutional details are not discussed in this report. For an extensive analysis of wage and price-setting features that could facilitate the emergence of second-round effects in response to energy price movements, see the work of the Eurosystem Inflation Persistence and Wage Dynamics Networks.[79]

3.3.1 AN ANALYSIS BASED ON INPUT-OUTPUT TABLES

The main advantage of using input-output tables is that they provide a refined sector decomposition of the production process, based upon the interrelationships between the different branches of activity in the economy via the cross consumption of intermediate inputs. This allows the sectors likely to be impacted most by indirect effects to be pinpointed more precisely. However IOT should be used with some caution as they are based on a static structure. In particular, as prices rise, users of energy are assumed not to substitute away from more expensive products. In addition, this approach does not allow an assessment of second-round effects – profit margins and wages are assumed to remain constant – and they do not take into account any possible monetary policy reaction to shocks.[80]

79 The results of the Inflation Persistence Network are summarised in Altissimo et al. 2006. Studies produced by the Wage Dynamics Network are available on the ECB's website at www.ecb.europa.eu.

80 For a detailed overview of the methodology, see Annex 2.7.

Table 10 Impact of a 10% increase in energy prices on producer prices: direct and indirect impact

(2005)

	DE	IE	GR	ES	FR	IT	NL	AT	PT	SI	SK	FI	euro area
Direct	0.17	0.13	0.27	0.20	0.16	0.19	0.38	0.22	0.25	0.21	0.42	0.22	0.20
Indirect	0.15	0.12	0.21	0.24	0.14	0.21	0.41	0.20	0.28	0.16	0.36	0.21	0.20
Total	0.33	0.25	0.47	0.44	0.30	0.40	0.79	0.42	0.52	0.36	0.78	0.43	0.39
Share of energy in production	*3.3*	*2.5*	*5.0*	*4.5*	*3.5*	*4.2*	*6.3*	*5.1*	*6.0*	*3.2*	*10.1*	*4.5*	

Source: Eurosystem staff calculations based on IOT 2005.
Note: Results for the euro area are computed as the weighted average of country results.

Considering first the impact on *producer prices*, for the euro area in aggregate the IOTs suggest that the overall impact of a 10% energy price increase on producer prices would amount to 0.39% in 2005 (see Table 10). The direct and indirect effects each contribute half to the overall development. The direct effect emerges through the immediate energy use, while the indirect effect through the consumption of other products which use energy as an intermediate input. They reflect the immediate and intermediate impact on producer prices and cannot be equated with the overall direct and indirect effects on consumer prices discussed in other sections. Among the 12 countries where data are available, the lowest overall impacts are recorded by Ireland (0.25%), France (0.30%), Germany (0.33%) and Slovenia (0.36%), while the largest impacts are obtained in Portugal (0.52%), Slovakia (0.78%) and the Netherlands (0.79%). In almost all cases, the direct and indirect impacts contribute approximately one-half to the overall impact, except in Greece and Slovenia where the direct impact exceeds somewhat the indirect one.

Turning to differences across branches of activity, unsurprisingly the branch the most impacted is the energy sector itself, facing a cost increase of 4.9% following a 10% rise in energy prices in the euro area (see Table 11). Looking at broad non-energy sectors, the largest increase in costs after that of the energy prices increase is recorded by agriculture and fishing (0.35%), followed by the manufacturing industry (0.29%), construction (0.20%) and services (0.16%). However, large differences are found within these broad sectors: within the manufacturing industry, the cost increase appears to be especially high in the chemicals (0.7%) and basic metal industries (0.59%). On the other hand, the impact is found to be very limited (lower than 0.15%) in tobacco products, wearing apparel and furs, office machinery and computers, radio, television and communications equipment, and medical, precision and technical instruments. Within the services sector, the transport sub-sector exhibits a much higher impact than other services.

Detailed sector results by country help to explain the overall relative position of each country presented above. In particular, they help to disentangle, for each country, the pure "energy consumption effect" (stemming from a higher energy intensity of some sectors of production) from the "structure effect" (stemming from the relative specialisation of a country in high energy-consuming sectors). It indicates, for example, that the lowest overall impact in Germany and France is the

Table 11 Impact of a 10% increase in energy prices on producer prices: breakdown by main branch of activity

(2005)

	DE	IE	GR	ES	FR	IT	NL	AT	PT	SI	SK	FI	euro area
Agriculture and fishing	0.36	0.35	0.37	0.29	0.34	0.29	0.53	0.47	0.37	0.63	0.54	0.28	0.35
Manufacturing	0.27	0.11	0.44	0.34	0.21	0.27	0.59	0.35	0.31	0.29	0.44	0.31	0.29
of which:													
Chemicals	0.70	0.03	0.36	0.92	0.50	0.38	1.86	1.11	0.91	0.38	1.61	0.80	0.70
Basic metal	0.64	2.59	0.88	0.54	0.29	0.52	0.43	1.43	0.27	0.70	1.29	0.72	0.59
Energy	4.82	4.75	5.26	5.15	4.12	4.90	7.27	4.41	5.20	3.13	4.23	4.95	4.88
Construction	0.18	0.23	0.36	0.18	0.16	0.23	0.17	0.26	0.45	0.44	0.33	0.22	0.20
Services	0.12	0.13	0.15	0.20	0.13	0.18	0.18	0.16	0.22	0.25	0.38	0.22	0.16
Trade	0.14	0.11	0.16	0.21	0.20	0.24	0.18	0.13	0.23	0.20	0.32	0.27	0.19
Transport	0.63	0.54	0.39	0.79	0.46	0.44	0.91	0.62	0.97	1.14	1.21	0.59	0.60
Land transport services	0.47	0.60	1.11	0.90	0.62	0.50	0.85	0.74	1.32	1.54	1.47	0.68	0.64
Water transport services	0.50	0.44	0.16	1.42	0.57	0.29	0.93	0.81	0.61	0.90	1.30	0.60	0.63
Air transport services	2.46	1.06	0.37	1.85	0.67	1.01	2.14	1.22	1.38	1.19	1.40	1.30	1.53
Telecommunications	0.09	0.10	0.17	0.19	0.12	0.14	0.09	0.08	0.08	0.10	0.13	0.09	0.12
Other services	0.07	0.10	0.10	0.12	0.08	0.12	0.11	0.11	0.15	0.12	0.20	0.15	0.10

Source: Eurosystem staff calculations based on IOT 2005.

Table 12 Impact of a 10% increase in energy prices on consumer prices overall, direct and indirect impact

(2005)

	DE	IE	GR	ES	FR	IT	NL	AT	PT	SI	SK	FI	euro area
Direct	0.25	0.30	0.20	0.16	0.21	0.22	0.22	0.27	0.22	0.45	0.38	0.14	0.22
Indirect	0.12	0.14	0.17	0.16	0.12	0.17	0.13	0.14	0.19	0.17	0.25	0.20	0.14
Total	0.37	0.44	0.36	0.32	0.34	0.39	0.35	0.42	0.40	0.61	0.63	0.34	0.36
Share of energy in consumption	*4.5*		*3.3*	*3.0*	*4.6*	*4.3*	*4.1*	*4.6*	*3.9*	*6.1*	*9.2*	*2.6*	

Source: Eurosystem staff calculations based on IOT 2005.

consequence of the combination of a favourable production structure (less oriented towards energy-intensive industries) and a relatively moderate energy intensity in all branches of activity, except agriculture and fishing. On the other hand, the high impact in the Netherlands is explained by a structural effect (specialisation in energy and chemicals industries) and by a higher energy intensity in agriculture and fishing. The high impact in Portugal is related to a higher energy content in the agriculture and fishing, construction, and services sectors, as well as by a larger than average share of the energy industry in the economy (which is however somewhat compensated by a lower specialisation in other highly energy-intensive sectors).

The overall impact on *consumer prices* may be calculated by taking the results obtained for the increase in production cost across branches of activity and weighting them by the corresponding share in consumption. For the euro area in aggregate, IOT suggest that a 10% increase in energy prices would feed into a 0.36% increase in consumer prices (see Table 12). Like producer prices, the rise in consumer prices before taxes can be split into a direct effect through the direct use of energy products and an indirect effect through the consumption of products which use energy as inputs. For the euro area, the contribution of the direct consumption of energy products amounts to 0.22% while the indirect contribution amounts to 0.14%. Thus around 60% of the increase in expenditures is attributable to the direct consumption of energy products. The dispersion of the impact on consumer prices is lower than for producer prices, which is consistent with a lower heterogeneity in households' consumption pattern than in production structures across euro area countries. The impact ranges from 0.32% in Spain to 0.63% in Slovakia.

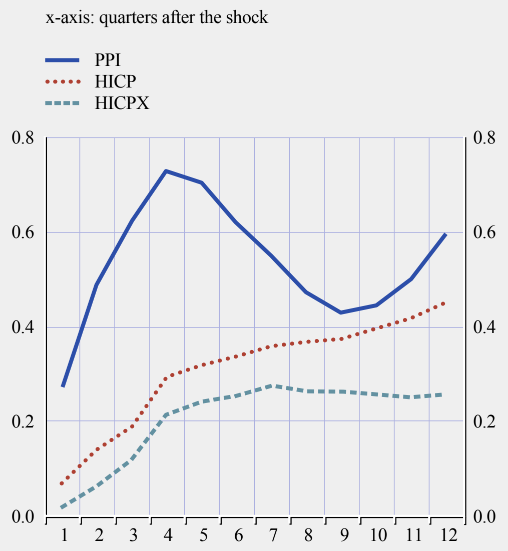
3.3.2 AN ANALYSIS BASED ON SMALL-SCALE STRUCTURAL MODELS

Small-scale structural models, such as Structural Vector AutoRegression models, provide a convenient framework for analysing indirect effects as they allow for dynamic and detailed interrelations among prices at different stages of the production/pricing chain. McCarthy (2000) and Hahn (2003) provide an application to selected industrialised countries and the euro area respectively. In this section, SVARs both for the euro area and for the six largest countries are estimated and the responses of producer and consumer prices to an oil price shock discussed.

Chart 45 presents the impulse response function, cumulated over 12 quarters, to an oil price shock (a 10% rise in oil prices) from the SVAR model of Hahn (2003), updated over a relatively long sample period (1971Q3-2009Q1). The model includes oil prices in USD, non-energy commodity prices in USD, the three-month interest rate, the output gap, the nominal effective exchange rate of the euro, the producer price index for manufacturing and the

Chart 45 Impact of a 10% oil price shock on euro area prices

(percentage deviation from baseline)



Source: Eurosystem staff calculations.

HICP. To capture indirect effects, a second model is estimated in which the HICP is replaced with the overall index excluding energy.[81] According to these models, the initial impact of a 10% increase in oil prices on PPI is about 0.3%, which rises to a peak effect of around 0.7% after one year, decreasing thereafter. This profile may be related to the sequential impact of direct effects on producer energy prices and indirect effects on producer prices more generally.[82] The cumulated effect after three years is 0.6%, somewhat higher than the results for manufacturing from the static IOT analysis (but in the latter the manufacturing sector excludes energy while the PPI for manufacturing covers some part of the energy sector). The effect on the HICPX is very small in the first quarter, but rises steadily to about 0.25% after two years without further effects thereafter.

Overall oil price shocks affect headline HICP gradually leading to an increase in the HICP of 0.07% in the first quarter, of a cumulated 0.3% after one year and of 0.45% after three years. This overall impact is broadly similar to the results from the IOT analysis.

It has been suggested that the pass-through of oil prices to producer and consumer prices has declined over time (see, for example, Hooker 2002 and Blanchard and Gali 2007). Empirical evidence indicates that, among other factors, monetary policy regimes oriented to the maintenance of price stability contribute to creating a more stable macroeconomic environment (Benati and Surico 2009; Blanchard and Riggi 2009). To check whether the oil price pass-through has also declined in the euro area over time, the SVAR is re-estimated over a rolling window and impulse responses are averaged over two sub-periods. The former includes the 1970s and excludes the most recent ten years, and the latter includes the most recent decade but excludes data prior to 1980. Results are shown in Table 13. Comparing the results of the first and second sample, there is clear evidence that oil price changes have, to some extent, lost their power to affect inflation in the euro area since the early 1980s. The pass-through to PPI and to non-energy items in the HICP basket has weakened by around one-third across the two sub-samples. The response of overall HICP has halved.[83]

81 Taking into account data properties, all variables are included as log first differences apart from the short-term interest rate and the output gap which are used in levels. The output gap is constructed by applying the Hodrick-Prescott filter to real GDP data. The VAR model includes a constant and four lags. Shocks are identified by using a Choleski decomposition with the following ordering: oil prices, non-energy commodity prices, short-term interest rate, output gap, exchange rate, PPI and HICP/HICPX. The original model of Hahn (2003) includes non-oil import prices instead of non-energy commodity prices but this change does not affect the impulse responses of the PPI, HICP and HICPX to an oil price shock. Since the oil price is ordered first, responses to an oil price shock are invariant to changes in the ordering of the other variables.

82 The reported PPI response is the one in a model that includes headline HICP. This response does not differ substantially from the one estimated in the model in which headline HICP is replaced with HICP excluding energy.

83 In addition to a lower share of energy input into the economy, relatively small indirect effects could also result from a shift in the objective of monetary policy towards maintaining a low inflation environment (Taylor 2000). The rather limited indirect effects of oil price changes over more recent times are confirmed by Landau and Skudelny (2009) who analyse in a mark-up framework, inter alia, the transmission of energy price shocks via the different stages of the distribution chain. They suggest a long-run impact of a 10% rise in oil prices of about 0.1% on the HICP excluding energy and unprocessed food. Most estimations in this study start only in the 1990s when, as stated above, the pass-through might have been somewhat lower than before.

Table 13 Impact of a 10% oil price shock on euro area prices

(percentage deviation from baseline after 12 quarters)

	Full sample	First sample	Second sample
PPI	0.59	0.85	0.56
HICP	0.45	0.68	0.36
HICPX	0.25	0.29	0.20

Source: Eurosystem staff calculations.
Notes: Full sample refers to 1971Q3-2009Q1. First sample is the average of 33 consecutive estimations for the sample periods 1971Q3-1995Q3 up to 1979Q4-2000Q4. Second sample is the average of 34 consecutive estimations for the sample 1980Q1-2001Q1 up to 1988Q1-2009Q1.

It is also informative to consider whether there are large differences in the transmission process of oil prices in the individual Member States' inflation rates. To investigate this, SVARs for Belgium, Germany, Spain France, Italy and the Netherlands have been estimated using a similar set-up as in the case of the euro area. Owing to data availability constraints, the country estimates cover the period 1985Q1-2009Q1. Table 14 shows the effects in these countries on the PPI, the HICP and the HICPX. To allow for comparison, the euro area estimate over the same sample period has been added.

Three interesting results emerge. First, in all countries (and in the euro area) the immediate impact on the PPI is usually larger than the impact on HICP which, in turn, is generally larger than that on HICPX, given the high direct effects on HICP energy. Although this was not the case according to the static analysis using IOT, this was partly attributable to the fact that in the IOT analysis, total producer prices including services and energy were analysed. When looking at the impact on manufacturing producer prices only, the input-output tables also yield stronger effects on producer prices than on consumer prices. Second, industrial producer prices tend to respond much more in Spain and the Netherlands, while they respond less in Germany and France. The relatively strong response for the Netherlands is mainly related to a relatively high share of energy in total production, leading to a somewhat stronger effect on producer prices of energy and, thereby, on total producer prices (see Section 3.3.1). Note that the producer prices used in this section include the energy sector. In addition, the results for Spain and the Netherlands could be relatively strong because of the manufacturing chemicals sector. Third, the effect of an oil price shock on headline inflation is stronger in Spain and Italy, mainly reflecting the behaviour of the non-energy HICP component. This is consistent with the findings using IOT. Initially the impacts on total and non-energy HICP are relatively similar. However, after a period of time, different second-round effects yield rather heterogeneous results, with the strongest impact for Spain. It should be noted that this result could also partly be related to a relatively strong effect of the transport sector (see Table 11), owing to its energy intensity which is above the euro area average. Overall, the ranges of estimates across countries are of a similar magnitude as in the input-output table analysis above.

Table 14 Impact of a 10% oil price shock on prices across euro area countries

(percentage deviation from baseline)

	PPI			HICPX			HICP		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
BE	0.8	0.2	0.2	0.0	0.1	0.1	0.3	0.2	0.2
DE	0.4	0.3	0.4	0.0	0.1	0.1	0.2	0.3	0.3
ES	1.1	0.9	0.6	0.1	0.3	0.3	0.3	0.4	0.4
FR	0.3	0.5	0.4	0.0	0.1	0.1	0.2	0.3	0.3
IT	0.8	0.4	0.5	0.1	0.2	0.2	0.3	0.4	0.5
NL	1.9	1.1	1.1	0.0	0.1	0.2	0.2	0.3	0.4
euro area	0.8	0.3	0.3	0.0	0.1	0.1	0.2	0.3	0.2

Source: Eurosystem staff calculations.

3.3.3 RESULTS FROM LARGE-SCALE MACROECONOMETRIC MODELS

The impact of changes in energy prices, and in particular, oil prices, on consumer prices does not only depend on the reaction of nominal variables (prices and costs such as wages). It also depends on the response of the real side of the economy to an oil price increase (as discussed in Chapter 2) and the two-way interaction between nominal and real variables. While these interlinkages can be manifold, so-called structural or large-scale macroeconometric models are, in principle, capable of capturing them to a significant extent and should hence provide a more complete picture of the impact of a change in energy prices (see, for example, Álvarez et al. 2009).

Clearly a crucial factor determining the impact of energy price fluctuations on inflation is the reaction of wages. Starting with the simulation results which allow for wage responses, the left-hand side of Table 15 reports the percentage impact of an oil price increase with respect to the baseline (unchanged oil prices). The weighted average of the country simulation suggests that a 10% increase in oil prices leads to a rise in the euro area HICP of about 0.2% in the first year, increasing to 0.45% in the third year. This is very much in line with the results from the SVAR for the full sample and the input-output table analysis shown above. Differences across countries can broadly be associated with differences in the energy share in the HICP basket, with Greece, Slovenia and Slovakia on the high side and France, Malta and Austria on the low side. For the majority of countries and the euro area as a whole, only around half (40-60%) of the long-run effect has been passed through after one year, which indicates that indirect effects and/or second-round effects are at work.

The simulation results for the HICPX, also reported in Table 15 for most of the euro area countries, provide further evidence of important effects on consumer prices beyond the direct impact. For the euro area as a whole and most of the countries (Belgium, Germany, France, Italy, Cyprus, Luxembourg and Slovenia),the impact on core inflation measured by the HICPX is very small in the first year (up to 0.1%) but increases gradually up to the third year to around 0.2%. This is again very much in line with the VAR evidence previously shown, although with a slightly higher dispersion across countries. Slovakia stands out once more with a higher than average impact (0.5% after three years) while the effect on HICP excluding energy is below 0.2% in Germany, France, Italy, the Netherlands and Austria.

Wage reactions are also quite heterogeneous across countries. Wages grow rather strongly in Slovakia following an oil price increase: after three years, compensation per employee is 0.6% higher compared with the baseline. Nominal wages in Belgium, Luxembourg and Germany show a rather similar reaction in the longer term (around 0.4%), but the impact in Belgium and Luxembourg is more immediate, most likely reflecting the existence of formal wage indexation[84]. The adjustment in Germany, where no formal wage indexation is in place, is more spread out, pointing to implied nominal wage resistance. By contrast, oil price changes are estimated to have no effect on wages in Ireland and a relatively small impact on wages in Italy and Austria, with an increase in compensation per employee of slightly more than 0.1% in the third year.

Comparing the reactions in the HICPX to those in the HICP, it is possible to obtain an idea of the relative size of direct effects on the one hand, and indirect and second-round effects on the other. According to the macroeconometric models, at the euro area level, the indirect/second-round effects, at 0.2%, account for roughly half of the impact on total HICP (0.45%). This implies that direct effects, and indirect or possible second-round effects, have almost the same size. This is consistent with the results of the SVAR (long sample). The IOT analysis suggests that the indirect effects are somewhat smaller than

84 In Belgium the impact of oil price movements on wages via the indexation mechanism is mitigated by the use of the so-called health index as the reference for indexation. That index excludes the prices of petrol and diesel from the overall index.

Table 15 Effect of a 10% oil price increase on consumer prices according to traditional structural models

(annual averages; percentage deviation from baseline (cumulated))

	Wage reaction on			Wage reaction off		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
HICP						
Belgium	0.32	0.51	0.54	0.29	0.36	0.34
Germany	0.33	0.50	0.54	0.33	0.47	0.47
Ireland	0.09	0.20	0.22	-	-	-
Greece	0.08	0.36	0.65	-	-	-
Spain	0.30	0.47	0.46	0.27	0.34	0.26
France	0.12	0.21	0.32	0.10	0.15	0.21
Italy	0.21	0.37	0.44	0.21	0.34	0.40
Cyprus	0.33	0.52	0.56	0.30	0.37	0.32
Luxembourg	0.41	0.55	0.62	0.41	0.44	0.44
Malta	0.33	0.30	0.34	0.33	0.29	0.32
Netherlands	0.20	0.43	0.48	0.20	0.41	0.44
Austria	0.18	0.18	0.19	-	-	-
Portugal	0.24	0.38	0.58	0.21	0.27	0.38
Slovenia	0.59	0.78	0.82	0.55	0.55	0.55
Slovakia	0.51	0.74	0.90	0.51	0.70	0.78
Euro area average	0.24	0.39	0.45	0.23	0.34	0.36
HICP excluding energy						
Belgium	0.04	0.16	0.22	0.00	0.00	0.00
Germany	0.07	0.15	0.17	0.07	0.12	0.09
Ireland	-	-	-	-	-	-
Greece	-	-	-	-	-	-
Spain	0.12	0.35	0.36	0.09	0.21	0.15
France	0.01	0.07	0.15	-0.01	0.01	0.03
Italy	0.01	0.10	0.18	0.00	0.06	0.14
Cyprus	0.08	0.23	0.34	0.04	0.07	0.08
Luxembourg	0.01	0.13	0.22	0.01	0.01	0.01
Malta	0.26	0.19	0.24	0.26	0.19	0.21
Netherlands	0.03	0.11	0.13	0.03	0.09	0.09
Austria	0.12	0.12	0.14	-	-	-
Portugal	0.03	0.18	0.38	0.00	0.07	0.18
Slovenia	0.05	0.26	0.30	0.00	0.01	0.01
Slovakia	0.14	0.39	0.54	0.14	0.34	0.42
Euro area average	0.05	0.15	0.20	0.03	0.09	0.10
Compensation per employee						
Belgium	0.13	0.35	0.41	-	-	-
Germany	-0.01	0.16	0.39	-	-	-
Ireland	0.00	0.02	0.02	-	-	-
Greece	0.04	0.26	0.43	-	-	-
Spain	0.11	0.27	0.32	-	-	-
France	0.06	0.15	0.25	-	-	-
Italy	0.03	0.12	0.13	-	-	-
Cyprus	0.13	0.17	0.23	-	-	-
Luxembourg	0.31	0.41	0.43	-	-	-
Malta	-0.04	0.28	0.25	-	-	-
Netherlands	0.02	0.12	0.18	-	-	-
Austria	0.06	0.11	0.12	-	-	-
Portugal	0.06	0.17	0.29	-	-	-
Slovenia	0.13	0.38	0.41	-	-	-
Slovakia	0.16	0.37	0.56	-	-	-
Euro area average	0.04	0.17	0.28	-	-	-

Source: Eurosystem staff calculations.

the direct effects. However, this seems to be plausible, given that the latter does not include any wage reaction (see also below on the simulation results when switching off the wage channel). The models for Belgium, France, Italy, Cyprus, Luxembourg and Slovenia also suggest that direct effects are about the same size as indirect (and second-round) effects, with an impact on the HICPX in relative terms to the HICP ranging between 40% and 60%. In the models for Germany and the Netherlands, the reactions of the HICPX relative to the HICP are rather small, suggesting that direct effects dominate. For Germany, this is congruent to the estimate obtained on the basis of the SVAR and the input-output table analysis. In Spain, Malta, Austria and Portugal, indirect and second-round effects are the main drivers behind the response in total consumer prices. For Spain, this is confirmed by the SVAR analysis, but not entirely when using input-output tables.

For a number of countries, results are also available for an oil price scenario when switching off the wage channel. They assume that wages remain unchanged following an oil price increase, which implies that there are no second-round effects via wage changes. Such an exercise is not without caveats. Switching off the wage channel implies that wages cannot respond to both the first-round price effects owing to a change in the oil price and the impact on activity, which suggests that all the necessary adjustment would fall on employment. This is a very strong assumption, which can have an impact on the stability properties of the models and the results should therefore be interpreted with caution. Notwithstanding this, a noteworthy outcome of this exercise is that in most countries, the impact of an oil price increase on the HICPX is relatively muted once wage reactions are not allowed. For the euro area as a whole, the *indirect effects* amount to 0.1% on a cumulative basis by the third year. This implies that approximately half of the total impact on HICPX (at 0.2%) comes from *second-round effects* via wage changes, triggered by either explicit wage indexation or via wage negotiations. Regarding country reactions, the cumulative indirect effects amount to between 0.1-0.2% in the third year for seven euro area countries (Germany, Spain, Italy, Cyprus, Malta, the Netherlands and Portugal). Indirect effects are on the high side in the model for Slovakia (0.4%). There are no or very small indirect effects in Belgium, France, Luxembourg and Slovenia, which suggests that almost all impact on the HICPX stems from second-round effects. In this respect, policies aiming at overcoming wage indexation mechanisms in the euro area and making wages generally more flexible are of high importance.

Against this background, it would be of interest to explore whether an asymmetric impact of energy price fluctuations exists. The risk of inflationary pressures emerging from second-round wage effects is particularly likely when institutional mechanisms, such as wage indexation, enforce downward real wage rigidities. These rigidities would then feed into an asymmetric reaction of consumer prices. However, unfortunately, the set-up of most macroeconometric models does not allow an assessment of this issue.

Results from an oil price scenario using the available DSGE models in the Eurosystem are presented in Table 16. Results are shown from the NAWM for the euro area, the Aino model of Suomen Pankki – Finlands Bank, Banco de España's BEMOD model and a calibrated DSGE model of the Deutsche Bundesbank. Since agents in these models react to future policy actions, the specification of the monetary policy reaction is crucial. Here we report only results of DSGE models in which the policy rules are kept active. Furthermore, the exchange rate and world demand and prices (except for the Finnish model in both cases) also react to the shock.[85]

85 All the models include a direct link between imported prices of oil and domestic demand prices, in the form of shares of oil in demand components. Excise taxes also play a role in the models. All the models, except the NAWM, also included some supply-side effect in that firms use oil in production. The elasticity of substitution is either calibrated to different values or imprecisely estimated, which may explain some of the differences in the results. Last but not least, the way the shocks were implemented also differed across models to some extent. The German model simulates a 10% increase on impact, generated through a shock to global oil demand, with a dampening down effect afterwards.

Table 16 Effect of a 10% oil price increase on inflation (annual averages) according to DSGE models

(percentage deviation from baseline (cumulated))

	HICP			HICPX		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
DE	0.88	0.67	0.27	0.40	0.47	0.17
ES	0.20	0.23	0.25	-	-	-
FI	0.77	0.84	0.90	-0.03	0.05	0.14
Euro area	0.12	0.15	0.13	0.00	-0.01	-0.03

Source: Eurosystem staff calculations.
Note: The results for FI are based on a version of the Aino model including a Taylor rule.

Oil prices seem to have a much higher initial impact on HICP in the Finnish and German cases. The higher impact in the Finnish model may be explained by higher shares of oil use in that country, while the German results may depend more on the calibration of the model, in particular the low calibration for the elasticity of substitution. While the oil price impact fades away in the German model, the Finnish model suggests an increasing impact over time. By contrast, the models for Spain and the euro area suggest a smaller initial impact compared with traditional models with relative little dynamics, which is attributable to the monetary policy reaction. The models for Germany and Finland show notable indirect/second-round effects while, in the model for the euro area, the central bank reaction counteracts these effects.

Box 6

MONETARY POLICY RESPONSE TO ENERGY PRICE CHANGES AND THE ROLE OF INFLATION EXPECTATIONS

Given that energy price fluctuations can have substantial impacts on output and inflation, they call for an appropriate monetary policy response that aims to maintain price stability over the medium term. In doing so, monetary policy takes into account the nature of energy price movements that can be temporary or reflect more persistent, structural developments in energy markets, as well as their impact on the formation of inflation expectations.

As transitory energy price disturbances mainly entail short-run changes in headline inflation, a medium-term oriented monetary authority looks through the short-term volatility of headline inflation and does not attempt to fine-tune price and economic developments. In fact, according to the standard view on the transmission mechanism, monetary policy affects the economy with variable and uncertain lags and therefore any action implemented to undo the direct and immediate impact of energy price rises on headline inflation can at best be vain and, most likely, harmful, as it would become effective only when the temporary inflationary impact has already faded away.

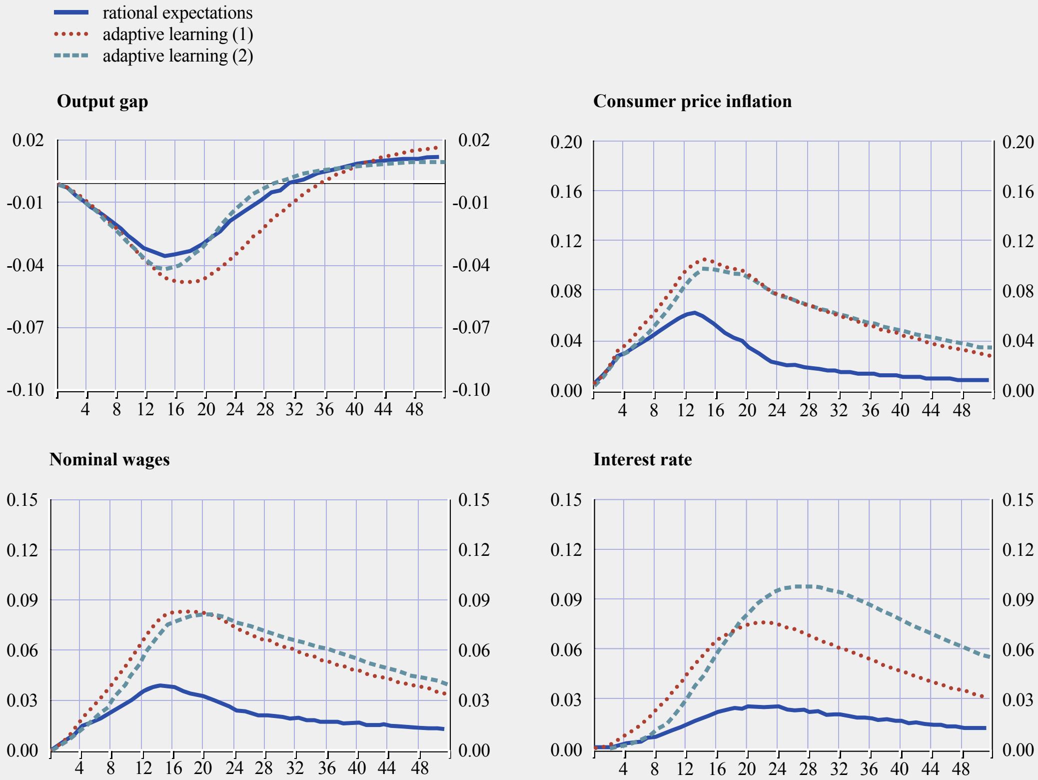
A more aggressive monetary policy response is however needed when there are clear signs of second-round effects on prices. Wage and price indexation, strong bargaining power on the worker side or high pricing power of firms, are features of an economy that make the impact of transitory energy price increases on inflation more persistent. They largely reflect the individually rational behaviour of economic agents attempting to reduce the impact of energy price rises on their real incomes by exerting upward pressures on nominal wages and profit margins. Collectively such behaviour eventually generates inflationary pressures, makes the task of monetary policy more challenging and delays the necessary adjustment on the real side of the economy.

Recurring energy price rises are also challenging from a monetary policy perspective as they can lead to a permanent upward shift in energy inflation. In general, permanent shocks produce a larger effect on the real economy and a permanent change in relative prices calls for sizeable sectoral reallocation. On the nominal side of the economy, the new equilibrium allocation would require a stronger correction of wages and profits. In such an economic environment, maintaining price stability entails a monetary policy stance that appropriately counterbalances the permanent effect on inflation over the medium term.

The monetary policy response must be tailored to the structure of the domestic economy and, in particular, take into account the strength of the second-round effects on headline inflation. In this respect, the solid anchoring of medium to longer-term inflation expectations is pivotal to ensuring that price and wage developments remain "in sync" with the central bank's price stability objective.

Rational expectations versus adaptive learning: unexpected and temporary 10% increase in real oil prices, spread over a five-year period – Taylor rule policy

(euro area variables; deviation from initial steady state in percentages – time unit = quarter)



Source: Eurosystem staff calculations.
Notes: Learning simulations are computed under constant gain adaptive learning, assuming that the economy is initially at the steady state and that agents start their learning process with the true parameters of the economy. The gain parameter amounts to 0.001. The simulations labelled "adaptive learning (1)" assume that private agents only learn about the variables whose expectations matter. The simulations labelled "adaptive learning (2)" assume that private agents learn about all variables. See Darracq-Pariès and Moyen 2009.

Insufficiently solid anchoring of inflation expectations risks undermining the credibility of the central bank. Medium to longer-term inflation expectations can drift away from the central bank's objective when recurrent energy price increases exerting upward pressures on headline inflation tarnish the reputation of the central bank in fulfilling its mandate. This can happen, for example, if economic agents cannot fully assess whether the deviations from the price stability objective are attributable to the mechanical impact of energy price rises on inflation, or to a loose monetary policy stance. The additional risks to price stability stemming from individuals not having perfect knowledge can be analysed in models including further assumptions on the mechanisms of expectation formation. Under the assumption of adaptive learning, individuals have a limited amount of information on which to form their expectations about the future path of the economy. Their inflation forecasts are not rational and diverge from the central bank's view on the outlook for inflation. Learning dynamics are a source of additional sensitivity of the economy to energy price movements compared with conventional models with fully rational expectations. The chart illustrates how departures from the rational expectations paradigm could amplify the transmission of oil price changes throughout the economy, leading to pronounced underlying inflationary pressures and sizeable wage increases. In this case, a lower policy tolerance for inflation volatility may limit private forecast errors and contribute to the solid anchoring of inflation expectations.

3.4 CONCLUSION ON THE IMPACT OF ENERGY PRICES ON INFLATION

In terms of an overall summary, estimates of the energy price pass-through into inflation according to the various approaches outlined above are reported in Table 17. Notwithstanding the different underlying assumptions, caveats and estimation periods used, there are some relatively clear and consistent findings.

The *direct pass-through* of oil prices into pre-tax prices of liquid fuels is complete and quick (mainly within two to three weeks), and there is little evidence of asymmetry. Over time, oil prices and taxes have been the main driving forces behind price increases, whereas distribution and refining margins have remained relatively stable. Gas prices strongly co-move with oil prices mainly owing to the substitutability of these energy sources and institutional arrangements. The direct pass-through of gas price changes to consumer prices takes approximately six to nine months. The link between electricity prices and oil, evident for wholesale markets, largely disappears for consumer electricity prices given their administered nature and different input compositions. Even in countries where price regulation has been largely abolished,

Table 17 Summary and decomposition of impact of a 10% increase in oil prices on HICP using different approaches

Approach	Specification	Direct	Indirect	Second round	Total
Disaggregated energy components[1]	€20	0.15%	N/A	N/A	N/A
	€50	0.29%	N/A	N/A	N/A
Input-output tables[2]	country avg	0.22%	0.14%	N/A	0.36%
SVAR	71-09	0.20%	0.25%		0.45%
	71-00	0.39%	0.29%		0.68%
	80-09	0.16%	0.20%		0.36%
Macro models	wage reaction on	0.25%	0.20%		0.45%
	wage reaction off	0.26%	0.10%		0.36%

Source: Eurosystem staff calculations.
1) Pass-through is a function of price level – estimates calculated on the basis of constant refining and distribution costs and margins and indirect taxes.
2) Based on 2005 values (oil averaged €47/barrel). Implicitly assumes constant margins.

price adjustments remain relatively infrequent compared with fuels and gas. Owing to the full pass-through into pre-tax prices, and the broad constancy of margins and indirect taxes, the overall direct pass-through of oil prices into consumer energy prices is a function of the crude oil price level. At €20 per barrel pass-through to consumer energy prices is around 15%, at €50 per barrel it is around 30%. If oil prices were to increase to €100 per barrel, elasticity (assuming broadly constant refining and distribution margins and excise taxes) would rise to above 40%.

Price levels may vary across energy markets owing to taxes and cost structures, which may in turn be a function of energy policy itself. However, differences in competition and market concentration as well as the degree of vertical integration also undoubtedly have a role. In this regard, pre-tax price dispersion is generally more sizeable in electricity and gas markets compared with liquid fuel markets. However, there is evidence that liberalisation efforts have had a beneficial impact on price levels across the euro area. In this context, further reforms towards a more competitive environment creating a level playing field across the euro area would diminish price dispersion and benefit both consumers and firms.

The evidence on *indirect and second-round effects* of energy prices from the IOT analysis and from dynamic simulations of various model specifications gives an overall internally consistent picture. *At the producer level*, a 10% oil price increase leads to an increase in output prices in the manufacturing sector in the euro area, not only via the energy sector itself, but also through energy-intensive branches (chemicals and metals). The magnitude of the impact at the producer level is rather homogeneous across most countries, with the important exception of the Netherlands, where the high share of energy-intensive sectors in manufacturing output makes producer prices much more responsive to oil price fluctuations. Services prices may also be affected by energy shocks at the early stage of production, for example in the air transport sector as shown by the IOT analysis. *At the consumer level*, the prices of non-energy products respond to oil price shocks very gradually. The cumulated effect after three years of a 10% oil price increase is estimated to be 0.2%, half of which seems to be a second-round effect coming from the endogenous reaction of wages to energy price rises.[86] The overall (indirect and second-round) effect on non-energy consumer prices has also weakened over the past twenty years. Models in which expectations play a more substantial role (DSGE models) point to a somewhat milder reaction of core inflation to commodity prices. At the country level, there are important differences in the transmission of energy commodity surprises to non-energy consumer prices with impacts ranging from 0.1 to 0.5%. The role of second-round effects seems to be generally higher in countries that have automatic wage indexation schemes.

Overall, the pass-through of oil prices into consumer prices is complex and a function of many factors including the price level of oil, the amount of indirect taxation (excises), other structural aspects of the economy including the sector specialisation of activity, and wage and price-setting institutions. Indirect and second-round effects appear to have moderated compared with the 1970s and early 1980s owing, in part, to changes in economic structure but also, more importantly perhaps, to changes in monetary policy and wage and price-setting behaviour.

Ultimately, wage and price-setting behaviour and a credible monetary policy are the key determinants of whether inflationary pressures from energy prices translate into inflation over a medium-term horizon. Whilst there is little monetary policy can do about the first-round effects of energy price shocks, in particular international oil price changes, it can shape second-round effects. Monetary policy-making

86 An important caveat to this result is that it is obtained by switching off the wage channels of the macro models used at national central banks; the consequences of such a modification on the models' behaviour are unclear.

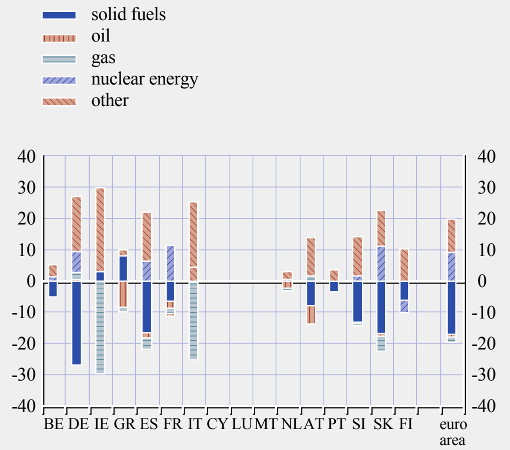
becomes more complicated if inflation expectations are unanchored by energy price changes. If the central bank is not credible, and energy price fluctuations strongly affect expectation formation, more drastic monetary policy action would be required to restore price stability, which would imply stronger output volatility in the short run. Thus, monetary policy best counteracts the price and output volatility induced by energy price fluctuations by implementing a credible medium-term-oriented monetary policy strategy stabilising inflation expectations.

ANNEXES

I DETAILED CROSS-COUNTRY CHARTS AND TABLES

Chart A1 Change in share of primary energy production by fuel

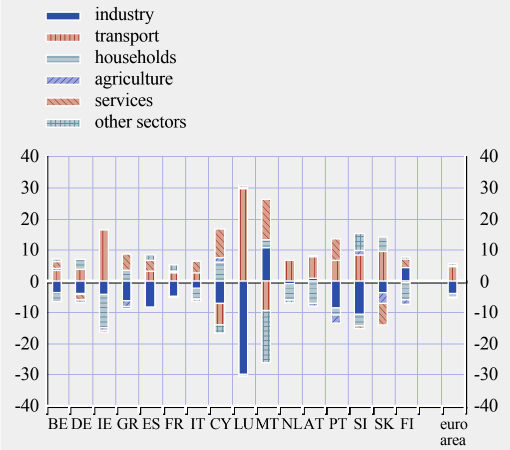
(percentage point variation in share of total – 1990 to 2007)



Sources: Eurostat and Eurosystem staff calculations.

Chart A3 Final energy consumption by sector

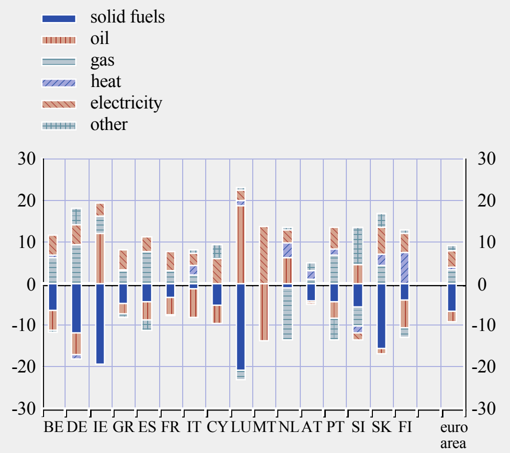
(percentage point variation in share of total – 1990 to 2007)



Sources: Eurostat and Eurosystem staff calculations.

Chart A2 Final inland consumption by product

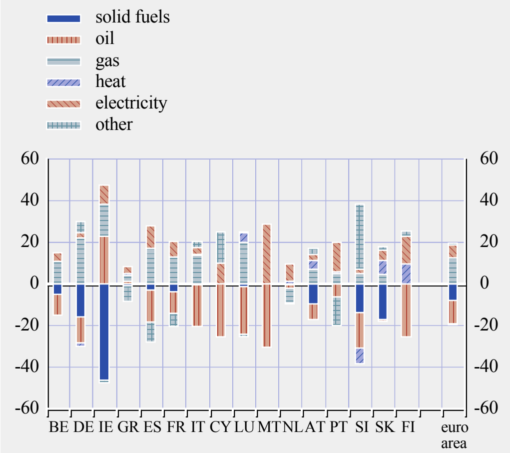
(percentage point variation in share of total – 1990 to 2007)



Sources: Eurostat and Eurosystem staff calculations.

Chart A4 Final energy consumption – households

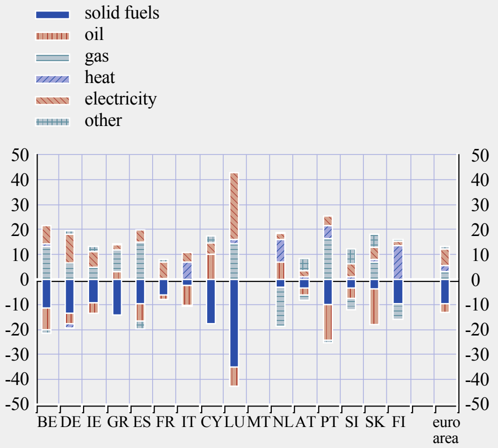
(percentage point variation in share of total – 1990 to 2007)



Sources: Eurostat and Eurosystem staff calculations.

Chart A5 Final energy consumption – industry

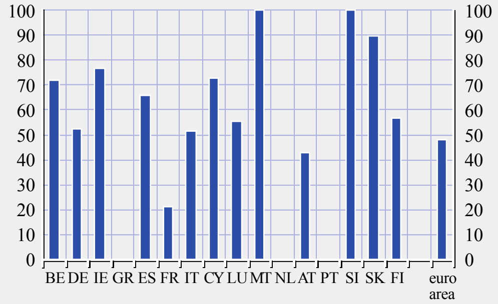
(percentage point variation in share of total – 1990 to 2007)



Sources: Eurostat and Eurosystem staff calculations.

Chart A7 Market share of the three largest companies (C3) in the liquid fuel distribution market in 2005

(percentages)



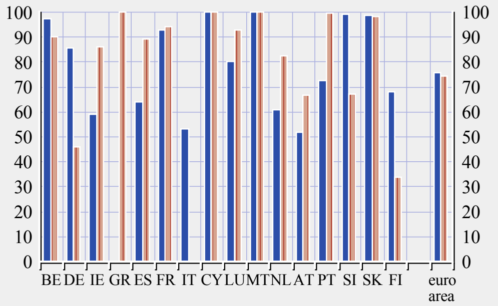
Sources: NCBs, from national sources.

Chart A6 Market share of the three largest companies (C3) in 2007 – country breakdown

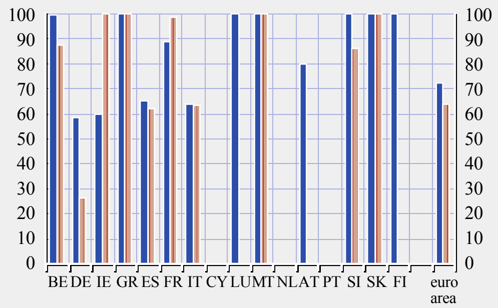
(percentages)

wholesale electricity market
retail electricity market

a) Electricity market

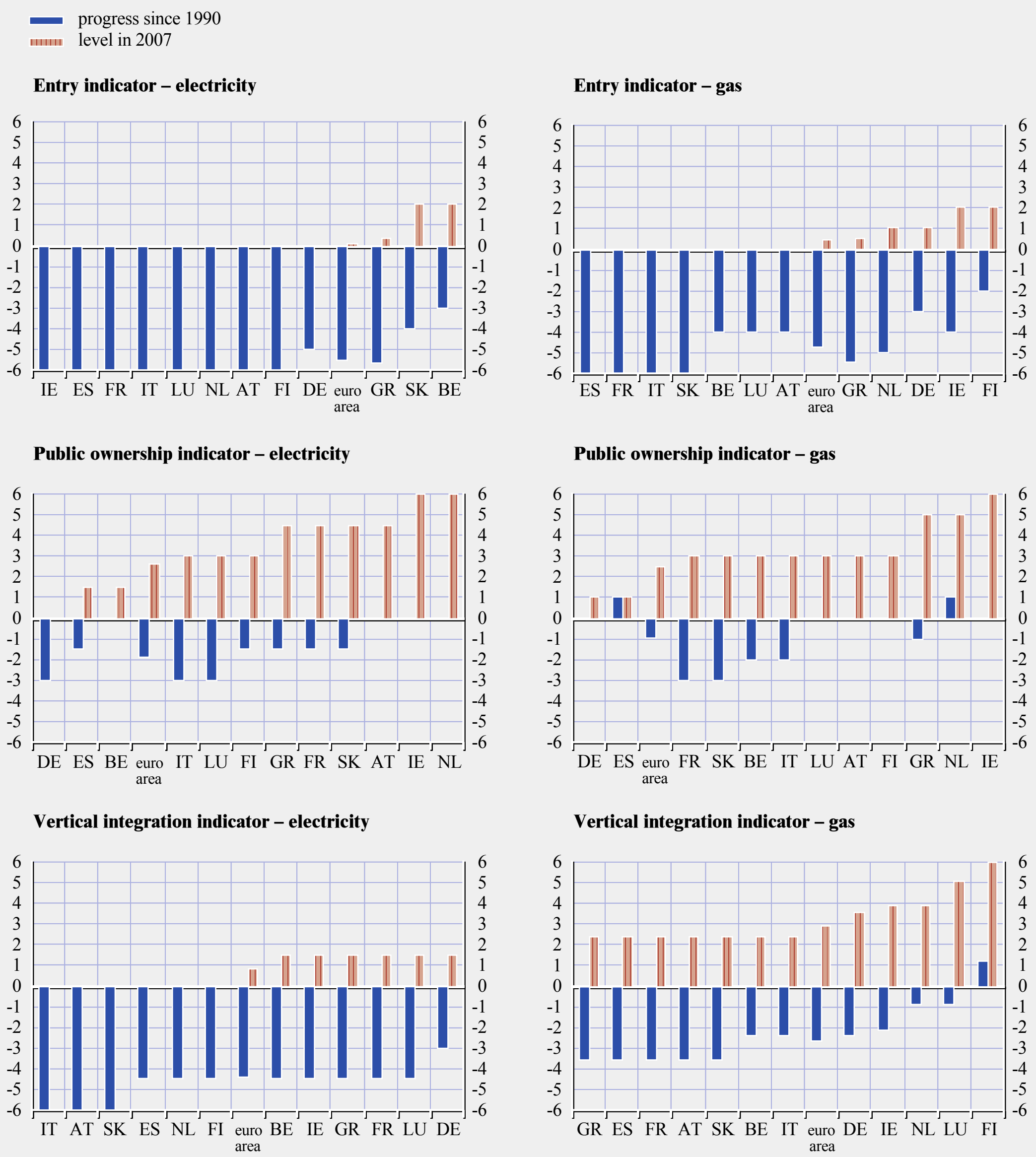


b) Gas market



Sources: NCBs, European Commission and Eurosystem staff calculations.

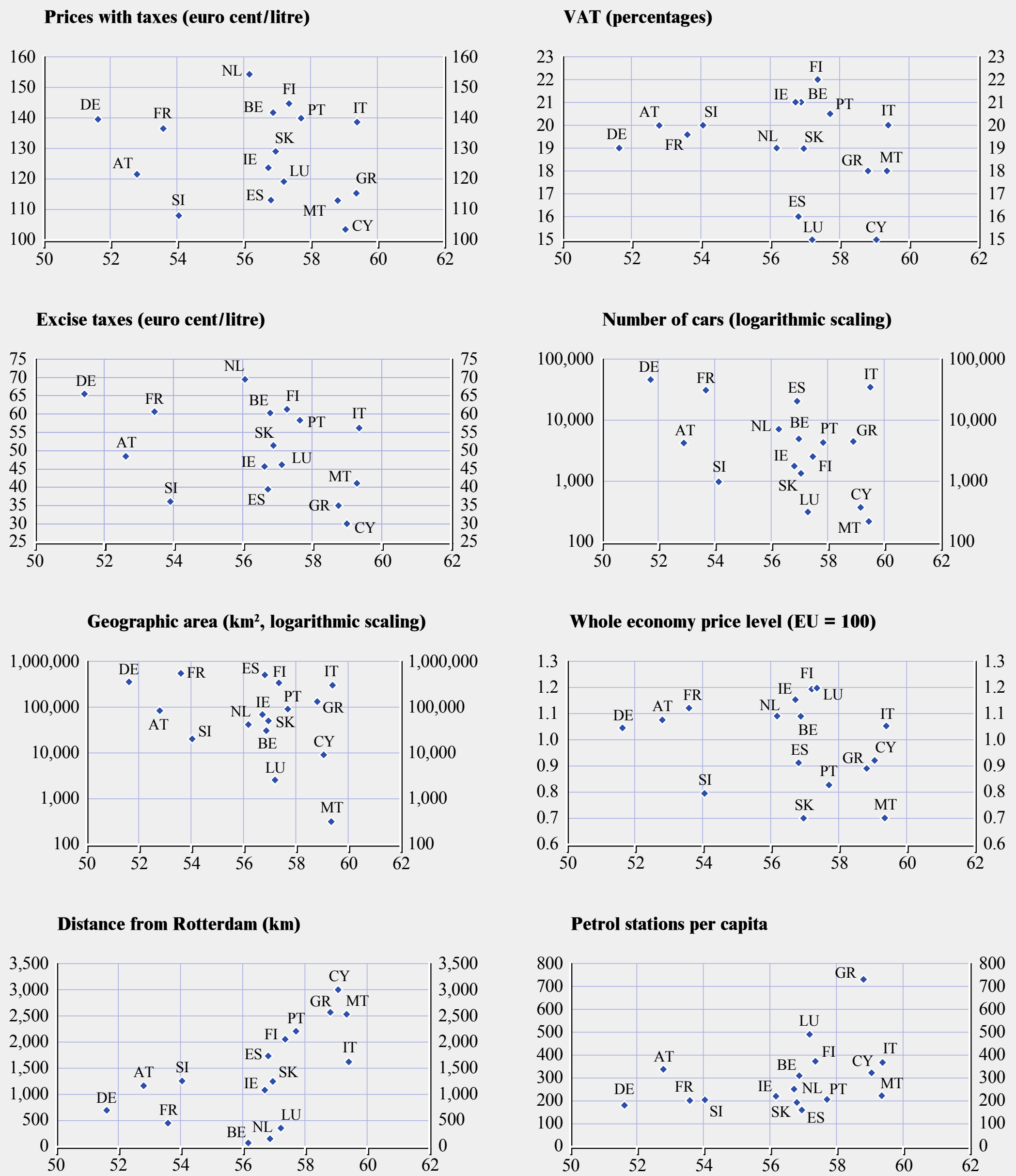
Chart A8 OECD regulation indicator sub-indices



Sources: OECD and Eurosystem staff calculations.
Notes: The indicators are measured on a scale of 0 to 6, reflecting the increasing restrictiveness of regulatory provisions on competition (see Conway and Nicoletti 2006) for more detail.

Chart A9 Cross-sectional charts – petrol

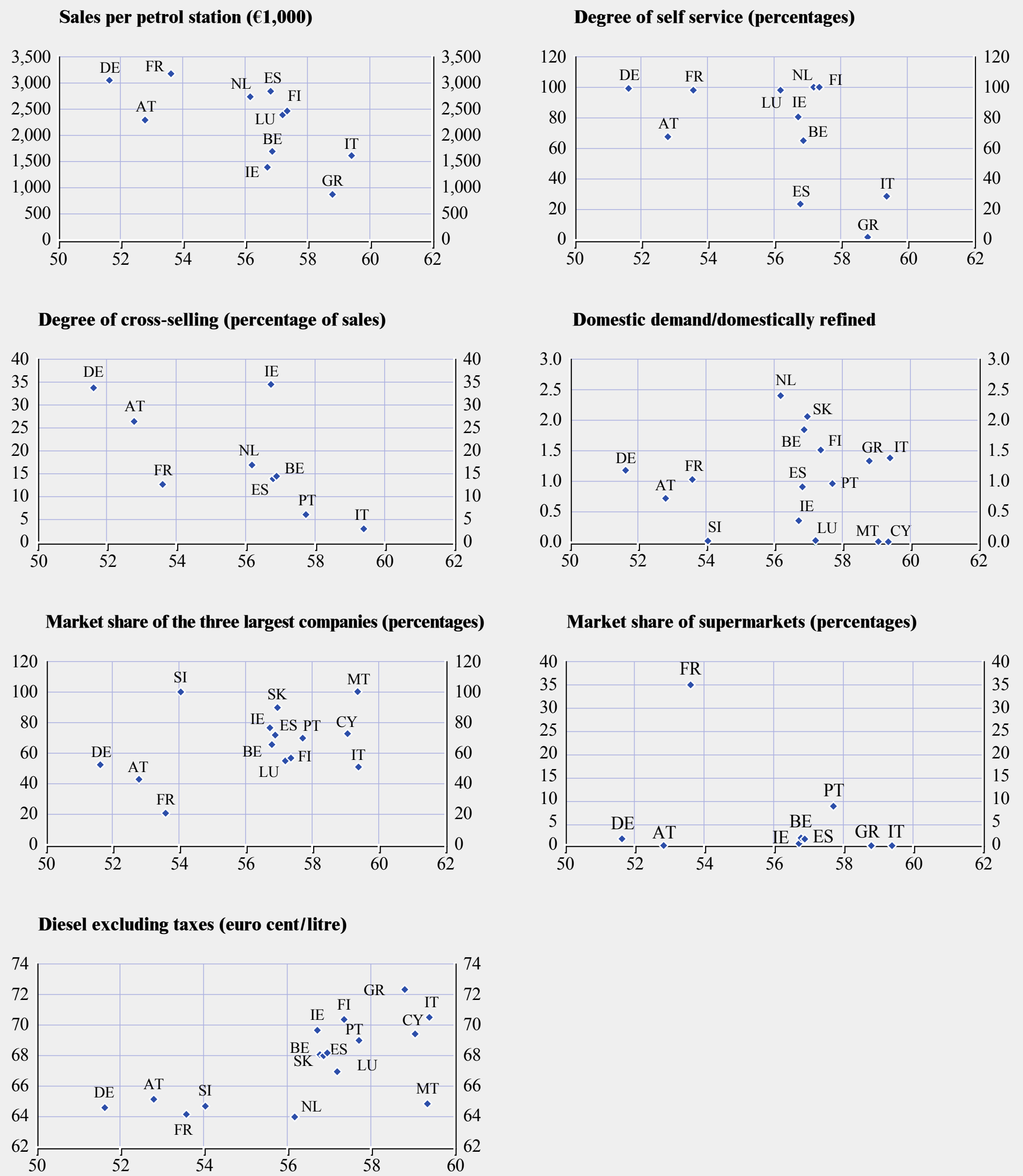
(x-axis: petrol, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer petrol prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Chart A9 Cross-sectional charts – petrol (cont'd)

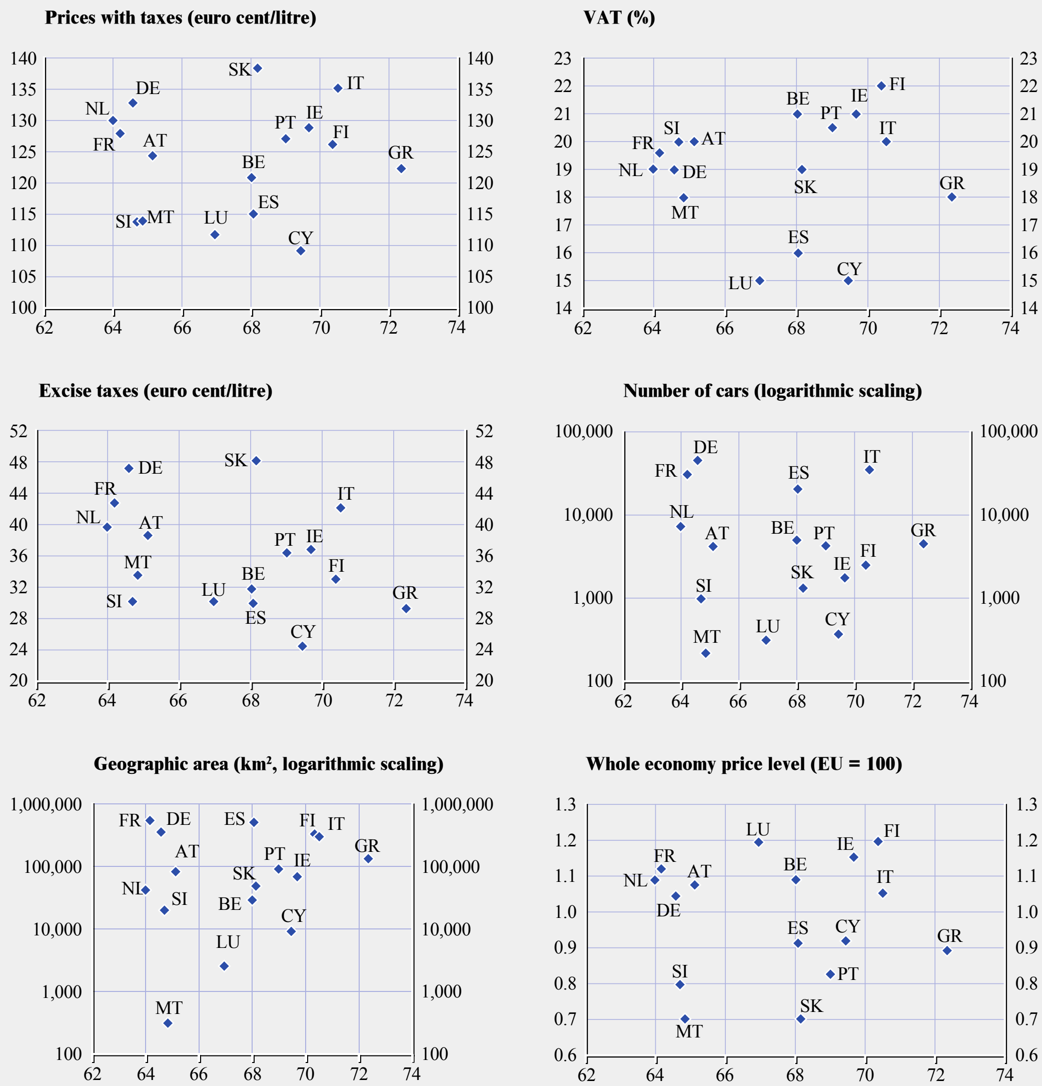
(x-axis: petrol, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer petrol prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Chart A10 Cross-sectional charts – diesel

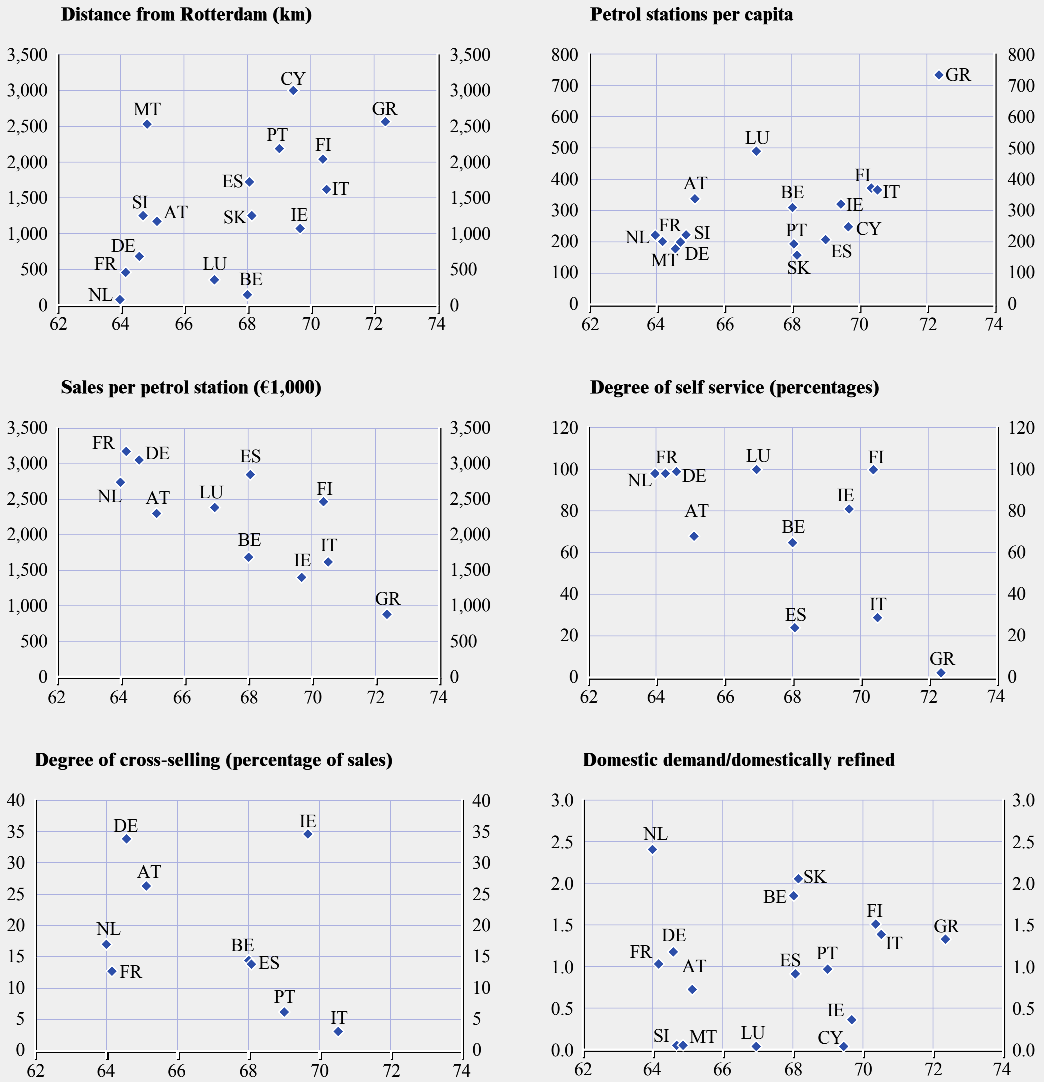
(x-axis: diesel, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer diesel prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Chart A10 Cross-sectional charts – diesel (cont'd)

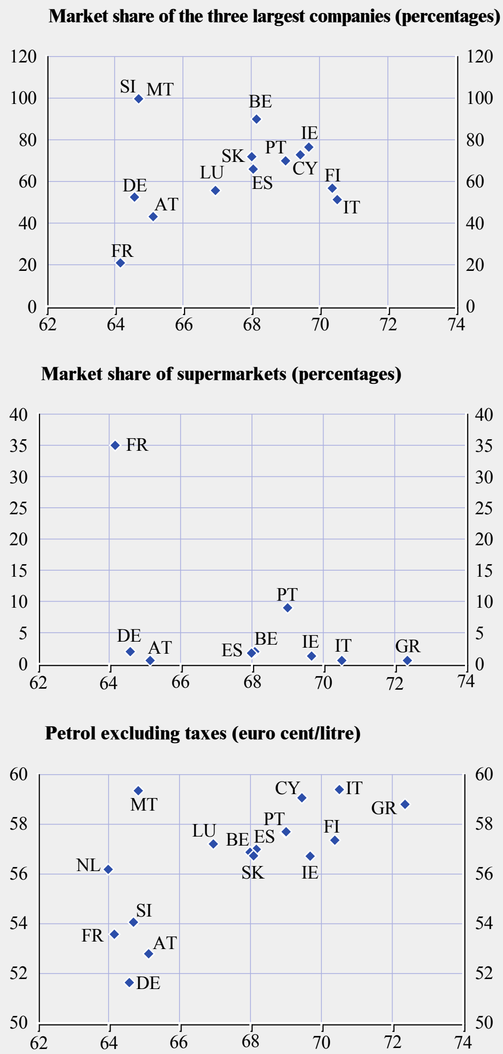
(x-axis: diesel, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer diesel prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Chart A10 Cross-sectional charts – diesel (cont'd)

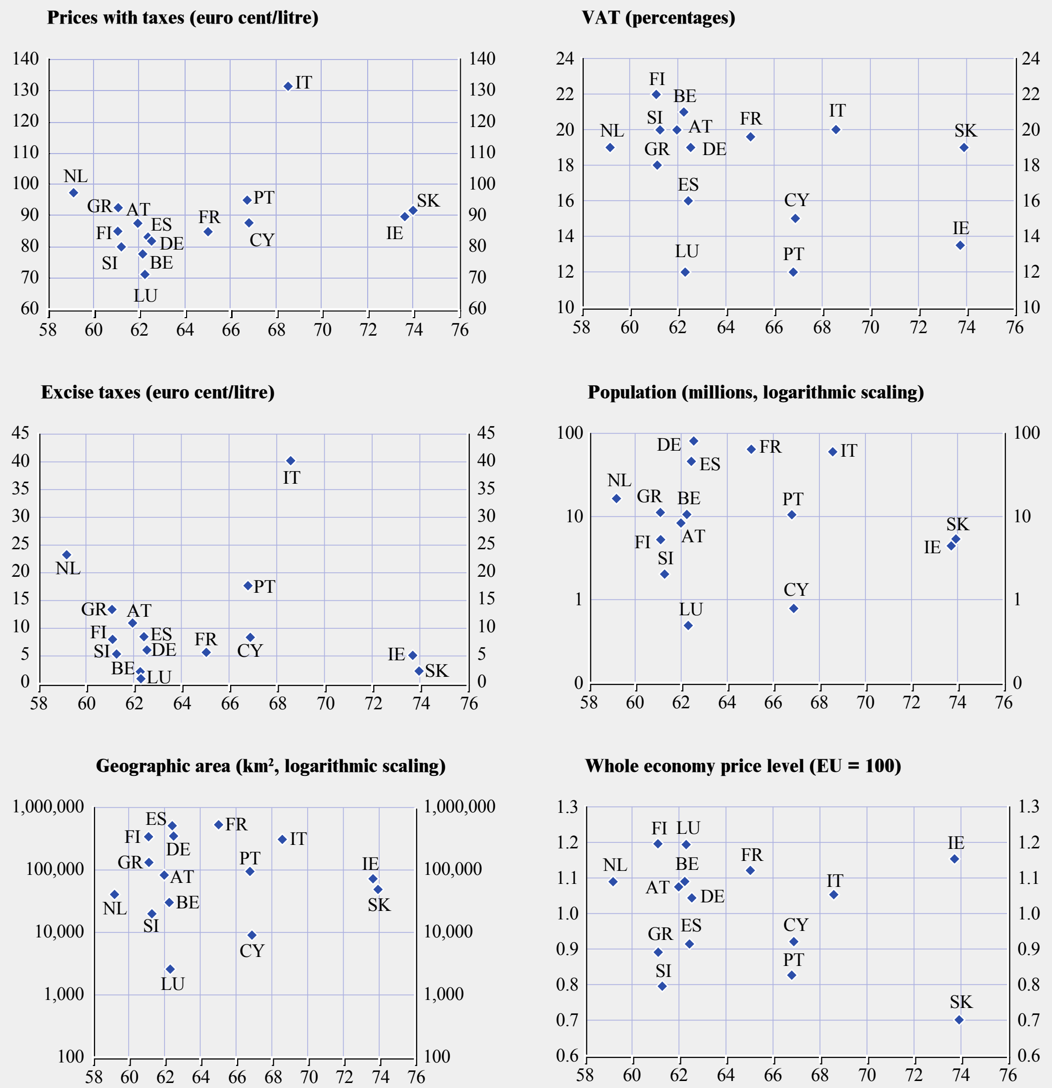
(x-axis: diesel, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer diesel prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Chart A11 Cross-sectional charts – heating fuel

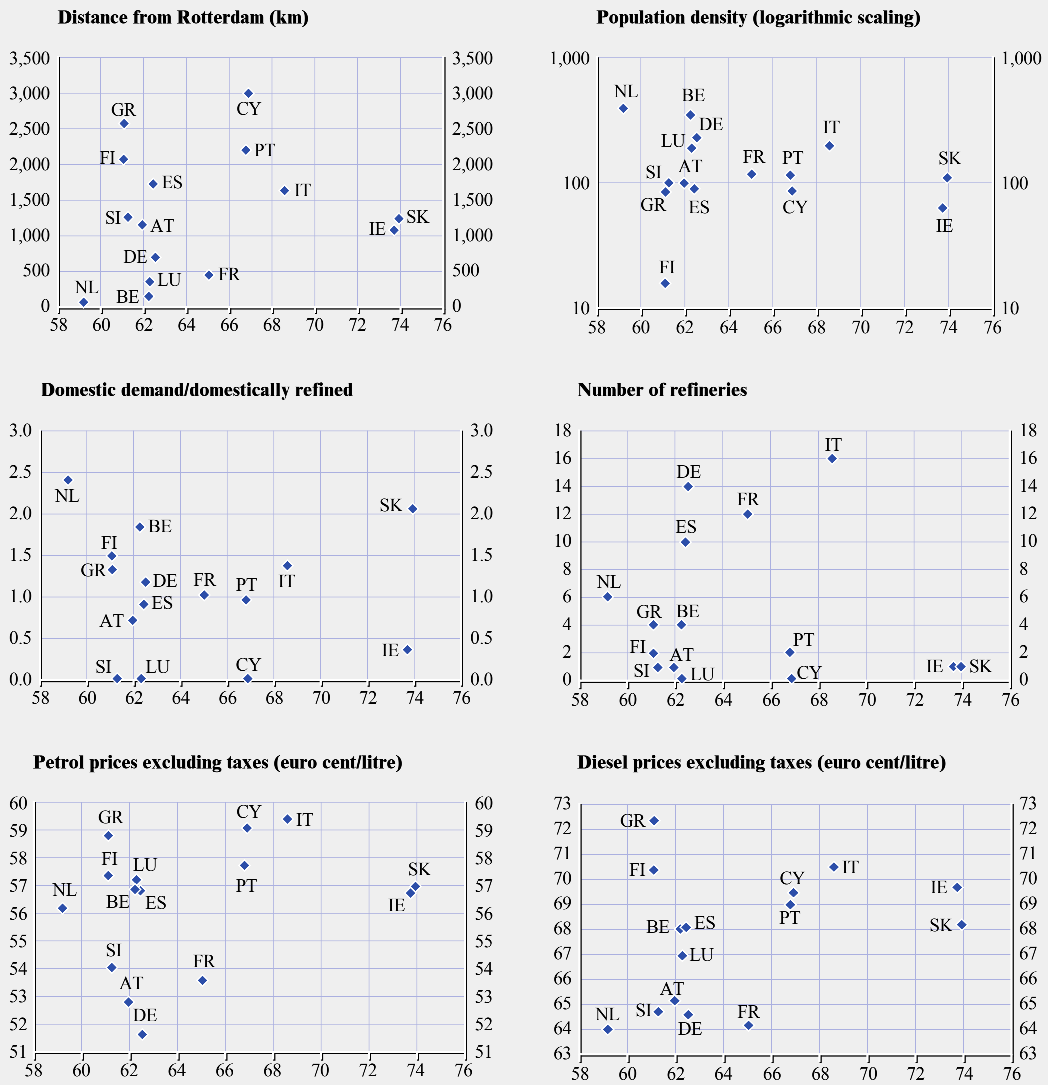
(x-axis: heating fuel, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer gas (heating) oil prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Chart A11 Cross-sectional charts – heating fuel (cont'd)

(x-axis: heating fuel, excluding taxes)



Sources: Eurostat, European Commission, various national sources and Eurosystem staff calculations.
Notes: Consumer gas (heating) oil prices (euro cent/litre), excluding taxes, in 2008 are shown on the horizontal axes. The variable shown on the vertical axes is given by the chart title.

Table A1 Overview of euro area electricity generation

	euro area	BE	DE	IE	GR	ES	FR	IT
Size (TWh) (2007)	**2,318,882**	**88,820**	**637,101**	**28,226**	**63,497**	**303,293**	**569,841**	**313,887**
Growth (1990-2007)								
Total	2.1	1.3	0.9	4.0	3.6	4.2	1.8	2.2
Nuclear	*1.2*	*0.7*	*-0.5*	*-*	*-*	*0.1*	*2.0*	*-*
Non-renew. conv. thermal	*2.2*	*1.7*	*0.3*	*3.7*	*3.4*	*5.8*	*1.1*	*2.2*
Renewables	*4.4*	*8.7*	*9.3*	*7.3*	*6.2*	*5.3*	*1.5*	*2.8*
Share (2007) (%)								
Nuclear	31	54	22	-	-	18	77	0
Non-renew. conv. thermal	52	40	62	89	92	61	10	83
Coal	*15*	*7*	*21*	*19*	*0*	*23*	*4*	*14*
Lignite	*10*	*-*	*26*	*8*	*55*	*1*	*0*	*0*
Oil	*4*	*1*	*2*	*7*	*15*	*6*	*1*	*11*
Gas	*22*	*29*	*12*	*55*	*22*	*31*	*4*	*55*
Other	*1*	*3*	*2*	*0*	*0*	*1*	*1*	*2*
Renewables	20	10	20	11	9	22	14	20
Hydro	*10*	*2*	*4*	*4*	*5*	*10*	*11*	*12*
Wind	*4*	*1*	*6*	*7*	*3*	*9*	*1*	*1*
Other	*6*	*7*	*10*	*1*	*1*	*3*	*2*	*6*
Gross trade flows (2007)[1]	**19**	**28**	**17**	**5**	**13**	**8**	**14**	**16**
Net imports (1990-2007)[1]	**1**	**5**	**0**	**2**	**3**	**1**	**-12**	**16**
Inter-trading (2007)[1), 2)]	**9**	**10**	**7**	**0**	**3**	**3**	**2**	**1**

Sources: Eurostat and Eurosystem staff calculations.
1) As a percentage of total final inland consumption of electricity.
2) Measures offsetting imports and exports; calculated as the minimum of either imports or exports.

Table A1 Overview of euro area electricity generation (cont'd)

	CY	LU	MT	NL	AT	PT	SI	SK	FI
Size (TWh) (2007)	**4,871**	**4,001**	**2,296**	**103,241**	**63,430**	**47,253**	**15,043**	**28,056**	**81,249**
Growth (1990-2007)									
Total	5.5	6.5	4.4	2.1	1.4	3.0	1.1	0.9	2.4
Nuclear	*-*	*-*	*-*	*1.1*	*-*	*-*	*1.2*	*1.4*	*1.2*
Non-renew. conv. thermal	*5.5*	*10.7*	*4.4*	*1.7*	*0.8*	*3.0*	*1.2*	*-1.3*	*3.3*
Renewables	*-*	*1.7*	*-*	*11.8*	*2.0*	*3.4*	*1.0*	*4.8*	*3.1*
Share (2007) (%)									
Nuclear	-	-	-	4	-	-	38	55	29
Non-renew. conv. thermal	0	72	0	87	30	64	40	27	41
Coal	*-*	*-*	*-*	*24*	*10*	*26*	*4*	*10*	*17*
Lignite	*-*	*-*	*-*	*-*	*0*	*-*	*33*	*7*	*9*
Oil	*-*	*0*	*-*	*2*	*2*	*10*	*0*	*3*	*1*
Gas	*-*	*72*	*-*	*57*	*16*	*28*	*3*	*6*	*13*
Other	*0*	*0*	*0*	*4*	*3*	*0*	*0*	*2*	*1*
Renewables	0	30	0	14	76	40	23	20	42
Hydro	*-*	*23*	*-*	*0*	*61*	*22*	*22*	*16*	*17*
Wind	*0*	*2*	*0*	*3*	*3*	*9*	*-*	*0*	*0*
Other	*0*	*6*	*-*	*11*	*13*	*9*	*2*	*4*	*25*
Gross trade flows (2007)[1]	**0**	**243**	**0**	**28**	**59**	**25**	**80**	**91**	**22**
Net imports (1990-2007)[1]	**0**	**293**	**0**	**16**	**2**	**5**	**-9**	**3**	**13**
Inter-trading (2007)[1), 2)]	**0**	**72**	**0**	**5**	**24**	**5**	**39**	**42**	**4**

Sources: Eurostat and Eurosystem staff calculations.
1) As a percentage of total final inland consumption of electricity.
2) Measures offsetting imports and exports; calculated as the minimum of either imports or exports.

Table A2 Estimated future energy trends, baseline and policy action scenarios

			European Commission (DG-TREN, 2008)				IEA (2009)			
			Baseline scenario		Action scenario		Reference scenario		450 scenario	
	2005		2020		2020		2020		2020	
	Index	Share	Index	Share	Index	Share	Index	Share	Index	Share
Primary energy demand	**100**	**100**	**105-109**	**100**	**92-95**	**100**	**95**	**100**	**92**	**100**
Oil	100	37	97-105	34-36	85-91	34-36	84	32	77	31
Gas	100	25	100-113	23-26	78-90	21-23	104	27	96	26
Solids	100	18	106-107	17-18	68-79	13-15	81	15	64	12
Renewables	100	7	160-180	10-12	220-223	16-16	196	14	217	16
Nuclear	100	14	86-97	11-13	85-91	13-14	79	12	100	15
Final energy demand	**100**	**100**	**111-116**	**100**	**98-102**	**100**	**107**	**100**	**103**	**100**
Industry	100	28	110-114	27-28	105-109	30-30	93	24	91	25
Residential	100	26	104-109	25-25	89-92	24-24	126	48	123	49
Tertiary	100	15	111-118	15-15	89-92	14-14				
Transport	100	31	117-121	33-33	104-108	33-33	96	28	86	26
Other										
Oil	100	42	101-110	39-40	88-94	38-39	102	40	93	38
Gas	100	25	100-109	22-23	82-89	21-22	100	23	95	23
Solids	100	5	104-106	4-4	94-94	4-4	58	2	53	2
Electricity	100	20	127-127	22-23	108-109	22-23	113	21	112	22
Heat	100	4	107-112	3-3	100-100	3-4	159	5	151	5
Other	100	5	162-191	7-8	213-220	10-11	182	8	204	9
Electricity generation	100	100	124-125	100	105-107	100	110	100	109	100
Nuclear	100	30	87-98	21-24	85-91	25-26	77	22	99	28
Renewables	100	15	169-182	20-22	223-224	31-32	211	29	230	31
Fossil fuels	100	55	123-133	54-59	83-84	43-44	100	50	81	41
CO2 energy emiss.	98	-	98-105	-	78-80	-	88	-	77	-

	Index	%	Index	%	Index	%
Dependence	**100**	**52.1**	**116-123**	**61-64**	**107-112**	**56-59**
Oil	100	81.6	113-114	93-93	112-113	92-92
Gas	100	57.7	129-134	75-77	123-127	71-73
Solids	100	39.2	145-149	57-59	125-128	49-50

Sources: European Commission, IEA and Eurosystem staff calculations.
Notes: Dependence is defined as net imports as a percentage of total gross inland consumption. In the European Commission projections, the baseline scenario includes trends and policies implemented up to the end of 2006 and the action scenario assumes implementation of new policies to reach energy and climate targets. In the IEA projections, the reference scenario describes what would happen if governments take no new initiatives beyond those already adopted by mid-2009 and the 450 scenario assumes governments adopt commitments and policies to limit the long-term concentration of greenhouse gases in the atmosphere to 450 parts per million of carbon dioxide equivalent.

Table A3 HICP weights

(2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
HICP excl. energy	90.4	89.1	88.3	91.2	92.7	89.6	91.9	92.2	88.0	89.1	93.5	89.8	92.2	89.1	88.4	83.7	92.9
Energy	9.6	10.9	11.7	8.8	7.3	10.4	8.1	7.8	12.0	10.9	6.5	10.2	7.8	10.9	11.6	16.3	7.1
Liquid fuels	4.7	4.7	4.6	4.8	5.8	6.5	4.4	4.0	7.9	8.5	4.0	4.1	3.9	5.8	7.0	2.4	4.8
Transport	4.0	3.6	3.7	3.9	3.6	6.0	3.7	3.3	7.0	7.7	4.0	4.1	3.3	5.6	5.5	2.4	4.3
Home heating	0.7	1.1	1.0	0.9	2.1	0.5	0.7	0.7	0.8	0.8	0.0	0.0	0.6	0.2	1.5	0.0	0.5

Sources: Eurostat and Eurosystem staff calculations.

Table A4 Annual average rates of change

(percentages; 1996-2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	2.0	2.0	1.5	2.8	3.8	2.9	1.7	2.4	2.7	2.3	2.8	2.2	1.7	2.6	6.0	6.0	1.7
HICP excl. energy	1.8	1.7	1.2	2.7	3.8	2.8	1.6	2.4	2.3	2.2	2.6	1.8	1.5	2.6	4.4	4.8	1.5
Energy	3.9	4.5	4.6	4.8	4.1	3.6	3.1	3.2	7.1	4.6	6.7	5.9	3.5	3.6	6.7	13.8	4.0
Liquid fuels	4.6	6.2	5.1	4.9	4.7	4.6	4.3	3.2	7.2	5.9	6.2	4.2	4.7	4.6	6.9	5.2	4.4
Transport	3.9	4.4	4.2	4.4	4.4	4.3	3.7	2.9	6.5	4.8	6.2	4.2	3.9	4.6	6.8	5.1	3.8
Home heating	8.5	12.6	10.3	8.2	6.5	8.6	8.1	4.4	12.2	11.4	-	-	8.9	-	8.7	-	10.3

Sources: Eurostat and Eurosystem staff calculations.

Table A5 Standard deviation of month-on-month rates of change

(percentage points; 1996-2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	0.3	0.8	0.4	0.5	1.2	0.5	0.3	0.4	1.1	0.6	1.4	0.5	0.3	0.4	0.5	0.9	0.4
HICP excl. energy	0.3	0.9	0.4	0.5	1.3	0.5	0.2	0.5	1.2	0.6	1.4	0.6	0.3	0.4	0.5	0.5	0.3
Energy	1.5	2.1	1.7	1.8	2.8	1.8	1.6	1.2	2.7	3.0	2.3	2.0	1.7	1.3	2.4	3.7	2.2
Liquid fuels	2.7	3.8	3.4	3.2	3.7	2.8	2.7	2.0	3.3	3.8	2.9	2.7	3.1	2.3	3.7	3.0	3.3
Transport	2.4	2.8	3.0	2.9	3.4	2.7	2.4	2.0	3.1	3.5	2.9	2.7	2.9	2.3	3.5	3.0	3.1
Home heating	4.9	7.1	6.6	5.3	6.7	4.6	5.1	2.2	5.8	7.1	-	-	4.8	-	5.7	-	6.9

Sources: Eurostat and Eurosystem staff calculations.

Table A6 Frequency of change in index

(percentages; 1996-2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	89	95	90	90	98	93	91	90	98	93	94	95	91	94	97	94	91
HICP excl. energy	98	99	86	91	99	98	99	91	99	98	99	100	98	99	100	100	99
Energy	100	100	98	95	99	100	100	94	99	99	35	99	99	96	100	95	100
Liquid fuels	100	99	98	98	99	100	100	94	57	91	31	99	99	69	100	91	100
Transport	98	99	96	94	99	99	97	96	57	91	30	99	98	69	97	91	98
Home heating	99	98	98	98	60	99	100	96	43	85	-	-	100	-	97	-	98

Sources: Eurostat and Eurosystem staff calculations.

Table A7 HICP weights

(2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
HICP excl. energy	90.4	89.1	88.3	91.2	92.7	89.6	91.9	92.2	88.0	89.1	93.5	89.8	92.2	89.1	88.4	83.7	92.9
Energy	9.6	10.9	11.7	8.8	7.3	10.4	8.1	7.8	12.0	10.9	6.5	10.2	7.8	10.9	11.6	16.3	7.1
Non-oil	4.8	6.2	7.0	4.0	1.5	3.9	3.7	3.8	4.2	2.5	2.5	6.2	3.9	5.1	4.6	13.9	2.3
Gas	1.8	3.0	2.0	1.0	0.1	1.3	1.4	2.4	0.6	1.0	0.3	4.1	0.8	1.6	0.9	4.0	0.0
Electricity	2.3	3.1	3.1	2.1	1.2	2.6	2.1	1.3	3.4	1.3	2.2	2.0	1.9	3.4	2.3	4.5	2.2
Heat energy	0.6	0.0	1.8	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.6	0.0	0.8	4.9	0.1
Solid	0.1	0.1	0.1	1.0	0.3	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.6	0.1	0.7	0.4	0.0

Sources: Eurostat and Eurosystem staff calculations.

Table A8 Annual average rates of change

(percentages; 1996-2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	2.0	2.0	1.5	2.8	3.8	2.9	1.7	2.4	2.7	2.3	2.8	2.2	1.7	2.6	6.0	6.0	1.7
HICP excl. energy	1.8	1.7	1.2	2.7	3.8	2.8	1.6	2.4	2.3	2.2	2.6	1.8	1.5	2.6	4.4	4.8	1.5
Energy	3.9	4.5	4.6	4.8	4.1	3.6	3.1	3.2	7.1	4.6	6.7	5.9	3.5	3.6	6.7	13.8	4.0
Non-oil	3.5	3.3	4.4	5.4	2.6	1.9	1.7	3.3	7.1	3.5	7.3	7.4	2.6	2.6	6.6	16.5	4.0
Gas	5.5	6.2	6.2	6.4	5.6	4.5	5.2	4.1	9.1	5.9	5.6	8.7	4.6	6.1	10.1	18.1	-
Electricity	1.8	1.7	2.8	5.2	2.2	0.8	-0.3	2.3	7.7	2.5	7.8	5.5	2.1	1.5	5.3	16.5	3.8
Heat energy	5.8	-	6.2	5.4	-	-	4.4	-	-	8.0	-	-	2.3	-	10.1	15.9	4.7
Solid	2.5	1.5	1.7	5.3	4.6	-	2.3	-	0.6	1.1	-	-	2.6	0.5	7.0	8.9	7.3

Sources: Eurostat and Eurosystem staff calculations.

Table A9 Standard deviation of month-on-month rates of change

(percentage points; 1996-2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	0.3	0.8	0.4	0.5	1.2	0.5	0.3	0.4	1.1	0.6	1.4	0.5	0.3	0.4	0.5	0.9	0.4
HICP excl. energy	0.3	0.9	0.4	0.5	1.3	0.5	0.2	0.5	1.2	0.6	1.4	0.6	0.3	0.4	0.5	0.5	0.3
Energy	1.5	2.1	1.7	1.8	2.8	1.8	1.6	1.2	2.7	3.0	2.3	2.0	1.7	1.3	2.4	3.7	2.2
Non-oil	0.7	1.4	0.9	1.5	1.1	1.1	0.7	1.2	2.9	1.1	3.6	2.5	0.9	0.7	1.1	4.6	0.9
Gas	1.3	2.5	1.8	3.7	0.8	2.7	1.7	1.2	3.8	2.4	3.0	3.1	1.9	1.2	2.2	6.6	-
Electricity	0.6	1.1	1.2	2.2	1.3	0.9	0.4	1.5	3.5	1.4	4.4	2.7	1.1	0.9	1.6	6.0	0.9
Heat energy	0.9	-	0.8	1.4	-	-	7.8	-	-	1.8	-	-	0.6	-	2.8	4.8	1.6
Solid	0.5	1.1	0.3	1.2	0.6	-	0.4	-	0.7	1.0	-	-	1.0	1.9	2.4	1.0	5.1

Sources: Eurostat and Eurosystem staff calculations.

Table A10 Frequency of change in index

(percentages; 1996-2009)

	euro area	BE	DE	IE	GR	ES	FR	IT	CY	LU	MT	NL	AT	PT	SI	SK	FI
HICP	89	95	90	90	98	93	91	90	98	93	94	95	91	94	97	94	91
HICP excl. energy	98	99	86	91	99	98	99	91	99	98	99	100	98	99	100	100	99
Energy	100	100	98	95	99	100	100	94	99	99	35	99	99	96	100	95	100
Non-oil	100	99	86	50	98	48	90	80	99	94	27	52	96	95	100	83	87
Gas	91	92	83	45	96	46	80	82	37	80	23	37	45	77	92	59	-
Electricity	72	87	60	17	12	10	17	35	98	60	11	50	41	15	18	7	68
Heat energy	96	-	93	91	-	-	8	-	-	93	-	-	39	-	89	35	28
Solid	95	81	83	55	79	-	90	-	28	21	-	-	94	94	61	98	97

Sources: Eurostat and Eurosystem staff calculations.

Table A11 Key structural features of European transport fuel markets

	Stock of passenger cars (000s) 2006	Passenger cars per 1,000 capita 2006	1,000 passenger car km travelled per capita 2006	Number of petrol stations 2007	Petrol stations per (1,000,000) capita 2007	Sales per petrol station (€1,000) 2007
euro area	166,255	507	10.1	83,408	256	2,600
BE	4,976	468	10.4	3,295	310	1,689
DE	46,570	567	10.6	14,902	181	3,058
IE	1,779	401	6.6	1,092	251	1,400
GR	4,543	405	8.1	8,200	733	876
ES	20,637	453	7.7	8,668	193	2,848
FR	31,002	483	11.4	12,929	203	3,180
IT	35,297	589	11.8	21,879	368	1,618
CY	373	471	6.5	252	321	-
LU	315	645	14.8	235	490	2,385
MT	218	529	4.9	91	222	-
NL	7,230	440	9.1	3,610	220	2,743
AT	4,205	504	8.7	2,810	338	2,299
PT	4,290	404	6.8	2,200	207	-
SI	980	480	11.5	410	203	-
SK	1,334	247	4.8	860	159	-
FI	2,506	472	11.8	1,975	373	2,470

Sources: European Commission, various national sources and Eurosystem staff calculations.

Table A11 Key structural features of European transport fuel markets (cont'd)

	Share of self-service stations (%) 2007	Degree of cross-selling (% of sales) 2005	Number of refineries 2008	Share of demand covered by domestic refineries (%) 2005	Market share of the three largest companies (%) 2005	Share of supermarket retailers (%) 2007
euro area	72	18	74	122	49	8.8
BE	65	14	4	185	72	2.0
DE	99	34	14	118	53	2.0
IE	81	35	1	36	77	1.0
GR	1	-	4	133	-	0.3
ES	24	14	10	91	66	2.1
FR	98	13	12	103	21	35.0
IT	29	3	16	139	51	0.4
CY	-	-	0	0	73	-
LU	100	-	0	0	55	-
MT	-	-	0	0	100	-
NL	98	17	6	241	-	0.3
AT	68	26	1	72	43	0.0
PT	-	6	2	97	70	9.0
SI	-	-	1	0	100	-
SK	-	-	1	206	90	-
FI	100	-	2	151	57	-

Sources: European Commission, various national sources and Eurosystem staff calculations.

Table A12 Pass-through of refined gas oil prices into consumer prices (excl. taxes) for diesel and heating fuel (from models estimated over the period 2000-2009)

(euro cent)

	Diesel						Heating fuel					
	Week 1	Week 2	Week 3	Week 4	Week 8	Week 12	Week 1	Week 2	Week 3	Week 4	Week 8	Week 12
Euro area	**3.3**	***7.8***	***9.0***	**9.3**	**10.1**	**10.5**	**1.6**	***5.6***	**7.5**	**8.3**	**9.9**	**10.2**
BE	2.4	*8.1*	9.0	9.3	10.1	10.9	2.2	*7.9*	9.0	10.1	10.5	10.4
DE	4.1	9.1	9.8	9.5	10.0	10.5	1.5	*7.5*	9.4	9.5	11.2	11.0
IE	-0.3	3.0	4.5	*7.1*	8.8	9.9	0.1	-0.0	0.7	1.2	2.7	6.5
GR	1.0	*5.3*	8.1	9.9	10.9	11.9	1.1	*5.6*	8.2	9.1	10.7	10.3
ES	1.2	3.2	*6.9*	8.8	10.1	9.7	1.5	4.0	*5.8*	6.9	8.7	9.3
FR	2.6	*7.1*	8.8	9.3	10.0	10.4	1.7	*6.6*	8.7	9.6	10.9	11.1
IT	3.5	*6.5*	7.6	8.5	9.6	9.8	1.0	3.6	*5.9*	7.2	9.1	9.3
LU	2.1	*8.3*	10.1	10.1	10.4	10.4	1.7	*8.0*	9.9	9.9	11.3	11.1
NL	4.9	*8.9*	10.2	9.4	9.8	10.7	4.7	*9.2*	9.9	9.4	10.4	10.5
AT	3.0	*7.8*	9.3	9.6	9.6	9.8	1.3	*5.1*	7.0	8.0	9.7	9.8
PT	-0.1	0.9	3.4	*5.1*	5.9	6.4	-0.2	0.7	2.0	3.4	6.1	7.7
FI	4.0	*7.5*	7.5	8.2	10.5	10.5	3.7	*6.7*	5.2	5.2	8.6	8.5

Sources: Eurosystem staff calculations
Notes: Figures underlined and in italics denote 50% pass-through reached. Figures underlined denote 90% pass-through reached. Results on pass-through for the most recent members of the euro area (Cyprus, Malta, Slovenia and Slovakia) were not estimated as data are only available from 2005. The models used are described in Annex 2.4.

Table A13 Disaggregated prices for household consumers, 2008 H2

(consumer band Dc – annual consumption between 2,500 and 5,000 kWh)

	Composition of household prices in euro per 100 kWh				Share in price without tax (%)	
	Total price	Energy and supply	Network costs	Taxes and levies	Energy and supply	Network costs
Euro area	18.2	-	-	-	-	-
Euro area [1]	*19.8*	*8.5*	*5.1*	*6.1*	*63*	*37*
BE	20.8	9.0	6.9	3.6	56	44
DE	22.0	8.0	5.4	8.5	60	40
IE	20.3	-	-	-	-	-
GR	11.0	-	-	-	-	-
ES	15.6	8.9	3.8	2.8	70	30
FR	12.3	-	-	-	-	-
IT	22.0	11.1	4.9	5.4	70	30
CY	20.4	-	-	-	-	-
LU	15.6	6.2	7.5	1.9	45	55
MT	15.4	12.4	2.2	0.8	85	15
NL	17.8	-	-	-	-	-
AT	17.7	6.8	5.9	5.0	53	47
PT	15.3	7.0	4.0	4.3	64	36
SI	11.6	4.6	4.6	2.4	50	50
SK	15.3	6.5	6.3	2.4	51	49
FI	12.7	5.5	4.1	3.2	58	42

Source: European Commission (2009a), Eurostat and Eurosystem staff calculations.
1) Denotes euro area aggregate calculated on the basis of available country data (i.e. excluding Ireland, Greece, France, Cyprus and the Netherlands – approximately 25% of the euro area coverage). Italics denote Eurostat/Eurosystem estimates.

Table A14 Simulation results for the expenditure components of GDP

(percentage point deviation from baseline)

	Real private consumption			Investment			Employment		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Belgium	-0.04	-0.11	-0.12	-0.11	-0.45	-0.72	0.01	-0.04	-0.14
Germany	-0.31	-0.53	-0.60	-0.17	-0.31	-0.34	0.04	0.00	-0.06
Ireland	0.00	-0.09	-0.19	0.00	-0.07	-0.09	0.00	0.00	-0.01
Greece	-0.04	-0.11	-0.20	-0.26	-1.06	-2.31	-0.01	-0.05	-0.14
Spain	-0.06	-0.12	-0.21	-0.10	-0.43	-0.55	0.00	-0.15	-0.34
France	-0.04	-0.07	-0.10	-0.01	0.01	0.02	0.00	-0.01	-0.02
Italy	-0.09	-0.31	-0.40	-0.04	-0.21	-0.42	-0.01	-0.08	-0.16
Cyprus	-0.01	-0.06	-0.16	-0.02	-0.05	-0.07	0.00	-0.01	-0.02
Luxembourg	-0.01	-0.04	-0.08	0.00	-0.15	-0.24	0.00	0.00	-0.01
Malta	-0.12	-0.21	-0.14	-0.41	-0.93	-0.81	0.00	-0.17	-0.10
Netherlands	-0.03	-0.13	-0.15	-0.05	-0.19	-0.24	-0.01	-0.02	-0.01
Austria	-0.17	-0.19	-0.13	-0.08	-0.08	-0.02	-0.04	-0.05	-0.03
Portugal	-0.07	-0.13	-0.20	-0.09	-0.11	-0.17	-0.01	-0.03	-0.04
Slovenia	-0.11	-0.08	-0.13	0.40	-0.01	-0.20	0.01	-0.02	-0.06
Slovakia	-0.34	-0.42	-0.39	-0.05	-0.08	-0.07	-0.02	-0.04	-0.06
Weighted average	-0.14	-0.27	-0.33	-0.09	-0.24	-0.35	0.01	-0.04	-0.11
Minimum	-0.34	-0.53	-0.60	-0.41	-1.06	-2.31	-0.04	-0.17	-0.34
Maximum	0.00	-0.04	-0.08	0.40	0.01	0.02	0.04	0.00	-0.01

	Exports			Imports			Net exports		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Belgium	-0.08	-0.31	-0.46	-0.04	-0.18	-0.26	-0.04	-0.12	-0.14
Germany	-0.02	-0.07	-0.09	-0.18	-0.22	-0.24	0.07	0.05	0.06
Ireland	0.00	0.00	-0.01	0.01	-0.04	-0.10	-0.01	0.03	0.07
Greece	0.00	-0.04	-0.13	-0.19	-0.65	-1.24	0.07	0.18	0.14
Spain	-0.03	-0.14	-0.11	-0.11	0.12	0.00	0.03	-0.08	-0.04
France	-0.01	-0.03	-0.07	-0.06	-0.09	-0.10	0.02	0.02	0.01
Italy	0.00	-0.02	-0.05	-0.06	-0.17	-0.19	0.02	0.04	0.04
Cyprus	0.00	-0.03	-0.07	0.03	0.02	-0.04	-0.02	-0.02	-0.01
Luxembourg	0.00	-0.02	-0.04	-0.01	-0.04	-0.08	0.02	0.03	0.05
Malta	-0.21	-0.33	-0.35	-0.08	-0.38	-0.45	-0.11	0.13	0.07
Netherlands	-0.09	-0.15	-0.16	-0.10	-0.25	-0.26	0.00	0.06	0.04
Austria	0.00	-0.01	-0.01	-0.07	-0.06	-0.03	0.04	0.03	0.01
Portugal	-0.03	-0.13	-0.26	-0.06	-0.12	-0.17	0.02	0.01	-0.02
Slovenia	0.00	-0.03	0.00	0.04	-0.08	-0.10	-0.03	0.04	0.07
Slovakia	-0.07	-0.16	-0.23	-0.22	-0.34	-0.39	0.13	0.12	0.06
Weighted average	-0.03	-0.09	-0.12	-0.10	-0.15	-0.19	0.03	0.02	0.02
Minimum	-0.21	-0.33	-0.46	-0.22	-0.65	-1.24	-0.11	-0.12	-0.14
Maximum	0.00	0.00	0.00	0.04	0.12	0.00	0.13	0.18	0.14

Source: Eurosystem staff calculations.
Notes: The simulations assume exogenous monetary and fiscal policy. Beyond this, the models are not harmonised and can differ with respect to their size, estimation period and theoretical underpinning. For a more detailed discussion, see Section 2.2 and Fagan and Morgan (2005).

2 TECHNICAL ANNEXES

2.1 TECHNICAL ANNEX TO BOX 2: SECURITY OF ENERGY SUPPLY

Energy security is a multifaceted concept. In order to outline its various facets, this box makes use of a synthetic indicator, known as an energy security index, which incorporates information from a number of relevant variables. The indicator draws from and develops on the methodology proposed by Avedillo and Muñoz (2007). The variables used, and the reasons for choosing them, are as follows:

1. Degree of self-sufficiency of primary energies: it is assumed that greater control over energy resources provides greater assurance that the economy will keep functioning in the event of an interruption in supply. This variable is defined as the proportion of consumption covered by a country's primary energy production, that is:

   $$\frac{\text{primary energy production}_j}{\text{primary energy consumption}_j}$$

   where j is the euro area, each euro area Member State or the United States.

2. Reliability of imports: assuming equality in the share accounted for by primary energy production, the impact of an interruption in external supply is reduced by higher diversification of imports and by higher political stability of the supplying countries. The variable has been calculated by multiplying the share of each source in the supply of a given fuel (oil or gas) by the political security of that country:

   $$\left[\sum_i s_i g_i\right]^* g/M + \left[\sum_i s_i p_i\right]^* p/M$$

   where $s_i = 7 - r_i$ and r_i is the risk of each source country i with values between 0 and 7[87]; g_i is the proportion of gas imported by country j from country i; p_i is the proportion of crude oil imported by country j from country i; M=g+p.

3. Negotiating power in gas markets: sometimes an exporting country may be as dependent on its exports to a consumer country as vice versa, and this endows the latter with much negotiating power thereby reducing the risk of interruption in supply. This variable is defined as each country's share of the purchases from its main supplier of gas, since this fuel causes the greatest energy security conflicts in Europe:

   $$\frac{\text{natural gas exports}_i^j}{\text{total natural gas exports}_i}$$

   where i is the primary supplier of natural gas to country j.

4. Imports of liquefied natural gas : LNG imports afford the sector flexibility because they enable the importer to use different suppliers or import routes if the need arises. This variable consists of LNG imports as a proportion of total natural gas imports:

   $$\frac{\text{liquefied natural gas imports}_j}{\text{total natural gas imports}_j}$$

5. Degree of electrical connectivity: provides flexibility to the electricity sector in the event of unforeseen occurrences. It is calculated as imports plus exports as a fraction of electricity consumption:

   $$\frac{\text{electricity imports}_j + \text{electricity exports}_j}{\text{electricity consumption}_j}$$

6. Self-sufficiency in electricity generation: the vulnerability of the electricity system to international shocks decreases with increasing domestic electricity production.

87 For more details on the risk variable, see the country risk classifications available on the OECD's website at www.oecd.org

The variable is the proportion of total electricity that is produced with domestic energy (renewable and nuclear):

$$\frac{\text{electricity production with renewable and nuclear}_j}{\text{total electricity production}_j}$$

7. Degree of diversification of primary energies: diversification mitigates the vulnerability of energy systems by reducing the impact of a possible interruption in the supply of any of the raw materials in a country's energy basket. It is defined as one minus the Herfindahl index.

$$1-\sum_i e_i^2$$

where i is primary energy consumption (petroleum, natural gas, coal, nuclear and renewables).

The foregoing variables were calculated for the various Member States of the euro area and the United States. The euro area is measured in two different ways: first, assuming that it is an integrated single market and, therefore, subtracting energy exchanges within the area. The variable thus constructed is denoted "euro area (aggregated)". Second, the euro area is measured as a simple mean of the countries, denoted "euro area (average)". Owing to lack of information, the euro area is taken as being formed by the 16 countries currently composing it, less Cyprus, Luxembourg and Malta. For this reason, the period considered is 1993-2006. The sources used to construct these variables are Eurostat, the EIA and the OECD. These variables are represented in Charts A12 to A18.

As can be seen in the charts, the situation and behaviour of each country in respect of the different variables considered is fairly heterogeneous, although some general trends can be identified. Specifically, the degree of self-sufficiency in primary energies decreased over time as a result of consumption growing faster than production. In this respect, the situation of the euro area countries differs somewhat from that of the United States. However, in general, the euro area countries have increased the reliability of their imports, owing to the more stable socio-economic situation of their suppliers and to the replacement of some of these suppliers by countries with lower geopolitical risk. The negotiating power of the euro area countries in the gas market has not changed much, given that the source of the bulk of these countries' gas imports has, with some exceptions such as the Netherlands[88], remained the same. Similarly, the degree of electrical connectivity has also increased, although the growth in the flow of electricity between countries has taken place within the euro area, so this trend is not observed in the euro area in aggregate. LNG imports continue to be low, although they represent a substantial volume in Spain. The differences in the levels of self-sufficiency in electricity generation reflect the different national energy policies followed. Thus France, which clearly espouses nuclear energy, and Austria, which embraces renewable energies, are notable for their self-sufficiency in electricity generation. Ireland, however, has no nuclear power stations and generates little power from renewable sources. That said, the variability of this variable increases with the increasing weight of renewable energies. Since self-sufficiency in electricity generation is generally higher in the larger countries than in the smaller ones, the level for the aggregate euro area is higher than that for the average euro area. Moreover, this is one of the variables in which the euro area is less vulnerable than the United States. Finally, the degree of diversification of primary energy has increased in seven of the euro area countries but has fallen in Belgium and Ireland, the final result being very slight growth in the euro area as a whole. Chart A19 gives the energy security indices thus calculated for the United States and

88 For the Netherlands, this variable is higher than one because of intra-EU statistical discrepancies (the use of different methods for calculating the statistical value of dispatches – f.o.b. value – arrivals – c.i.f. value – and triangular trade). Nevertheless, the aggregated euro area variable is not affected by these discrepancies because its main supplier of gas is Russian.

the two definitions of the euro area. The figure for the aggregate euro area is higher than that for the average euro area because the structure for the euro area as a whole is more balanced than that of the Member States individually.

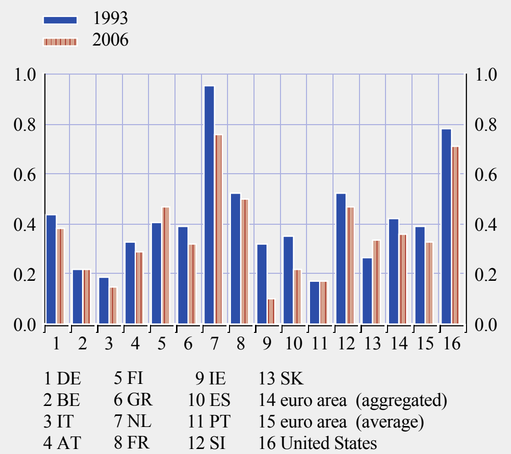
Principal factor analysis was used to calculate the weights of the above variables in the synthetic indicator. This procedure requires all the variables to be expressed in the same units of measurement, so the seven variables were first normalised using the min./max. method. In keeping with standard practice, the factors meeting the following three criteria were selected: having associated eigenvalues larger than one; individually contributing to the explanation of the overall variance by more than 10%; and cumulatively contributing to the explanation of the overall variance by more than 60%. Based on these criteria and assuming the euro area to be an integrated single market, a single factor is selected, which explains 82% of the overall variance. The weight of each variable in the energy security index is equal to the square of its factor loading divided by the overall variance explained by that factor.[89] The weights thus obtained are given in Table A15. These same weights were used to calculate the euro area (average) index.[90]

Charts A20 and A21 show how the situation of the euro area (aggregated) has been changing with respect to the United States. It can be seen from the charts that the euro area has progressively lost comparative advantage in respect of the proportion of LNG in natural gas imports, owing to the faster growth of this kind of import in the United States. However, the electricity sector continues to be less vulnerable in the euro area than the United States, given the euro area's higher self-sufficiency and connectivity.

89 For more details about methodology, see OECD 2005.

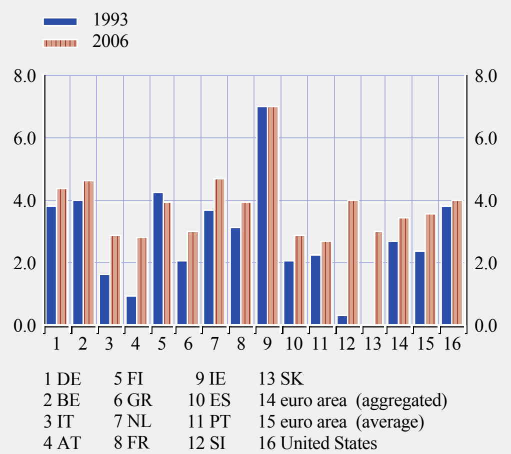
90 The euro area (average) is also calculated by averaging the security indices of each of the 13 Member States which result from applying factoral analysis to these countries and the United States. Despite the fact that in this case the weights of the various variables in the index are somewhat different, the index for the average euro area is practically the same.

Chart A12 Degree of self-sufficiency of primary energies



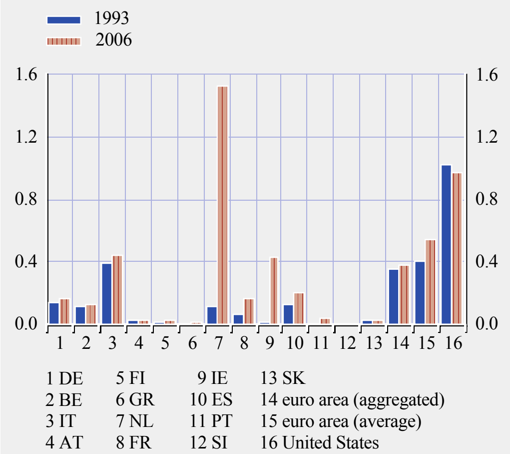
Source: Eurosystem staff calculations.

Chart A13 Reliability of imports



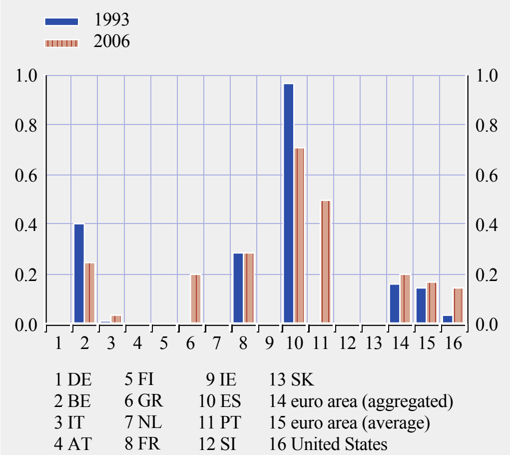
Source: Eurosystem staff calculations.

Chart A14 Negotiating power in gas market



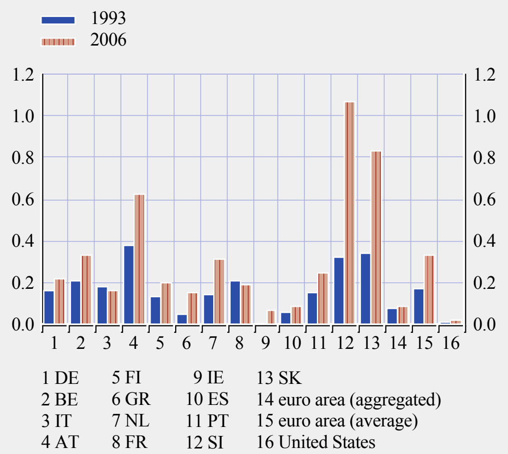
Source: Eurosystem staff calculations.

Chart A15 Imports of liquefied natural gas



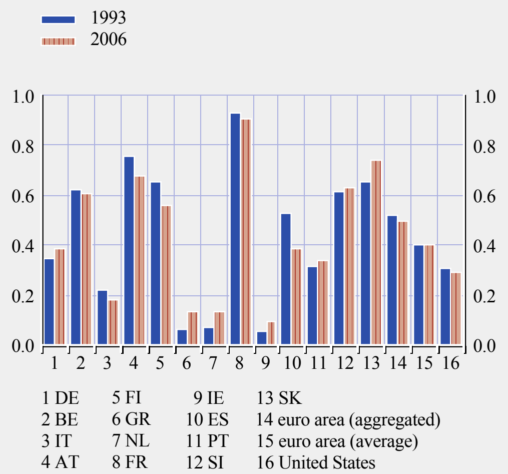
Source: Eurosystem staff calculations.

Chart A16 Degree of electrical connectivity



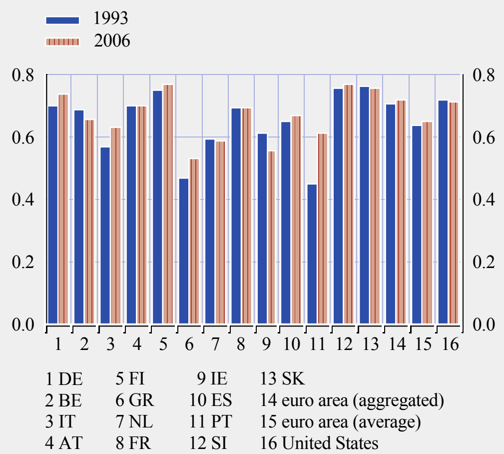
Source: Eurosystem staff calculations.

Chart A17 Self-sufficiency in electricity generation



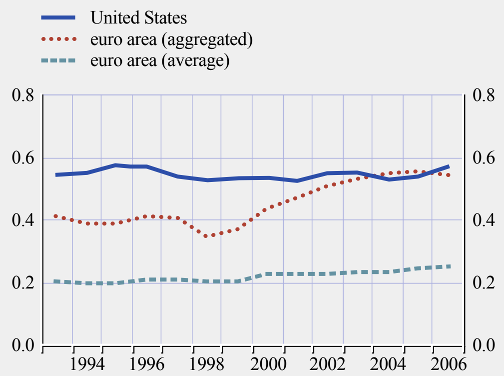
Source: Eurosystem staff calculations.

Chart A18 Degree of diversification of primary energies



Source: Eurosystem staff calculations.

Chart A19 Energy security index



Source: Eurosystem staff calculations.

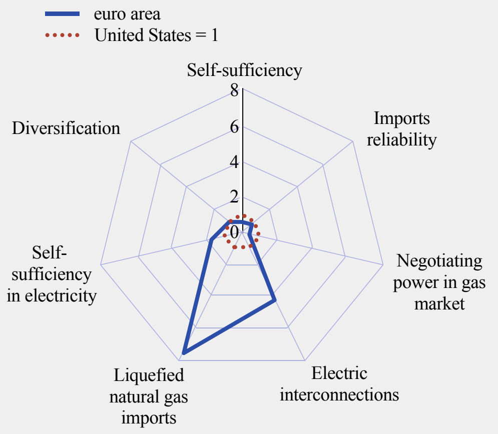
Table A15

Variable	Weight in energy security index
Degree of self-sufficiency of primary energies	0.168
Reliability of imports	0.142
Negotiating power in gas markets	0.170
Imports of liquefied natural gas	0.156
Degree of electrical connectivity	0.108
Self-sufficiency in electricity generation	0.165
Degree of diversification of primary energies	0.090

Source: Eurosystem staff calculations.

Chart A20 Energy security

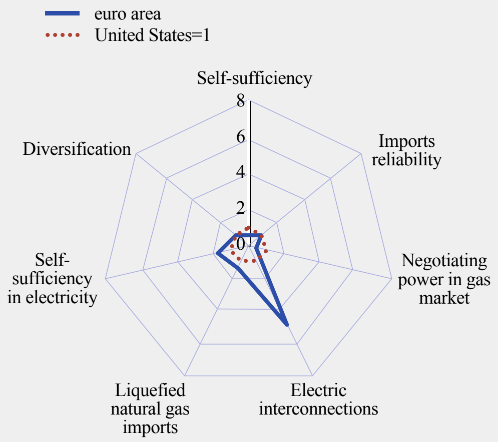
(1994)



Source: Eurosystem staff calculations.

Chart A21 Energy security

(2006)



Source: Eurosystem staff calculations.

2.2 OIL PRICE SHOCKS AND EURO AREA OUTPUT IN THE BLANCHARD-GALI (2007) FRAMEWORK

In the past decade a broad consensus over the diminishing importance of oil price shocks on output fluctuations has emerged, mainly motivated by the muted response of GDP in the industrialised economies to the oil shocks observed since the late 1990s compared with the 1970s.

In an influential paper Blanchard and Gali (2007), using a SVAR, show that the output reaction to an oil price shock for a set of industrialised economies lessened substantially after the mid-1980s. In some cases, the GDP response has even become positive, lending support to the view that recent oil price shocks have been driven by a global demand expansion that has lifted global output together with commodity prices.

In their contribution, Blanchard and Gali analyse separately the three largest euro area countries (Germany, France and Italy) but not the euro area as a whole. Here we report the results obtained by fitting their VAR model to euro area data. The variables in the VAR are the log of the dollar price of oil[91], consumer inflation, GDP inflation, the wage rate, real GDP and employment. The last five variables enter the model in quarterly rates of growth. The deviation of labour productivity from a quadratic trend enters each equation as an exogenous variable.

This exercise differs from that carried out by Blanchard and Gali in two respects. First, Blanchard and Gali identify only the oil shock by assuming that the oil price is not affected contemporaneously by any other variable in the system (which is equivalent to assuming that the oil price shock is equal to the residuals of the oil price equation). Here we adopt a slightly different approach, as we identify all the shocks by using a Choleski factorisation of the residual variance matrix. Oil prices are ordered first so that the definition of an oil price shock is consistent with that used by Blanchard and Gali. Second, rather than splitting the sample in two, we use two windows containing, respectively, 36 and 35 samples of 85 observations and then average responses across these two sets of estimates. The former sample includes the 1970s, while the latter excludes them.

The results, presented in Table A16, are broadly consistent with those of Blanchard and Gali. The negative impact of oil price shocks on GDP falls significantly when one excludes the 1970s from the analysis: the cumulated impact on GDP falls from four to less than two decimal points. Note that the full sample effects are very much in line with those reported in the main text for the euro area weighted average.[92]

91 The oil price is not converted into euros for consistency with Blanchard and Gali's specification where the price of oil is not converted into domestic currencies.

92 The results for inflation, not shown here in the interest of brevity, are consistent with those in Chapter 3 documenting the diminished inflationary effect of oil price shocks.

Table A16 Effect of a 10% oil price increase on GDP over different sample periods

(annual averages)

	Year 1	Year 2	Year 3
First sub-sample	-0.04	-0.23	-0.38
Second sub-sample	0.03	-0.05	-0.18
Full sample	-0.03	-0.25	-0.32
Weighted average from structural models	*-0.08*	*-0.19*	*-0.24*

Notes: This table indicates the short-run effects of a permanent increase in the price of oil by around 10% on annual real GDP in the euro area. Data are from the euro area-wide model. The figures denote cumulated deviations in percentage points from the respective baseline simulation with unchanged oil prices. The estimations of the model over the full sample are based on data from 1970Q1 to 2008Q4. The results for the different sub-samples refer to averages of results over two overlapping periods. The former period consists of 36 samples starting with 1970Q3-1991Q3 and ending with 1979Q2-2000Q2. The latter consists of 35 samples starting with 1979Q3-2000Q3 and ending with 1987Q4-2008Q4.

2.3 COMPARISON OF WEEKLY OIL BULLETIN AND HICP DATA

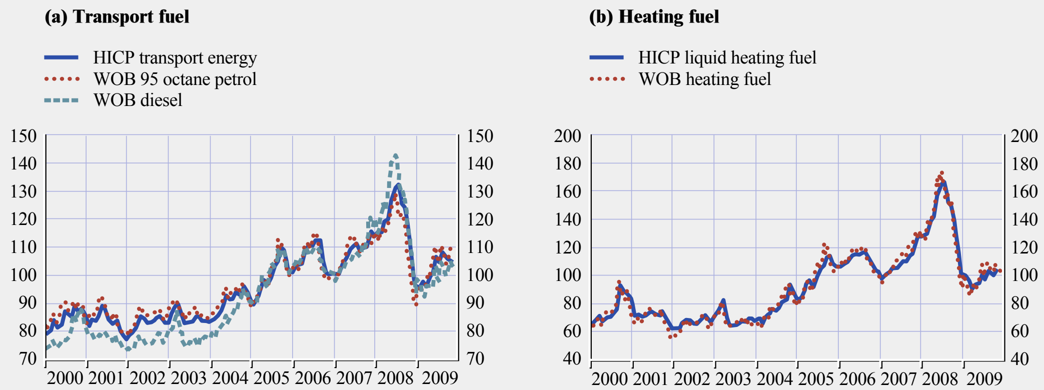
Although HICP data are the official consumer price data for the European Union and are compiled to a very high standard in order to ensure maximum comparability, they involve some drawbacks when used for the purposes of analysing consumer liquid fuel prices. First, HICP data are only available in index form and not in terms of actual price levels. This has important implications for the analysis of oil price pass-through and for the comparison of price levels. Second, they are only available inclusive of tax which, combined with the first point, prevents the calculation of pre-tax prices. Lastly, HICP data are only available at a monthly frequency. Given the high volatility of oil prices and the high frequency of changes in consumer liquid fuel prices, it is possible that data at a higher frequency could provide better insight into very short-term developments in consumer liquid fuel prices.

Fortunately, data available from the European Commission's weekly Oil Bulletin on consumer liquid fuel prices do not suffer many of these drawbacks. First, these data are available in terms of absolute prices (i.e. cent per litre). Second, they are available both in terms of pre-tax and post-tax prices and information is provided on excise taxes and VAT rates. Third, they are available at a weekly frequency – the data are generally collected on the Monday of each week. Furthermore, data are also available in a very timely fashion, usually within two to three days of the reference period (at present, the data are released by the European Commission on the Wednesday evening of the same week that the data are collected). In addition, the weekly Oil Bulletin data are available for both petrol (euro 95) and diesel prices and have been publicly available since 1994 – a similar period to the HICP liquid fuel data. The availability of diesel prices is very important given the growing relevance of diesel cars for the euro area market – see Chart A23. On the other hand, it should be noted that the data are not compiled with the same degree of harmonisation and assurance of quality as the HICP data. This may particularly be an issue when we come to consider price level differences.[93]

Chart A22 below illustrates that the weekly Oil Bulletin and HICP data for transport and

93 For an overview of methodologies and cross-country differences in the collection of the weekly Oil Bulletin data, see European Commission 2009b. Countries differ in the source of data used, the degree of market coverage obtained and, in a number of instances, data are not collected on the Monday as is the case for most countries. A potentially more substantial difference, particularly when it comes to comparing price levels, is that some countries report prices with fidelity discounts while the Netherlands only reports "advised" rather than actual pump prices.

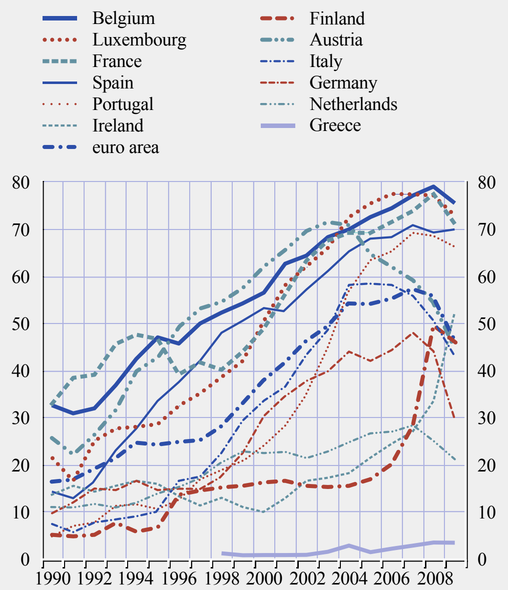
Chart A22 Weekly Oil Bulletin (WOB) and HICP data



Sources: Eurostat, European Commission (DG-TREN) and Eurosystem staff calculations.

Chart A23 Relative importance of diesel across euro area countries

Diesel cars as a percentage of total new passenger car registrations



Sources: Eurostat, ACEA (European Automobile Manufacturers' Association), ANFA (the Spanish association of car manufacturers) and Eurosystem staff calculations.

heating fuels for the euro area co-move very closely indeed. For heating fuels, the correlation coefficient is 0.998 in level terms and 0.956 when considering month-on-month changes. For transport fuels, the respective correlation coefficients are 0.999 and 0.985. The high degree of correlation is observed across most countries for which data are available with some exceptions. In Ireland, the correlation in levels is quite high but relatively low in terms of month-on-month changes; this is because the Irish Oil Bulletin data are only collected at a monthly frequency. The correlation of data for Greece is very low for heating fuel, as the Oil Bulletin data are quite seasonal owing to seasonal variations in excise rates which are not evident in the HICP data. Overall, notwithstanding some country-specific caveats, the very close co-movement of the weekly Oil Bulletin and HICP data suggest that conclusions made based on the analysis of weekly Oil Bulletin data will most likely hold for official HICP also.

2.4 ECONOMETRIC ASSESSMENT OF OIL PRICE PASS-THROUGH INTO CONSUMER LIQUID FUEL PRICES

The pass-through from oil to gasoline prices has been extensively studied in a variety of countries, with the bulk of papers written on US data and some recent interest in the largest euro area countries. The existing empirical evidence is, however, extremely heterogeneous in terms of the underlying research question, data and methodology used. For instance, most studies have focused on testing the hypothesis that gasoline prices in a specific country respond more promptly to upward than to downward oil price changes. However, very few have tackled the question whether the pass-through is complete or not, and whether there exist substantial cross-country differences in the speed of adjustment of downstream prices to oil price fluctuations. Some studies have used monthly data, while others have focused on changes at a weekly or even daily frequency. Some papers have argued that the adjustment is non-linear, but few have explicitly clarified the value added of modelling non-linearity against simpler linear alternatives. Critical assessments of the existing evidence can be found in Geweke (2004) and Manera and Frey (2007). However, even these relatively recent overviews have been made somewhat outdated by revived interest and research on the topic, sustained by the effect of volatility of oil prices in the past decade on consumer price inflation, particularly across euro area countries.

Given the diversity of methodologies and datasets covered, it is not surprising that the findings of this literature have been mixed. In the United States, a number of studies based on weekly data and on error correction models (Karrenbock 1991, Borenstein et al. 1997, Balke et al. 1998, Borenstein et al. 2002, Lewis 2003, Ye et al. 2006) have tended to find some asymmetry in the response of gasoline prices to various measures of upstream costs (oil prices or wholesale gasoline prices) with some support for non-linear adjustment (Radchenko 2005 and Al Gudhea et al. 2007). Notable exceptions are given by the GAO report (1993), Burdette and Zyren (2002 and 2003) and Bachmaier and Griffin (2003). Bachmaier and Griffin not only find little support for the asymmetry hypothesis but also, specifying their model in absolute price differences rather than log differences, report impulse responses showing a full pass-through to both negative and positive oil price changes. Studies on the euro area aggregate and on euro area countries confirm that the choice of working in levels rather than log differences has important consequences for the results – see, for example, Meyler 2009 and Rodriguez 2009.

The (*symmetric*) pass-through from refined oil prices to pre-tax prices is modelled using the framework of the equation below.

$$\Delta P^C_{i,t} = c_{i,j} + \sum_{k=1}^{n} \alpha_{i,j,k}\, \Delta P^C_{i,t\text{-}k} + \sum_{k=0}^{n} \beta_{i,j,k}\, \Delta P^I_{j,t\text{-}k}$$
$$+ \gamma_{i,j}(P^C_{i,t\text{-}1} - \theta_{i,j} P^I_{j,t\text{-}1})$$

where, P^C_i is the consumer price (excluding taxes) of oil energy type i (petrol, diesel or heating fuel), P^I_j is the spot price of oil input j (refined gasoline or refined gas oil). In addition, we allow for, and test, a time trend variable in the error correction term.

The model we use to test for *asymmetry* is shown in the equation below.[94] This is similar to the first, with the exception that allowance is made for when refined prices are rising or falling.

$$\Delta P^C_{i,t} = \Delta^+_{i,t}\Big(c^+_{i,j} + \sum_{k=1}^{K1} \alpha^+_{i,j,k}\Delta P^C_{i,t\text{-}k} + \sum_{k=0}^{K2} \beta^+_{i,j,k}\Delta P^I_{j,t\text{-}k}$$
$$+ \gamma^{++}_{i,j}(P^C_{i,t\text{-}1} - \theta_{i,j}P^I_{j,t\text{-}1})^+ + \gamma^{+-}_{i,j}(P^C_{i,t\text{-}1} - \theta_{i,j}P^I_{j,t\text{-}1})^-\Big)$$
$$+ (1-\Delta^+_{i,t})\Big(c^-_{i,j} + \sum_{k=1}^{K1} \alpha^-_{i,j,k}\Delta P^C_{i,t\text{-}k} + \sum_{k=0}^{K2} \beta^-_{i,j,k}\Delta P^I_{j,t\text{-}k}$$
$$+ \gamma^{-+}_{i,j}(P^C_{i,t\text{-}1} - \theta_{i,j}P^I_{j,t\text{-}1})^+ + \gamma^{--}_{i,j}(P^C_{i,t\text{-}1} - \theta_{i,j}P^I_{j,t\text{-}1})^-\Big)^2$$

Generally, the results suggest little evidence of economically meaningful asymmetry (in a small number of cases, there is some evidence of statistically significant asymmetry,

Table A17 Summary of results of Wald tests for asymmetry in pass-through of refined oil prices into petrol, diesel and heating fuel prices

	Petrol	Diesel	Heating fuel
euro area	0.52	0.37	0.16
BE	0.59	0.54	0.25
DE	0.39	0.52	0.38
IE	0.94	0.19	0.26
GR	0.11	0.26	0.24
ES	0.88	0.81	0.10
FR	0.02*	0.43	0.06*
IT	0.19	0.00*	0.00*
LU	0.02*	0.81	0.55
NL	0.21	0.00*	0.07*
AT	0.82	0.03*	0.09*
PT	0.30	0.13	0.89
FI	0.39	0.03*	0.15

Note: * denotes statistically significant at standard levels.

however, when this is quantified the effect is quite marginal – see Table A17). Furthermore, the statistically significant results should be interpreted with caution as they may be misleading in one of two ways. First, in some of the models with tight confidence intervals, coefficients are significantly different in a statistical sense but not in an economic sense (i.e. the degree of apparent asymmetry while statistically significant is very small). Second, in some of the models with wide confidence intervals, coefficients are not statistically significantly different owing to large standard errors, but if the point estimates are taken at face value, they may imply economically meaningful differences in response to oil price rises and decreases. Ultimately, the fact that no statistically significant asymmetric effects are found across all fuel types in any of the countries would lend further support to the view that the power of these tests is relatively low and the evidence for asymmetry is not compelling.

94 Note that the long-term coefficient in the error correction term is the same for increases and decreases in upstream prices. This is because it does not make sense that the long-term coefficient would vary according to short-term price changes. In any case, we tested the euro area results allowing for different long-run coefficients and found that they were broadly similar.

2.5 GAS AND ELECTRICITY PRICE LEVELS (HICP INDEX VS. PRICE LEVEL DATA)

Gas and electricity price level data (with and without taxes, in euro per unit of energy) are collected by Eurostat on a semi-annual basis. Prices valid on the first day of January and July of each year were recorded until 2007, when the methodology was substantially changed. That change implied a new definition of the standard consumption[95] used and a focus on six-month average prices, so pre and post-2007 data are not directly comparable. Focusing on pre-2007 data allows a comparison of these price level data with HICP index data with a relatively large sample.

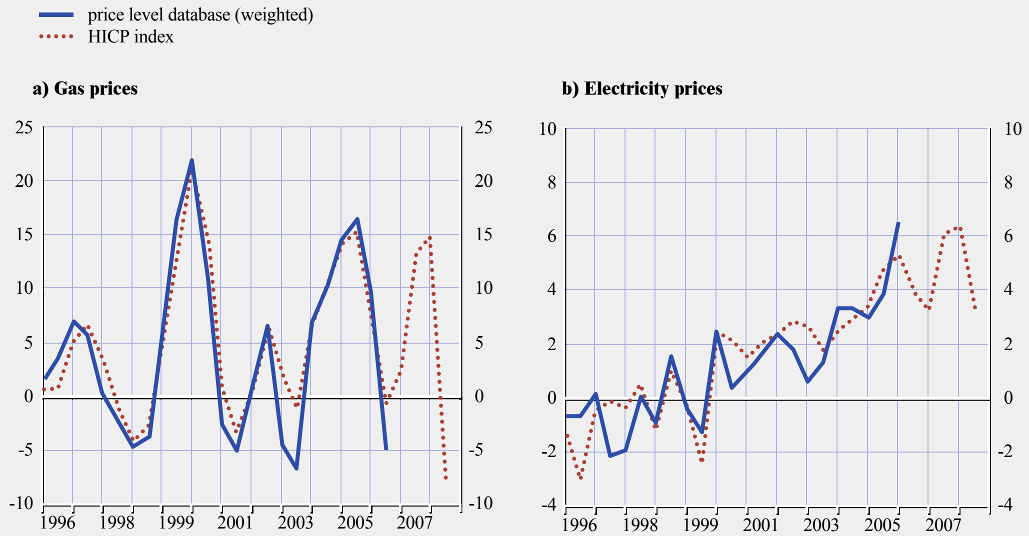
Considering gas prices, a high degree of correlation can be seen between year-on-year price changes between the two datasets for the euro area as whole, suggesting that these data are representative of prices faced by "typical" consumers. However, this is not systematically the case at the country level. For Germany, Ireland, France, Italy, Luxembourg, the Netherlands and Slovenia, a high correlation between the two data sources is found. In Belgium and Spain, the correlation between HICP index and price level data is weaker because there is an additional lag in the HICP index data compared with the price level data.[96] In Austria the HICP index and price level data are weakly correlated. For Portugal and Slovakia not enough data are available to draw strong conclusions: although correlation appears weak in Slovakia where the HICP seems to reflect a regulated price.

95 Definition of the standard consumptions (selected as structural or so-called Lisbon indicator).
Gas: *Households* pre-2007: type D3 (annual consumption 83.70 GJ); post-2007: type band D2 (annual consumption between 20 and 200GJ). *Industry* pre-2007: type I3-1 (annual consumption 41,860 GJ; load factor 200 days, 1,600 hours); post-2007: band I3 (annual consumption between 10,000 and 100,000 GJ).
Electricity: *Households* pre-2007: Dc (annual consumption 3,500 kWh of which night 1,300); post-2007: band Dc (annual consumption between 2,500 and 5,000 kWh). *Industry* pre-2007: Ie (annual consumption 2,000 MWh; maximum demand 500 kW; annual load 4,000 hours); post-2007: band Ic (annual consumption between 500 and 2,000 MWh).

96 In Spain this is the case particularly in the period 2000-05, but not thereafter. In Belgium no lag can be found after 2007: from 2007 the HICP only reflects current price evolutions, whereas before 2007 prices were recorded as 12-month averages to reflect an annual bill approach.

Chart A24 Euro area gas and electricity prices: comparison of HICP index and medium-sized household-level data[1)]

(annual rates of change on 1 January and 1 July; percentages)



Sources: Eurostat and ESCB calculations.
1) Price level data according to the pre-2007 methodology: prices valid on the first of January and the first of July. The same standard medium-sized household is used for each country. The euro area is weighted according to 2009 HICP countries and item weights, for countries for which data are available.

As to electricity prices, the correlation between year-on-year price changes according to the HICP database and the price level database is weaker than for gas prices, the euro area and at the country level. Although the relationship is relatively strong for some countries (Germany, Spain, Cyprus, Portugal and Finland) it is rather weak for others (Belgium, Italy, Luxembourg and the Netherlands). The weak result for Belgium is attributable to an additional lag in the HICP which has the same methodological origin as for gas prices. For other countries, a more general possible explanation could be that electricity prices vary more across different consumer types than is the case for gas (for example, inclusion of night tariffs). Thus, the Eurostat definition of a standard consumer (according to the Lisbon structural indicator database) may not be as representative for all consumers. Indeed, preliminary results considering the alternative household definitions tend to indicate that the standard consumer can differ from country to country (i.e. the correlation between HICP index and price level data can differ according to the standard consumer used, and the HICP is supposed to reflect the national consumption pattern very closely). This caveat should be kept in mind when analysing electricity price levels.

2.6 ECONOMETRIC ASSESSMENT OF THE IMPACT OF THE LIBERALISATION OF ELECTRICITY AND GAS MARKETS ON CONSUMER PRICES

The effect of the liberalisation of European gas and electricity markets on consumer prices has been estimated using a panel framework (see equation below).

$$P_{i,t} = \alpha_i + \sum_{j=1}^{N} \beta_j X_{j,t} + \gamma \mathrm{D}_t + \varepsilon_{i,t}$$

where $P_{i,t}$ is the level of consumer electricity (gas) price net of all taxes, α_i is a country, i fixed effect, D_t is a common time effect which captures a common trend across countries[97] and $X_{j,t}$ is a set of j explanatory variables, for $j = 1, ..., N$. They include competition/regulation indicators, consumption intensity and dependency indicators, international gas and oil prices and a set of control variables such as population and its density.

The model computes structural coefficients common across countries for the set of X_t explanatory variables. The sample is based on the available data for 16 euro area countries analysed over 16 years – from 1991 to 2007. In order to obtain estimated coefficients that reflect a euro area average, the estimation procedure should account for country differences other than the differences already explained in the control variables and in fixed-term parameters. The baseline model outlined in the equation above has been augmented with weights – GDP weights specifically. These weights should help to capture and ameliorate a possible problem of heteroskedasticity in the dataset.

Four models for electricity prices and five models for gas prices have been estimated since the availability of different regulation and competition indicators provided by the OECD, namely: an aggregate indicator for competition and regulation, an entry barrier indicator, a vertical integration indicator, a public ownership indicator and a concentration indicator – C1, available for the gas market only. The indicators have a "descending interpretation" – in other words, the higher the level of the index, the more the market is concentrated, entry is difficult and/or, in general, competition is lacking or regulation tight. Hence, an estimated positive coefficient is expected for most of the indicators, with the possible exception of the vertical integration indicators, as discussed further below. The indicators are regressed separately for two reasons. First, most of them follow a common trend over time. This may give rise to a problem of collinearity, which could result in wrongly estimated coefficients if indicators are considered jointly. Second, separate regressions can be considered as a robustness check for variables other than the

97 A Levin, Lin and Chu's (2002) panel unit root test has been performed including individual fixed effects and a common trend. The null hypothesis of unit root is not accepted with probability less or equal to five per cent for both gas and electricity prices. As counterfactual evidence, a common trend has been estimated and subtracted from the price variables. Hence, the same panel unit root test – excluding common trend and constant – has been performed. The test does not accept the null hypothesis of unit root.

competition/regulation indicators since they are common across models.

The results suggest a statistically significant impact of regulation/competition indicators on prices in both the gas and electricity markets (Tables A18 and A19). Nonetheless, the precise magnitude of these results should be interpreted with caution. Although it is clear that both these sectors, previously highly regulated, have undergone some degree of liberalisation, this process does not lend itself easily to quantification. It may also be the case that the degree of regulation might be endogenous, e.g. if high prices are observed, regulation might be introduced in an attempt to counter this.

For the *electricity* market, the coefficient estimates for the aggregate indicator, as well as those for entry barriers and vertical integration, are positive and highly statistically significant whilst the coefficient for public ownership, although positive, is not statistically significant. The coefficients on the share of electricity generated using nuclear energy and fossil fuel inputs are negative, suggesting that these factors have, on average over the period considered, lowered prices whilst the coefficient on the share of hydropower is positive.[98] Gas prices impact positively on electricity prices, as expected, given that among fossils gas is the most used

98 Network industries usually do not price at marginal cost since the fixed costs of production are high and must be recovered in the price paid by consumers. Very often the price schedule consists of a two-part tariff aimed at recovering both fixed and marginal costs of production. Although the marginal cost of producing nuclear energy is close to zero, its fixed component is very large owing to high costs of installation and decommission. It should also be noted that the sign of these coefficients represents an average over the entire sample period, 1991-2007. At any point in time the coefficients on these variables can be both negative and positive depending on opportunity costs. Lastly, it should be noted that the equation also includes international gas/oil prices, which means that the upward impact from these prices observed over the period 1999-2009 may be captured by the coefficients.

Table A18 Regressions for electricity prices

	Dependent variable: net (excluding all taxes) electricity prices			
	(1)	(2)	(3)	(4)
Aggregate indicator	0.30			
	(12.40)*			
Entry barrier		0.21		
		(14.57)*		
Vertical integration			0.23	
			(11.01)**	
Public ownership				0.022
				(1.08)
Nuclear	-0.038	-0.032	-0.040	-0.022
	(-3.94)*	(-3.39)*	(-4.14)*	(-2.28)**
Oil and gas	0.014	-0.003	-0.017	0.009
	(-2.05)**	(-0.55)	(-2.43)**	(1.35)
Hydro	0.055	0.063	0.047	0.069
	(6.22)*	(7.14)*	(5.23)*	(7.46)*
International oil price – 1 lag	-0.0018	-0.0009	-0.0018	-.012
	(-0.47)	(-0.24)	(-0.47)	(-3.12)*
International gas price – 1 lag	0.23	0.23	0.26	0.36
	(7.81)*	(7.79)*	(9.06)*	(12.31)*
Population	-0.32	-0.29	-0.32	-0.36
	(-12.48)*	(-11.30)*	(-12.61)*	(-13.25)*
Population density	0.094	0.096	0.10	0.096
	(23.77)*	(24.33)*	(25.45)*	(22.30)*
Observations	1,570	1,570	1,570	1,570
R-squared	0.95	0.96	0.95	0.95

Notes: Country-specific fixed effects have been included as well as a common time trend effect.
Value of t statistics in parentheses.
* significant at 1%; ** significant at 5%; *** significant at 10%.

Table A19 Regressions for gas prices

	Dependent variable: net (excluding all taxes) gas prices				
	(1)	(2)	(3)	(4)	(5)
Aggregate indicator	0.11				
	(3.75)*				
Entry barrier		0.074			
		(5.29)*			
Public ownership			0.082		
			(3.23)*		
C1				0.09	
				(2.65)*	
Vertical integration					-0.057
					(-2.15)**
Gas dependency	-0.020	-0.019	-0.02	-0.022	-0.027
	(-7.78)*	(-7.17)*	(-7.65)*	(-8.11)*	(-7.55)*
Gas consumption intensity	-0.001	-0.001	-0.0007	-0.001	-0.0007
	(-3.84)*	(-4.41)*	(-2.71)*	(-3.78)*	(-2.85)*
International gas price – 1 lag	0.37	0.35	0.49	0.40	0.40
	(21.45)*	(14.95)*	(16.59)*	(16.56)*	(16.42)*
Population	-0.192	-0.18	-0.24	-0.20	-0.28
	(-5.87)*	(-5.83)*	(-8.43)*	(-5.99)*	(-8.92)*
Population density	0.017	0.017	0.018	0.018	0.021
	(10.53)*	(11.18)*	(12.55)*	(11.63)*	(13.17)*
Dep. lagged (-1)	0.51	0.53	0.49	0.50	0.49
	(20.41)*	(21.93)*	(20.45)*	(20.71)*	(20.24)*
Observations	1,542	1,542	1,542	1,542	1,542
R-squared	0.95	0.94	0.93	0.95	0.96

Notes: Country-specific fixed effects have been included as well as a common time trend effect. Value of t statistics in parentheses.
* significant at 5%; ** significant at 1%.

input. When included alongside gas, the oil coefficient is not significant.

In the *gas* market all indicators are significant with the expected positive sign, except for the vertical integration indicator which has a negative sign. However, as indicated above, a priori, the sign on the vertical integration variable is not clear. It should carry a positive sign if a reduced competition effect prevails, or a negative sign if an efficiency effect dominates. The results suggest that the second interpretation is correct. By contrast, the first interpretation seems to be more relevant for the electricity market. An alternative interpretation could be that since upstream gas supplies are quite integrated (coming mainly from Russia and Norway), downstream integration is required to offset the upstream negotiation position. It should also be noted that, based on the analysis contained in the main part of the text, the coefficient on international gas prices was expected to be close to one on average for the euro area. In Table A19, the estimated coefficient is generally around 0.4. Together with the coefficient on the lagged dependent variable[99] of roughly 0.5, this suggests an estimated long-run coefficient on lagged international gas prices of around 0.8. The coefficient may be biased downward owing to effects already attributed to the country-specific fixed effects.

2.7 INPUT-OUTPUT TABLES

Input-output tables provide a refined decomposition of the production process, based upon the interrelationships between different branches of activity in the economy via the cross consumption of intermediate inputs. Applying the cumulative approach, i.e. by going back up the production chain of a branch in order to take into account all the direct and

99 A lagged dependent variable has been included in the gas market models because autocorrelation of first order has been detected (i.e. LM test) for some single country regressions.

indirect inputs necessary for that production, it is possible to derive not only the direct use of energy inputs but also the indirect use, through consumption of other products which use energy as an intermediate input. Then, by introducing a change in the price of energy inputs, we can calculate the overall effect it has on the cost structure (producer prices), and on consumer prices. The overall impact can be decomposed into a direct impact (through direct energy use) and an indirect one (through consumption of other products which use energy as an intermediate input).

A cross-country comparison is possible using the IOT standardised across EU countries, collected by Eurostat. These tables are available with details of 59 branches, following the NACE classification. We dispose of IOT for 12 euro area countries in 2005, namely Germany, Ireland, Greece, Spain, France, Italy, the Netherlands, Austria, Portugal, Slovenia, Slovakia and Finland. The euro area results are obtained by a weighted average of available country results (the weights correspond to the country shares in the producer/consumer expenditures, as derived from IOT).

The main drawback of using IOT is their static character. The production and final demand structure and the corresponding technical coefficients are fixed: as prices rise, users of energy do not substitute away from more expensive products. Similarly, there are no second-round effects – the value of wages and profit margins remain constant – and no monetary policy response to the rise in consumer prices. These underlying assumptions suggest that the results will tend to overestimate the effects of an energy price increase.

A second limitation of this approach is that it is not possible to take into account the fact that the initial price level is not the same across countries (and across branches). A related important caveat is that IOT provide only fairly broad energy categories. Categories of energy inputs available in IOT and to which a direct impulse is given according to the energy shock are the following[100]:

– Coal and lignite; peat (NACE 10).

– Crude petroleum and natural gas; services incidental to oil and gas extraction (NACE 11).

– Coke, refined petroleum products and nuclear fuels (NACE 23).

– Electrical energy, gas, steam and hot water (NACE 40).

As we can see, electricity and gas belong to the same category. Even though gas and electricity prices may not move simultaneously, they must be modelled together when using the IOT to understand the impact of an energy price shock. Even if some co-movements are generally observed in the prices of energy inputs, especially internationally traded raw energy products, assuming perfect simultaneity constitutes a simplification.

Third, without information on the production structure for imported products, we are not able to model the indirect effects of energy price increases on import prices. We can account for the price effects of imported raw energy products or production inputs but not for the effect energy price rises might have on other imported products. Not taking into consideration increases in non-energy imported products suggests that our calculations of the impact of energy price increases could be on the down side.

To sum up, the 10% energy price increase we model is made up of three "components":

– a 10% increase in the price of imports of raw energy inputs;

100 Uranium and thorium ores (NACE 12) are not included in our definition of energy inputs, although they are included in the category "energy producing materials" according to the NACE classification.

– a 10% increase in the price of domestically produced raw energy inputs;

– a 10% increase in the price of imports of refined energy products.

Raw energy inputs refer to "Coal and lignite; peat" (NACE 10) and "Crude petroleum and natural gas" (NACE 11); refined energy inputs refer to "Coke, refined petroleum products and nuclear fuels" (NACE 23) and "Electrical energy, gas, steam and hot water" (NACE 40).

Finally, the choice of the reference year could clearly affect the results. If energy prices are particularly high in the reference year, then the share of energy costs in the overall cost structure will be high. The effect of the energy price increase on the overall costs will also be high, compared with a similar exercise conducted in a year with lower energy prices. The calculations presented in Section 3.3.1 mostly refer to 2005, which corresponds to the year of the last available dataset for a majority of euro area countries.

REFERENCES

Al - Gudhea, S., Kenc, T., Dibooglu, S., 2007. "Do retail gasoline prices rise more readily than they fall? A threshold cointegration approach", Journal of Economics and Business 59, pp. 560–574.

Altissimo F., M. Ehrmann and F. Smets (2006), "Inflation persistence and price-setting behaviour in the euro area – a summary of the IPN evidence", Occasional Paper Series 46, European Central Bank.

Álvarez, L. J., S. Hurtado, I. Sánchez and C.Thomas (2009), "The impact of oil price changes on Spanish and euro area consumer price inflation", Occasional Paper 0904, Banco de España.

Arpa M., Cuaresma J. C., Gnan E and Silgoner M. A, "Oil price shock, energy prices and inflation – a comparison of Austria and the EU". Oesterreichische Nationalbank (ONB) Monetary Policy and the Economy 2006; Q1/06; 53-77.

Asplund, M., Eriksson, R., Friberg, R., 2000. "Price adjustments by a gasoline retail chain", Scandinavian Journal of Economics 102(1), pp. 101–121.

Australian Competition and Consumer Commission – ACCC (2007), "Petrol prices and Australian consumers: Report of the ACCC inquiry into the price of unleaded petrol", December.

Avedillo, M. and M. A. Muñoz (2007), "Seguridad energética en Europa", Boletín Económico de ICE, No 2928, 16-31 December 2007, pp. 43-47.

Bachmeier, L. and J. Griffin (2006). "Testing for Market Integration: Crude oil, coal and natural gas", The Energy Journal, 27:2, pp 55-72.

Bachmeier, L. and Griffin, J. (2003) "New Evidence on Asymmetric Gasoline Price Responses", Review of Economics and Statistics, 85, pp. 772-776.

Balke, N. S., S. P. A. Brown and M. K. Yücel (2002), "Oil Price Shocks and the U.S. Economy: Where Does the Asymmetry Originate?", The Energy Journal, 23(3):27-52.

Balke, N., S. Brown, and M. Yücel, (1998), "Crude oil and gasoline prices: An asymmetric relationship?", Federal Reserve Bank of Dallas Economic Review, First Quarter, pp. 2-11.

Bartholomae F. and K. Morasch (2007). "Oil price indexing of natural gas prices: An economic analysis", Review of Economics, 58 Vol. 3, pp. 250-264.

Beck, R. and A. Kamps (2009), "Petrodollars and imports of oil exporting countries", ECB Working Paper, No 1012, February.

Bello, A., and S. Cavero (2008), "The Spanish Retail Petroleum Market: New Patterns of Competition Since the Liberalization of the Industry", Energy Policy Vol. 36, Issue 2, pp. 612-626.

Benati, L. and Surico, P., (2009), "VAR Analysis and the Great Moderation", American Economic Review, 99, pp. 1636-52, September.

Berben, R.-P., A. Locarno, J. Morgan and J. Vallés (2004), "Cross-country differences in monetary policy transmission", ECB Working Paper Series No 400, October.

Bernanke, B., (2006) "Energy and the economy", Speech made before the Economic Club of Chicago, Chicago, Illinois, June 15, 2006.

Bernanke B., (1983), "Irreversibility, Uncertainty and Cyclical Investment", Quarterly Journal of Economics, 98(1), pp. 86-106.

Blanchard, O. J. and M. Riggi (2009), "Why are the 2000s so Different from the 1970s? A Structural Interpretation of Changes in the Macroeconomic Effects of Oil Prices", NBER Working Paper No 15467.

Blanchard, O. J. and J. Gali (2007), "The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so different from the 1970s?", NBER Working Paper 13368.

Bohi D. R., M. A. Toman (1996), "The Economics of Energy Security", Kluwer Academic Publishers, Norwell, Massachusetts, USA.

Borenstein, S. and Shepard, A. (2002) "Sticky Prices, Inventories, and Market Power in Wholesale Gasoline Markets", RAND Journal of Economics, Vol. 33 ,pp. 116-139.

Borenstein, S., Cameron, A. C., Gilbert, R., 1997. "Do gasoline prices respond symmetrically to crude oil price changes?", Quarterly Journal of Economics 112, pp. 305-339.

Bosco, B., L. Parisio, M. Pelagatti and F. Baldi (2007), "A robust multivariate long run analysis of European electricity prices", Fondazione Eni Enrico Mattei Working Papers, No 162.

Breitenfellner, A., J. Crespo Cuaresma (2008), "Crude oil prices and the USD/EUR exchange rate", Monetary Policy & the Economy Q4/08.

Brown, S. and M. Yücel (2009), "Market arbitrage: European and North American natural gas prices", The Energy Journal, Vol. 30, Special Issue, May, pp. 167-168.

Brown, S. and M. Yücel (2007), "What drives natural gas prices?", Working Paper 0703, Federal Reserve Bank of Dallas.

Brunekreeft, G. and K. Keller (2000), "The electricity supply industry in Germany: market power or power of the market", Utilities Policy, Vol. 9, No. 1, March, pp. 15-29.

Buchan, D. (2009), "Energy and Climate Change: Europe at the Crossroads", Oxford University Press.

Burdette M. and Zyren J., "Gasoline price pass through". US Energy Information Administration, mimeo 2003; January.

Burdette M. and Zyren J., "Diesel fuel price pass through". US Energy Information Administration, mimeo 2002; July.

Commodity Futures Trading Commission, (2008), "Interim Report on Crude Oil".

Contín-Pilart, I., Correljé, A., and Palacios, M.B., 2006, "Competition, Regulation, and Pricing Behavior in the Spanish Retail Gasoline Market", Working Paper BILTOKI DT2006.02, University of the Basque Country.

Conway P. and G. Nicoletti, 2006, "Product market regulation in the non-manufacturing sectors of OECD countries: measurement and highlights", OECD Economics Department Working Papers No 530, December.

Council of European Energy Regulators (CEER) (2007), Fact Sheet on Unbundling, May.

Criqui, P. and S. Mima (2009) "Exploring the Energy Security – Climate Policy Nexus with the POLES Model", LEPII, CNRS-Université de Grenoble, France, paper presented at 2009 International Energy Workshop, Venice, Italy, June 17-19, 2009.

Darracq-Pariès, M. and S. Moyen (2009), "Monetary policy and inflationary shocks under imperfect credibility", ECB Working Paper Series No 1065.

Dhyne E., L. J. Alvarez, H. Le Bihan, G. Veronese, D. Dias, J. Hoffmann, N. Jonker, P. Lunnemann, F. Rumler and J. Vilmunen, 2006. "Price Changes in the Euro Area and the United States: Some Facts from Individual Consumer Price Data," Journal of Economic Perspectives, American Economic Association, vol. 20(2), pp. 171-192, Spring.

Edelstein, P. and L. Kilian (2008), "How Sensitive are Consumer Expenditures to Retail Energy Prices?", mimeo, University of Michigan.

Energy Information Administration, EIA (2003). The Global Liquefied Natural Gas Market: Status and Outlook, December.

ERGEG (2009), "Status Review of End-User Price Regulation as of 1 July 2008", Brussels: ERGEG.

ERGEG (2008) "ERGEG 2008 Status Review of the Liberalisation and Implementation of the Energy Regulatory Framework", Brussels.

Esteves, P. Soares, and P. Duarte Neves, (2004) "Oil prices and the economy", Banco de Portugal Economic Bulletin, December 2004, pp. 51-62.

Estrada, A. and P. Hernandez de Cos (2009), "Oil prices and their effect on potential output", Banco de España Occasional Paper Series, No 0902.

European Central Bank – ECB (2004), "Oil prices and the euro area economy", ECB Monthly Bulletin article, November 2004, pp. 51-63.

European Commission, 2009b. "Survey on the petroleum products' price data collection published in the weekly Oil Bulletin", mimeo Market Observatory for Energy, DG-TREN, February.

European Commission, 2009a. "Progress in creating the internal gas and electricity market" 2008 Benchmarking Report and Technical Annex (COM/2009/0115). Brussels.

European Commission (2009). "Report on progress in creating the internal gas and electricity market", Communication from the Commission to the Council and the European Parliament, Brussels, 11.3.2010, COM(2009) 0115 final.

European Commission (2008-2009), "Quarterly Report on European Electricity Markets", Volumes 1 and 2, Brussels.

European Commission (2008a). "An EU Energy Security and Solidarity Action Plan", COM(2008) 781 final, mimeo.

European Commission (2008). Impact assessment, SEC (2008)85, mimeo.

European Commission (2007a). "European Technology Platform SmartGrids: Strategic research agenda for Europe's electricity networks of the future", document prepared on behalf of the Advisory Council of the European Technology SmartGrids.

European Commission (2007). "Inquiry pursuant to Article 17 of Regulation (EC) No 1/2003 into the European gas and electricity sectors (Final Report)", Communication from the Commission, Brussels, 10.1.2007, COM(2006) 851 final.

European Sea Ports Organisation – ESPO (2008). "Annual Report 2007-2008".

Fagan, G. and Morgan (2005), "Econometric models of the Euro-Area Central Banks", Edward Elgar, Cheltenham.

Finon D. and Glachant J. M. (2004), "Competition and Market Integration in Europe: Towards a multi-energy and multidomestic oligopoly", in "Reshaping of European Electricity and Gas Industry: Regulation, Markets and Business Strategies", Finon D. and Midttun A. (eds.), Elsevier, 2004, chapter 8, pp. 237-255.

Frankel, J. A. (2006), "The effect of monetary policy on real commodity prices", in "Asset prices and monetary policy", edited by J. Campbell, University of Chicago Press.

Frey G. and M. Manera, 2007. "Econometric Models Of Asymmetric Price Transmission," Journal of Economic Surveys, Blackwell Publishing, vol. 21(2), pp. 349-415, 04.

GAO (General Accounting Office), 1993, "Energy security and policy: Analysis of the pricing of crude oil and petroleum products", GAO/RCED-93-17, March.

Gautier, E., and R. Le Saout (2009), "Price Rigidity: Evidence from French Gasoline Daily Price Quotes", mimeo Banque de France.

Geweke, J., 2004. "Issues in the 'Rockets and Feathers' gasoline price literature". Report to the Federal Trade Commission. March.

Hahn, E. (2003), "Pass-Through of External Shocks to Euro Area Inflation", ECB Working Paper Series, 243, July.

Haigh, M. S., J. Hranaiova and J. A. Overdahl (2005), "Price Dynamics, Price Discovery and Large Futures Trader Interactions in the Energy Complex", CFTC Working paper, April.

Hamilton, J. (2009), "Causes and Consequences of the Oil Shock of 2007-08". Brooking Papers on Economic Activity, Spring 2009.

Hamilton, J. D. (2008), "Understanding Crude Oil Prices", NBER Working Paper 14492.

Hartley, P., K. B. Medlock III, and J. Rosthal (2007), "The relationship between crude oil and natural gas prices", mimeo, The James A. Baker III Institute for Public Policy, November.

Hastings, J., 2004, "Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California," American Economic Review 94:1, pp. 317-328.

Hicks, B. and Kilian, L. (2009), "Did Unexpectedly Strong Economic Growth Cause the Oil Price Shock of 2003-2008?", CEPR Discussion Paper, No 7265.

Higgins, M., T. Klitgaard and R Lerman (2006), "Recycling Petrodollars", Current Issues Federal Reserve Bank of New York, Vol. 12, No 9, December 2006.

Hooker, M. A. (2002), "Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications versus Changes in Regime", Journal of Money, Credit and Banking, Vol. 34:2, pp. 540-561.

Hotelling, H. (1931), "The economics of exhaustible resources", Journal of Political Economy 39(2): 137-175.

ICF International (2007), "Analysis of the economic impact of energy product prices on competitiveness of the energy and manufacturing sectors in the EU: comparison between EU and US", Report submitted to the European Commission, DG Transport and Energy, July.

International Energy Agency, OECD/IEA (2009b). World Energy Outlook 2009, Paris.

International Energy Agency (2009a), Medium-Term Oil Market Report, June 2009.

International Energy Agency, IEA/OECD (2009), World Energy Outlook, Paris.

International Energy Agency, OECD/IEA (2008c). World Energy Outlook 2008, Paris.

International Energy Agency, OECD/IEA (2008b). Electricity Information 2008, Paris.

International Energy Agency, OECD/IEA (2008a). IEA Energy Policy Reviews: The European Union 2008, Paris.

International Energy Agency (2007). Energy Security and Climate Policy, OECD/IEA, Paris.

International Energy Agency, OECD/IEA (2003). World Energy Investment Outlook 2003, Paris.

International Monetary Fund (2006), "World Economic Outlook, Chapter 5: The Boom in Nonfuel Commodity Prices – Can It Last?", September 2006.

IPCC – Intergovernmental Panel on Climate Change (2007). Fourth Assessment Report: Climate Change (AR4).

Jacquinot, P., M. Kuismanen, R. Mestre and M. Spitzer (2009), "An Assessment of the Inflationary Impact of Oil Shocks in the Euro Area", The Energy Journal, 30(1), pp. 45-83.

Jiménez-Rodríguez, R. and M. Sánchez (2005), "Oil price shocks and real GDP growth: empirical evidence from some OECD countries", Applied Economics, 37 (2), pp. 201-208.

Karrenbrock, J. "The behavior of retail gasoline prices: symmetric or not?" Federal Reserve Bank of St. Louis, July/August 1991, pp.19-29.

Kaufmann, R. K. and B. Ullman (2009), "Oil Prices, Speculation and Fundamentals: Interpreting Causal Relations among Spot and Futures Prices". Energy Economics, 31, Issue 4, pp. 550-558.

Kaufmann, R. K. and L.D. Shiers (2008), "The effect of resource uncertainty on the peak in global oil production and the production of alternatives", Ecological Economics, 67: pp. 405-411.

Kaufmann, R. K., Karadeloglou, P. and F. di Mauro (2008), "Will oil prices decline over the long run?", ECB Occasional Paper, No 98.

KEMA Consulting (2005), "Review of European Electricity Prices", A report carried out on behalf of EURELECTRIC (Union of the Electricity Industry), November.

Kemfert, C. (1998), "Estimated substitution elasticities of a nested CES production function approach for Germany", Energy Economics,Vol 20, pp. 249-264.

Khan, M. S. (2009), "The 2008 oil price bubble", Policy Brief No 09-19, Peterson Institute for International Economics.

Kilian, L. (2009), "Not all price shocks are alike: disentangling demand and supply shocks in the crude oil market", American Economic Review, 99:3, pp. 1053-1069.

Kilian, L. (2008b), "The economic effects of energy price shocks", Journal of Economic Literature, 46(4): 871-909.

Kilian, L., 2008a. "Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy?", The Review of Economics and Statistics, MIT Press, vol. 90(2), pp. 216-240, 03.

Kilian, L. and R. J. Vigfusson (2009), "Pitfalls in Estimating Asymmetric Effects of Energy Price Shocks", Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No 970.

Knetsch, T. A. and A. Molzahn (2009), "Supply-side effects of strong energy price hikes in German industry and transportation", Deutsche Bundesbank, Discussion Paper 26/2009.

Krautkraemer, J. A. (1998), "Nonrenewable resource scarcity", Journal of Economic Literature 36(4): 2065-2107.

Kroes N, European Commissioner for Competition Policy (2007), "A new European Energy Policy; reaping the benefits of open and competitive markets", Energy conference: E-world energy & water, Essen, 5 February.

Kruyt, B., D. P. van Vuuren, H.J.M. de Vries and H. Groenenberg (2009), Indicators for energy security, Energy Policy, Volume 37, Issue 6, June 2009, pp. 2166-2181.

Landau, B. and F. Skudelny (2009), "Pass-Through of external shocks along the pricing chain – a panel estimation approach for the euro area", ECB Working Paper Series, 1104.

Lewis, M., 2003, "Asymmetric price adjustment and consumer search: An examination of the retail gasoline market", University of California-Berkeley Working Paper, Nov. 2003.

Market Observatory for Energy (2008). "Europe's energy position: present and future", Luxembourg: Office for Official Publications of the European Union.

Martin, R., M. Roma and I. Vansteenkiste, (2005). "Regulatory reforms in selected EU network industries", European Central Bank Occasional Paper Series 28.

McCarthy, J. (2000), "Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies", Federal Reserve Bank of New York, Staff Report, No 3.

Meyler A. 2009. "The pass through of oil prices into euro area consumer liquid fuel prices in an environment of high and volatile oil prices". Energy Economics, Issue 6, Energy Sector Pricing and Macroeconomic Dynamics, November, pp. 867-881.

Miller, J. I. and R. A. Ratti (2009), "Crude Oil and Stock Markets: Stability, Instability and Bubbles". Energy Economics, 31, Issue 4, pp. 559-568.

Mork, K. A. (1989), "Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results", The Journal of Political Economy, 97(3): 740-744.

Nakov, A. and G. Nuño (2009), "A general equilibrium model of oilgopoly", Banco de España Working Paper, forthcoming.

Nakov, A. and A. Pescatori (2009), "Monetary Policy Tradeoffs with a Dominant Oil Producer", Journal of Monetary Credit and Banking, 42(1), pp. 1-32. Banco de España Working Paper, 0723.

National Bank van België/Banque Nationale de Belgique (2008), "Annex C: Consumer prices of electricity and gas for households", in "The trend in inflation in Belgium: an analysis by the NBB at the request of the federal government", Economic Review April 2008, special edition.

National Consumer Agency (2008) "Investigation into Petrol and Diesel Price Movements", December.

Neumann, A. (2009) "Linking Natural Gas Markets: Is LNG doing its job?" The Energy Journal, Special Issue of the International Association for Energy Economics, pp. 187-200.

Nomisma Energy (2007) "La rete carburanti: Il confronto con l'Europa", July. Study conducted by Nomisma Energia on behalf of Unione Petrolifera.

Nordhaus, W. (2009), "The Economics of an Integrated World Oil Market", Keynote Address, International Energia Workshop, Venice, Italy, June 17-19, 2009.

OECD (2009). "Competition Policy for Vertical Relations in Gasoline Retailing 2008" OECD Policy Roundtables.

OECD (2006). "Product market regulation in the non-manufacturing sectors of OECD countries: measurement and highlights", Economics Department Working Paper, No 530.

OECD (2005), "Handbook on constructing composite indicators: methodology and user guide", Statistics Working Paper No 13, STD/DOC (2005)3.

Onour, I. (2009), "Natural gas markets: How sensitive to crude oil price changes?", mimeo, Arab Planning Institute, April.

Peersman, G. and I. Van Robays (2009), "Oil and the Euro Area Economy", Economic Policy, Volume 24, Issue 60, pp. 603-651.

Polo M. and C. Scarpa (2007), "Take or Pay Contracts and Market Segmentation", Working Papers 5, IEFE, Bocconi University.

Polo M. and C. Scarpa, (2003). "The liberalization of energy markets in Europe and Italy", Working Papers 230, IGIER (Innocenzo Gasparini Institute for Economic Research), Bocconi University.

Radchenko, S. "Oil price volatility and the asymmetric response of gasoline prices to oil price increases and decreases", Energy Economics, Vol. 27(2005), pp. 708-730.

Reserve Bank of New Zealand (2005), "Oil prices and the New Zealand economy", Bulletin, Vol. 68, No. 4, December, pp. 5-15.

Rietveld P and van Woudenberg S. "Why fuel prices differ". Energy Economics 2005; Vol. 27, Issue 79-92.

Robinson, T. (2007b), "The convergence of electricity prices in Europe", Applied Economics Letters, Vol. 14, No. 7, pp. 473-476.

Robinson, T. (2007a), "Have European gas prices converged?", Energy Policy, Vol. 35, Issue 4, April, pp. 2347-2351.

Rodrigues, J. (2009), "Asymmetries in the adjustment of motor diesel and gasoline pump prices in Europe", Portuguese Competition Authority (AdC), Working Paper Series No 37, July.

Stern N. (2007), "The Economics of Climate Change: The Stern Review", Cambridge University Press.

Taylor, J. B. (2000), "Low Inflation, Pass-Through, and the Pricing Power of Firms", European Economic Review, Vol. 44/7, pp. 1389-1408.

Thompson, P. and T. G. Taylor (1995), "The Capital-Energy Substitutability Debate: A New Look", The Review of Economics and Statistics 77(3): 565-569.

Tol R. S. J. (2008), "The Economic Effects of Climate Change", Journal of Economic Perspectives, 23, pp. 29-51.

United Nations Framework Convention on Climate Change, UNFCC (2008), Investment and financial flows to address climate change. Technical paper.

Van der Werf, E. (2008), "Production functions for climate policy modelling: An empirical analysis", Energy Economics,Vol. 30, No 6, pp. 2964-2979.

Van Meerbeeck, W. 2003. "Competition and local market conditions on the Belgian retail gasoline market", De Economist, Vol. 151, No. 4.

Venditti, F., 2010. "Down the non-linear road from oil to consumer energy prices: no much asymmetry along the way", Banca d'Italia Temi di Discussione No 751, March.

Villar, J. and F. Joutz (2006) "The relationship between crude oil and natural gas prices" mimeo.

Walsh, P. P. and C. Whelan, 1999. "Loss leading and price intervention in multiproduct retailing: welfare outcomes in a second-best world1", International Review of Law and Economics, Elsevier, vol. 19(3), pp. 333-347, September.

World Bank (2009), State and Trends of the Carbon Market, May.

Ye, M., Zyren, J., Shore, J., Burdette, M., 2005. "Regional comparisons, spatial aggregation, and asymmetry of price pass through in U.S. gasoline markets". Atlantic Economic Journal 33, pp. 179–192.

Zachmann G. and C. von Hirschhausen, (2008) "First evidence of asymmetric cost pass-through of EU emissions allowances: Examining wholesale electricity prices in Germany", Economic Letters 99(3), pp. 465-469.