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The wage-price pass-through in the euro area: does the growth regime matter?

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ABSTRACT

This paper explores whether the transmission mechanism between wages and prices in the euro area is affected by the growth regime. Since the great financial crisis inflation developments have posed major puzzles to economists as inflation declined by less than was widely expected during the past recessions and rose by less during the subsequent recoveries. This paper analyses whether the wage-price pass-through may have contributed to these inflation puzzles. Applying the Threshold VAR model proposed by Alessandri and Mumtaz (2017) to the analysis of the wage-price pass-through, the paper examines whether the transmission mechanim of different types of shocks differs between recessions and expansions. The results point to differences in the wage-price pass-through between growth regimes for demand shocks but not for wage mark-up shocks. They show a much smaller response of prices relative to wages, i.e. a smaller wage-price pass-through, for demand shocks in recessions than in expansions. This is accounted for by a smaller relative response of profit margins. More generally, the results suggest that the slope of the price Phillips curve flattens in recessions on account of the lower wage-price pass-through, while the wage Phillips curve appears to be broadly stable across growth regimes. Overall, the results contribute to solve or diminish the puzzle of the missing disinflation of the past two recessions suggesting that inflation should be expected to recede by less during recessions than indicated by standard linear models.

JEL classification: C32, E31, J30

Keywords: Euro area inflation, wage-price pass-through, growth regimes, threshold VAR

NON-TECHNICAL SUMMARY

This paper explores whether the transmission mechanism between wages and prices in the euro area is affected by the growth regime and differs between recessions and expansions. Since the great financial crisis in 2008 inflation developments have posed major puzzles to economists as inflation declined by less during the past two recessions than was widely expected by economists ("missing disinflation") and likewise rose by less than envisaged in the subsequent recoveries ("missing inflation"). Numerous studies helped to improve the understanding of the inflation developments by e.g. exploring where the price and wage Phillips curves are alive or to what extent external factors, inflation expectations or structural trends related to the globalisation or technological progress may have played a role (see e.g. Auer et al. (2017), Cicarelli and Osbat (2017), Bonam et al. (2019)). An important aspect in the inflation analysis that helps to shed further light on these puzzles is the link between wages and prices. The wage-price pass-through essentially reflects the connection between the wage and the price Phillips curves. Analyses for both the euro area and the US indicate that the wage Philips curve has remained more intact than the price Phillips curve. This suggests that the wage-price pass-through has contributed to the inflation puzzles and leads to the question of what has happened in the transmission mechanism between wages and prices.

Based on reduced form models the empirical literature has for long indicated that there is only a loose link between wages and prices (e.g. Bidder (2015)). This finding was broadly confirmed more recently by Peneva and Rudd (2017) who examine the transmission mechanism of unit labour cost shocks to prices in the US. Several studies applying their approach to European countries, however, concluded that unit labour cost shocks do provide a link between labour costs and prices (see e.g. Bobeica et al (2019) and Deutsche Bundesbank (2019)). Gumiel and Hahn (2018) suggest that wages and prices are connected via different transmission channels concurrently and show that the wage-price pass-through is shock dependent which was confirmed in empirical analyses (see Hahn (2019) and Bobeica et al (2019)). The identified shock-dependence together with changes in the composition of the shocks over time creates a non-linear relationship and likely changes in the link between wages and prices over time which may have contributed to the inflation puzzles identified based on linear models. The complexity of the wage-price pass-through relationship, however, goes beyond the shock-dependence. A number of studies hint at changes in the relationship over time (see e.g. Deutsche Bundesbank

(2019) and de Luigi (2019)) and such changes were detected even when controlling for shock-dependence (Hahn (2019)). This suggests that there may have been also more profound structural changes in the relationship over time or likewise a dependence of the relationship on certain states of the economy as has been suggested recently with regard to e.g. the inflation environment (Bobeica et al (2019) and Boranova et al (2019)).

The present paper analyses the state-dependence of the wage-price pass-through in the euro area with regard to the growth regime by applying the Threshold VAR (TVAR) model proposed by Alessandri and Mumtaz (2017). As in Hahn (2019) demand and wage mark-up shocks are identified. The TVAR model then allows analysing the wage-price pass-through of these types of shocks for different levels of GDP growth, i.e. for expansions and recessions.

The main results of the paper are as follows: The TVAR model provides estimates of two growth regimes in the euro area, a recession and an expansion regime. The empirical results point to differences in the wage-price pass-through between expansions and recessions for demand shocks but not for wage mark-up shocks. For demand shocks, the response to a typical one standard deviation shock, which differs in magnitude across regimes and is larger in recessions, appears to be bigger in recessions than expansions for real GDP and compensation per employee but to be similar for the considered price variables. In relative terms, the results show a much smaller response of prices relative to wages, i.e. a smaller wage-price pass-through, for demand shocks in recessions than expansions. This is accounted for by a smaller relative response of profit margins in recessions. The results suggest that one should not expect a very different, i.e. stronger, absolute price response in recessions than expansions despite the much larger typical demand shock in recessions as the elasticities change between growth regimes. Such expectations appear, however, to have prevailed and led to the notion of “missing disinflation” in the past two recessions. The results also highlight differences between growth regimes for the relationship between activity and prices and suggest that the slope of the price Phillips curve flattens in recessions on account of the lower wage-price pass-through. The wage Phillips curve appears, by contrast, to be stable across growth regimes.

All in all, the analysis contributes to solve or diminish the puzzle of the missing disinflation of the past two recessions suggesting that inflation should be expected to recede by less during recessions than indicated by standard linear models. The results should, hence, help in forecasting inflation in the unfolding 2020 recession.

1. INTRODUCTION

Since the great financial crisis in 2008 inflation developments have posed major puzzles to economists both in the euro area and also more widely in other economies like the US. In the great recession and the sovereign debt crisis inflation did not decline by as much as was widely expected by economists in view of the sharp fall in economic activity and in the subsequent recoveries it rose by less than envisaged given the significant improvements in economic activity and a return of the unemployment rate to pre-crisis lows. These phenomena were described as the puzzles of "missing disinflation" and "missing inflation". Numerous studies looked into the sources of these developments and helped to improve the understanding of inflation developments in these periods examining e.g. whether the wage and price Phillips curves are still alive or to what extent external factors, inflation expectations or structural trends related to e.g. the globalisation, technological progress or demographic changes may have played a role (see e.g. Auer et al. (2017), Cicarelli and Osbat (2017), Bonam et al. (2019), Forbes (2019), Nickel et al. (2019), Belz et al. (2020)).

An important aspect in the inflation analysis that helps to shed further light on these puzzles is the link between wages and prices, i.e. the wage-price pass-through. The wage-price pass-through provides the connection of what happens between the wage and the price Phillips curves. For the euro area, it was found that standard wage and price Phillips curves can explain the broad movements of wages and prices over the past decade but significant parts of the "missing dis-/inflation" remain unexplained and the unexplained parts appear overall larger for the price than the wage Phillips curve (see Nickel et al. (2019), Bobeica and Sokol (2019) and Schnabel (2020)). The same appears to apply for the US, where the Phillips curve for wages is assessed to be more intact than that for prices (see Belz et al (2020)). This suggests that the wage-price pass-through has contributed to these puzzles and leads to the question of what has happened in the developments between wages and prices and which factors account for this link at all.

The empirical literature has for long indicated that the relationship between wages and prices is rather loose and that one should not infer too much from developments in wages for those in prices (see e.g. the literature survey by Bidder (2015)). This assessment was based on results from both correlation analyses and Granger causality tests as well as analyses of the usefulness of wage and labour cost indicators to predict developments in prices (see e.g. Emery and Chang (1996), Stock and Watson (1999), Hess and Schweitzer (2000), Stock and Watson (2008), Hu and Toussaint-Comeau (2010) and Knotek and Zaman (2014)).

More recently, Peneva and Rudd (2017) proposed a different approach to analyse the link between labour costs and prices. They estimate a time-varying parameter BVAR model for import prices, unit labour costs, core inflation and the unemployment gap in the US and identify unit labour cost shocks via a Cholesky decomposition. Using two different measures of unit labour costs impulse response analyses showed for one measure a decline in the pass-through of unit labour cost shocks to core inflation to zero over time and for the other a broadly stable positive impact over time. Historical decompositions, however, indicated that, independent of the indicator of unit labour costs used, the identified unit labour cost shocks explain only rather small parts of the movements in core inflation in the US over the past decade. Based on these findings Peneva and Rudd (2017) conclude that there is little evidence that independent movements in unit labour costs have had a material effect on core inflation in the US in recent years.

A number of studies applied the approach of Peneva and Rudd (2017) to European countries. Common among all of these studies is the use of a BVAR model to identify unit labour cost shocks based on a Cholesky decomposition. At the same time, the applied models differ somewhat with respect to the choice of variables, the estimation sample, the use of constant or time varying parameters and the use of a time series or panel data set up. In contrast to Peneva and Rudd (2017), these studies focus on impulse response analysis but do not report corresponding results from historical decompositions on the importance of the identified unit labour costs shocks for the movements in inflation. Bobeica et al. (2019) examine the pass-through of unit labour cost shocks to prices in the four largest euro area countries and the main economic sectors and find a clear pass-through of unit labour cost shocks to inflation with some heterogeneity across countries and sectors and no significant changes over time for the period since 1985. Estimates from the Deutsche Bundesbank (2019) for Germany likewise indicate a notable pass-through of unit labour cost shocks to inflation in Germany. They, moreover, point to a decline in the pass-through of the unit labour costs shocks to inflation in the mid-1990s compared to the 1970s. De Luigi et al. (2019) report a pass-through of unit labour cost shocks to inflation in most of the considered Central Eastern and South Eastern European countries but the impact is heterogeneous across countries and has weakened after the great recession. Finally, Boranova et al. (2019) explore the transmission of unit labour cost shocks to inflation in 27 European countries, distinguishing between 16 advanced economies and 11 newer EU member states, over the period 1995 to 2019. Their results show that unit labour cost shocks are transmitted to inflation in both sets of countries, but the pass-through is higher for the newer EU member states, and consistent with the results of De Luigi et al. (2019) the pass-through has declined in the period after the great recession.

A different perspective in analysing the wage-price pass-through compared to the previous approaches was introduced by Gumiel and Hahn (2018). This applies to both the earlier empirical literature as well as the approach proposed by Peneva and Rudd (2017). The earlier analyses mainly tried to pin down the relationship between wages and prices empirically using reduced form models or tried to identify whether the data are consistent with a certain type of the inflation process by introducing some structure to the model (see e.g. the cointegration analysis by Mehra (2000)) and Peneva and Rudd focused their analysis of the link between labour costs and prices on the transmission of unit labour cost shocks. Gumiel and Hahn (2018), by contrast, acknowledged that wages and prices may be connected via different transmission channels concurrently. As these channels may operate at the same time, and overlay each other, or in turns the signals on the link between the two variables may be blurred. This perspective is, hence, consistent with the finding of a lack of a clear empirical link between wages and prices based on reduced form models. But in contrast to concluding that the variables are rather unrelated to each other, it suggests that the link is complex and that specific efforts are needed to disentangle the different transmission channels at work. Correspondingly, Gumiel and Hahn (2018) analysed the wage-price pass-through in the euro area by exploring how different types of important structural shocks are transmitted between wages and prices. More specifically, they explored how aggregate demand shocks and supply shocks affecting wages, namely wage mark-up shocks, are passed through between wages and prices in the euro area. For the analysis of the wage-price pass-through it is not important that the identified shocks originate in labour costs as is implicitly assumed in the analysis by Peneva and Rudd (2017) by focusing on unit labour cost shocks, but it is important that the shocks are relevant for the movements in both wages or labour costs and prices and thereby create a link between the variables. Gumiel and Hahn (2018) analysed the wage-price pass-through in the context of the New Area Wide Model, a micro founded open economy model for the euro area (see Christoffel et al. (2008)). They show that the transmission mechanism between wages and prices differs for the two types of analysed shocks, both in terms of pattern and magnitude, i.e. it is shock-dependent. They also illustrate that in order to fully understand the transmission mechanism between labour costs and prices in the euro area, it is important to focus the analysis on wages instead of unit labour costs as the transmission of some types of shocks (demand shock) implies deviating patterns between the response of wages and unit labour costs.

Empirical estimates of the wage-price pass-through of demand and wage mark-up shocks in the euro area based on a BVAR model confirm the finding of shock-dependence and the differences in the responses of wages and unit labour costs for demand shocks (see Hahn (2019)). The analysis also illustrates that the pass-through of the shocks differs for different price variables and main components of the Harmonised Index of Consumer Prices (HICP) and shows that the transmission of the shocks appears to have undergone some changes over time for both the supply and demand shocks. Importantly, applying historical decompositions the results of Hahn (2019) also show that the identified shocks are of relevance for the movements in both wages and prices in the euro area and thereby create a relevant link between the variables. The results on shock dependence in the pass-through of labour costs to prices are also confirmed by Bobeica et al. (2019). Based on different BVAR specifications they show that the pass-through differs for various types of shocks in the large euro area countries and across the main economic sectors. Overall, the identified shock-dependence of the wage-price pass-through together with changes in the composition of the shocks over time creates a non-linear relationship between wages and prices and changes in the link between the variables over time. Depending on the types of shocks that may have been prevalent in certain periods, such non-linear behaviour may, hence, have contributed to the dis-/inflation puzzles in the euro area over the past decade identified based on linear models.

The above results have shown that the wage-price relationship is highly complex, shock dependency creates non-linearities in the relationship and a number of studies hint at changes in the wage-price pass-through over time (see Peneva and Rudd (2017), Deutsche Bundesbank (2019), De Luigi et al. (2019) and Boranova et al. (2019)) and such changes are even evident when accounting for shock-dependence (Hahn (2019)). This could be an indication that the relationship may have also undergone broader structural changes over time which could for instance arise from changes in labour market institutions or the monetary policy setting. It could, however, also be the case that the wage-price pass-through is affected by certain states of the economy. In this regard, Bobeica et al. (2019) suggest that the inflation environment plays a role and that a lower inflation environment is associated with a lower pass-through. This is confirmed by Boranova et al. (2019) who use an Interacted Panel VAR model to analyse the degree of the pass-through for different states of the economy and find that the pass-through is lower in periods of subdued inflation and inflation expectations, if the economy is subject to greater competitive pressures and when corporate profitability is robust.

The present paper contributes to the analyses of state-dependence of the wage-price pass-through and examines whether the growth regime may play a role. The link between wages and prices is determined by the movements in profit margins and labour productivity. For both of these variables it is conceivable that their response differs between recessions and expansions. Businesses may rather aim for higher profit margins and consider these in their price setting decisions if the economic environment is favourable and high demand strengthens their pricing power. In an unfavourable economic environment preserving market shares may play a larger role than profit margin considerations and profit margins may also be squeezed in case of unexpected adverse shocks. Labour productivity could likewise respond differently in expansions and recessions as recessions are typically characterised by stronger changes in output while the labour market flexibility and employment may not change to a similar degree.

The state-dependence of the wage-price pass-through on the growth regime is examined by applying the Threshold VAR (TVAR) model proposed by Alessandri and Mumtaz (2017) to the analysis of the link between wages and prices in the euro area. In terms of variables the set-up of the TVAR model includes a parsimonious version of the BVAR model of Hahn (2019) and as in Hahn (2019) demand and wage mark-up shocks are identified based on sign restrictions. The TVAR model then allows analysing the wage-price pass-through of these types of shocks for different levels of GDP growth, i.e. for expansions and recessions.

The main findings of the paper can be summarized as follows: The TVAR model provides estimates of two growth regimes in the euro area, a recession and an expansion regime, for the period of the European monetary union. The periods of the estimated recession regime correspond closely to the periods identified by the CEPR as growth pause or recession periods in the euro area. The empirical results point to differences in the wage-price pass-through between expansions and recessions for demand shocks but not for wage mark-up shocks. For demand shocks, the response to a typical one standard deviation shock, which differs in magnitude between the two regimes and is larger in recessions, is found to be bigger in recessions than expansions for real GDP and compensation per employee but to be similar for the considered price variables. In terms of the relative movements of the variables, the results show a much smaller response of prices relative to wages, i.e. a smaller wage-price pass-through, for demand shocks in recessions than expansions. This is accounted for by a smaller relative response of profit margins in recessions. The results suggest that one should not expect a very different, i.e. stronger, absolute price response in recessions than expansions despite the much larger typical demand shock in recessions as the elasticities change between growth regimes. Such expectations appear, however, to have prevailed and led to the notion of "missing disinflation" in the past two recessions. The results also highlight differences between growth regimes for the relationship between activity and prices and suggest that the slope of the price Phillips curve flattens in recessions on account of the lower wage-price pass-through. The wage Phillips curve appears, by contrast, to be stable across growth regimes.

The rest of the paper is structured as follows: Section 2 describes the data and the applied methodology. Section 3 presents the empirical results. Section 3.1 shows the estimated growth regimes. Section 3.2 presents detailed results on the wage-price pass-through of the demand shock. Section 3.3 shows corresponding results for the supply shock. Section 4 concludes.

2. DATA AND METHODOLOGY

The state-dependence of the wage-price pass-through on the growth regime is analysed by applying the TVAR model proposed by Alessandri and Mumtaz (2017) to the link between wages and prices.[1] The applied TVAR model can be written as follows:

$$Y_t = \left[c_1 + \sum_{j=1}^{P} B_{1,j}\, Y_{t-j} + \Omega_1^{1/2} e_t\right] S_t + \left[c_2 + \sum_{j=1}^{P} B_{2,j}\, Y_{t-j} + \Omega_2^{1/2} e_t\right](1 - S_t),$$

$$e_t \sim N(0,1) \qquad (1)$$

where

$$S_t = 1 \qquad \text{if} \qquad z_{t-d} \leq z^*. \qquad (2)$$

[1] I thank H. Mumtaz for providing me with the Matlab code of the TVAR model and helpful comments on its use.

Y_t denotes the vector of the N endogenous variables, c_1 *and* c_2 are vectors of the constants, B_1 and B_2 refer to the coefficient matrices of the TVAR model, P indicates the lag order of the model, and Ω_1 and Ω_2 are the covariance matrices of the residuals, respectively. The TVAR model allows for two distinct regimes $S_t = \{0,1\}$. The regimes are defined by the level of the threshold variable z_{t-d} relative to the threshold z^*, whereby the threshold variable is the dth lag of the variable z based on which the regimes are distinguished. Both the delay d and the threshold z^* are estimated. As indicated in equation (1) both the the transmission mechanism and the size of the shocks can change between the two regimes.

The baseline TVAR model of the wage-price pass-through includes as endogenous variables real GDP, compensation per employee, the GDP deflator and the HICP excluding energy and food (HICPX). That is, the vector of the endogenous variables is $Y_t = \{gdp_t, cpe_t, gdpd_t, hicpx_t\}$. This choice of variables allows analysing the pass-through from compensation per employee to the GDP deflator and to the HICPX. The inclusion of the two price variables, hence, enables to examine the wage-price pass-through to the price stage of domestic price pressures as well as to consumer prices and thereby to analyse in more detail at which price stages potential differences in the wage-price pass-through between growth regimes may occur.[2] At the stage of consumer prices, the inclusion of the HICPX in the model is preferred to that of the HICP as the HICPX represents the part of the HICP that should have the closest link to wages. Energy and food prices, which are excluded from the HICPX, are more volatile and to a larger extent affected by energy and food commodity price developments. Real GDP is used in the TVAR model as the threshold variable to distinguish the growth regimes. Real GDP is the natural candidate variable to distinguish recession and expansion periods as it is the most encompassing indicator of economic activity. The data used are at quarterly frequency and cover the period of the first quarter of 1999 to the second quarter of 2019. All series of equation (1) are included in the model in terms of log differences. The threshold variable in equation (2) is defined in terms of the year-on-year growth rate of real GDP. The reason for the choice of this transformation is the lower volatility of year-on-year growth rates compared to quarterly growth rates. Individual quarters of e.g. low quarterly GDP growth may reflect data volatility between quarters and may appear independent from any recessionary developments,

[2] See Hahn (2019) for a discussion of the differences in the price developments captured by the GDP deflator and the HICPX.

whereas low year-on-year growth rates are more likely to reflect genuine weakness in growth momentum. The definition of the threshold variable in terms of year-on-year growth rates should hence help to distinguish the growth regimes more clearly into genuine recession and expansion phases.[3] The source of all data is Eurostat.

The selection of variables included in the TVAR model represents a parsimonious version of the variables included in the BVAR model of the wage-price pass-through by Hahn (2019). Given the relatively short sample period and the complexity of the model a more parsimonious set-up of the model than in Hahn (2019) appeared warranted. However, additional insights in the wage-price pass-through are gained by estimating alternative models with slight modifications in the selection of the variables as will be outlined below. All of the other variables used in the alternative models are likewise included in terms of log differences and provided by Eurostat.

The estimation of the TVAR model follows the approach applied by Alessandri and Mumtaz (2017). Information on the priors and the applied Gibbs sampling algorithm of Chen and Lee (1995) is provided in Appendix 2.

The wage-price pass-through in the two growth regimes is analysed based on structural impulse response analysis. As in Alessandri and Mumtaz (2017) generalized impulse responses as suggested by Koop et al. (1996) are applied. In contrast to traditional impulse responses, generalized impulse responses are applicable to non-linear models as they account for history-dependence as well as shock-dependence with regard to the size and the sign of the shock. The generalized impulse responses are calculated via Monte Carlo integration. That is, the impulse response functions IRF for the two regimes $S = \{0,1\}$ are derived as the differences between the two conditional expectations obtained by simulating the model based on one of the structural shocks μ and for a scenario where all shocks are set to zero, respectively:

$$IRF_t^S = E(Y_{t+k}|\psi_t, Y_{t-1}^S, \mu) - E(Y_{t+k}|\psi_t, Y_{t-1}^S), \tag{3}$$

where ψ_t includes the parameters and hyperparameters of the TVAR model, Y_{t-1}^S the regime-specific history and k refers to the considered horizon.

[3] When quarterly real GDP growth is used as threshold variable in the TVAR model the estimated recession regime indeed includes somewhat more individual quarters of lower GDP growth but there is also a large overlap with the recession periods identified based on the year-on-year GDP growth threshold variable which implied similar empirical results to those shown in this paper.

The impulse responses are conditioned on the observations in each regime. More specifically, the impulse response for each regime is calculated as the average of the impulse responses received by simulating the model for all starting values in that regime. As mentioned above generalized impulse responses are history-dependent and depend also on the starting values within each regime. It may matter for instance if in the recession regime the shock occurs in a situation where GDP growth is strongly negative or just a little below the growth threshold. While the impulse responses may hence differ within each regime, the aim of calculating impulse responses conditional on the observations of the respective growth regimes is to try to capture the average or most generic behaviour of the economy in each regime (see also Alessandri and Mumtaz (2019)). Note also that the generalized impulse responses allow for the possibility of endogenous switches of the regime. That is, the economy can change the regime over the simulation horizon as both the developments of the endogenous variables and the parameters of the TVAR model are taken into account. In the current paper, for instance, GDP growth is one of the endogenous variables of the TVAR model as well as the threshold variable. As a result, a shock that impacts the future developments of GDP growth can trigger a change in the regime over the simulation horizon.

The identification of the structural shocks is conducted via sign restrictions. The model is partially identified. Two types of structural shocks are identified, a demand shock and a supply shock in the labour market affecting wages, i.e. a wage mark-up shock. As in the analyses of Gumiel and Hahn (2018) and Hahn (2019) the focus is on these two types of shocks as they trigger the two different important types of inflation, demand pull and cost push inflation, for which the transmission mechanism between wages and prices shall be explored. For the demand shock the standard restrictions of a co-movement of the activity and price variables are applied. That is, for a positive demand shocks real GDP, the GDP deflator and the HICPX are imposed to rise. For the wage mark-up shock, real GDP and the price variables are requested to move in opposite directions and wages are imposed to co-move with prices capturing changes in costs in line with a wage mark-up shock. More specifically, hence, for an inflationary wage mark-up shock real GDP is imposed to decline while the GDP deflator, the HICPX and wages are rising. All restrictions are imposed on the regime-specific impact matrices.

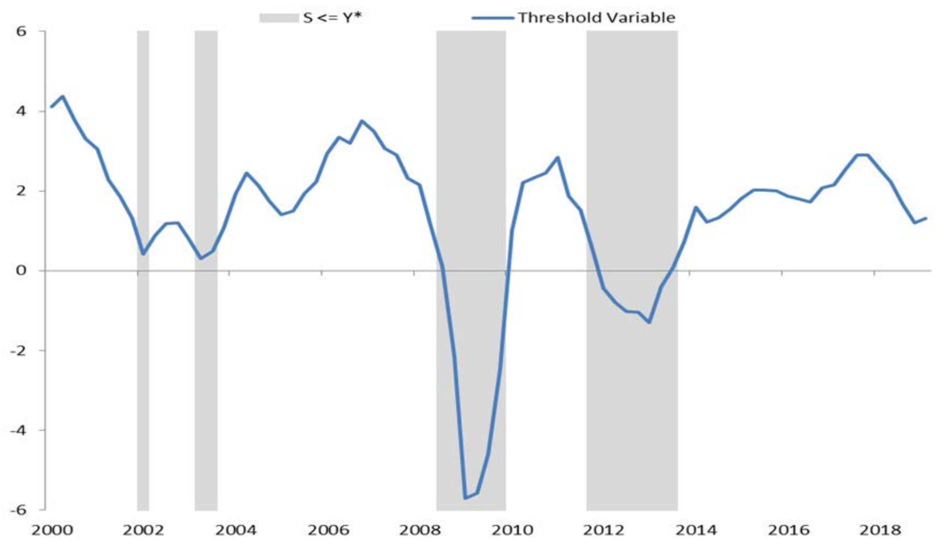
3. EMPIRICAL RESULTS

This section presents the empirical results on the wage-price pass-through in the euro area for the two growth regimes. Section 3.1 shows the estimated growth regimes for the euro area. Section 3.2 and 3.3 provide detailed examinations on the wage-price pass-through in the two regimes for demand and supply shocks, respectively.

3.1 Growth regimes

Figure 1 shows year-on-year GDP growth and the growth regimes estimated by the TVAR model for the period from 2000 to 2019. The shaded areas indicate the periods where GDP growth is below the threshold, which is estimated to correspond to a year-on-year GDP growth rate of 0.6 percent. The regime of GDP growth below this threshold, hence, includes low growth and recession periods. For brevity it is denoted in the following as “recession regime”, while periods of year-on-year GDP growth above this threshold are referred to as “expansion regime”. The euro area economy is estimated to have been in the recession regime in 2002Q1, in the middle of 2003, from 2008Q3 to the end of 2009 and from the end of 2011 to 2013Q3. The periods of the estimated recession regime, hence, correspond closely to those identified by the CEPR for the euro area as a growth pause (2003) or recession periods (2008Q2 to 2009Q2 and 2011Q4 to 2013Q1, respectively).

Figure 1: GDP growth and estimated growth regimes
(year-on-year growth)



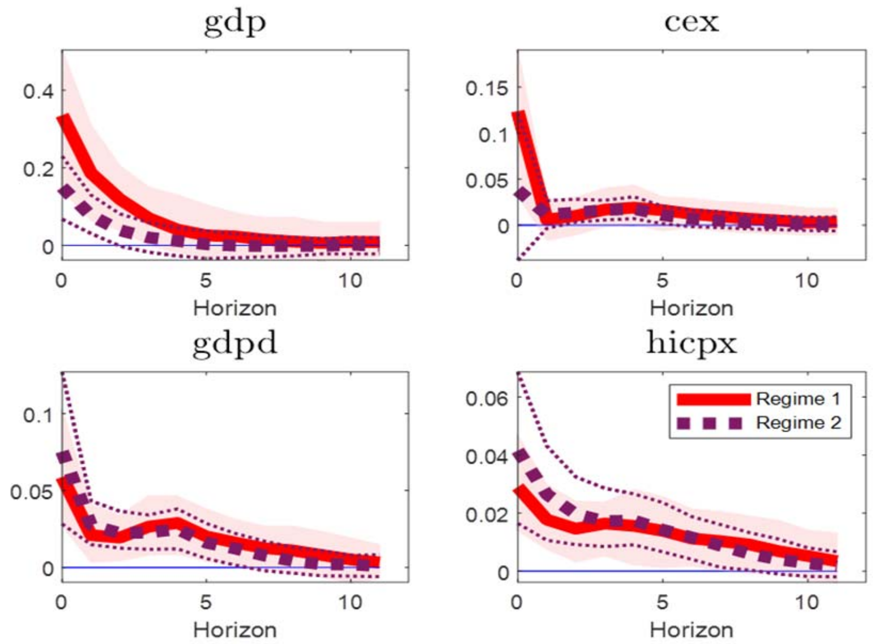
Note: The shaded areas represent the periods where real GDP growth is below the threshold.

3.2 The wage-price pass-through of a demand shock in the two growth regimes

3.2.1 Are there differences in the wage-price pass-through of a demand shock between regimes?

Figure 2 displays the estimated impact of a positive demand shock on the four variables included in the baseline model for the two growth regimes. It is worth noting in this context that while the results are shown for a positive demand shock for none of the regimes the generalised impulse responses provided empirical evidence of clearer disproportional effects with regard to the sign or the size of the shock.[4] Figure 2 includes the median impulse responses in log differences and the corresponding 68% credibility intervals for the two regimes. The dashed lines refer to the responses in the expansion regime and the red lines and shading to those in the recession regime. The magnitude of the shock corresponds to that of a typical demand shock, i.e. a one standard deviation increase in GDP, in each regime. That is, the magnitude of the shock is allowed to and does differ between the two regimes.

Figure 2: Impulse responses to a demand shock of one standard deviation in each regime
(log differences)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

[4] That is, while as mentioned above generalized impulse response functions allow for non-linearities with regard to history and, hence, the regime as well as the size and sign of the shock, no clear empirical evidence was found with regard to the latter types of non-linearities.

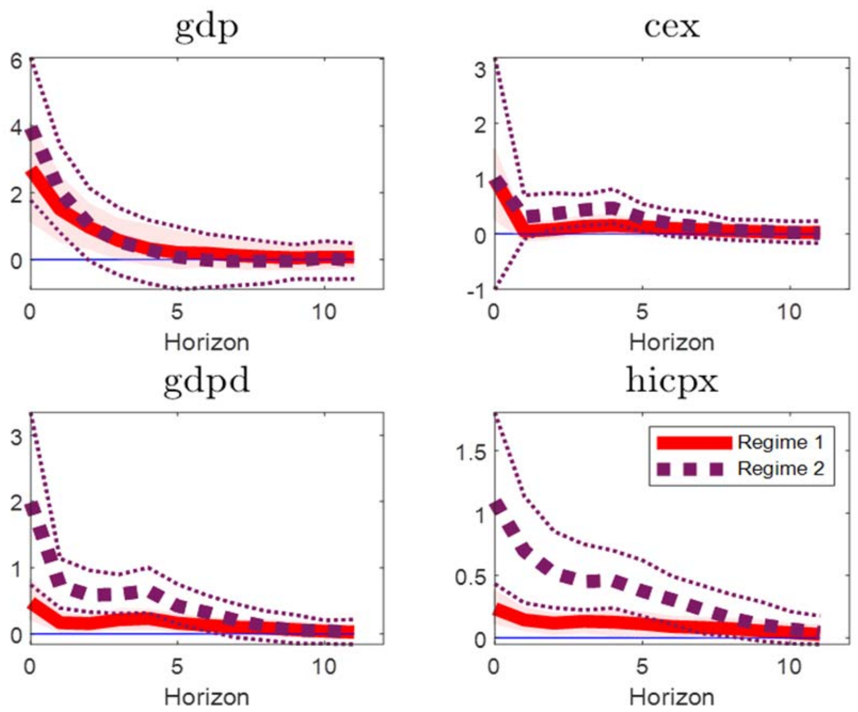
Figure 2 illustrates that a positive demand shock leads to an increase in GDP, the GDP deflator and the HICPX in both regimes as imposed by the sign restrictions for the first quarter. Without restriction compensation per employee is estimated to rise as well in the short-term in both regimes. The short-term response of compensation per employee is, however, only significantly different from zero in the recession regime. According to the median results a typical demand shock is about twice as large in the recession than in the expansion regime. The median responses to the one standard deviation shocks show a notably larger response of GDP as well as of compensation per employee to a typical demand shock in the recession regime. The median responses of both GDP and compensation per employee to the typical demand shock are in both regimes in the short term at the edge or outside the credibility intervals of the respective other regime which provides some evidence of significant differences in the responses of these variable between the two regimes to the typical demand shocks. The median responses of the GDP deflator and the HICPX are, by contrast, similar across regimes or somewhat smaller in the recession regime and not significantly different for the typical demand shocks between the two regimes.

The observed developments in the absolute responses of the variables for the two regimes imply differences in the relative responses between the variables for the two regimes. This applies in particular to the relative responses of the wage and price variables and, hence, the wage-price pass-through. The larger wage response for a typical demand shock in the recession regime combined with a similar or smaller price response indicates that the wage-price pass-through (i.e. the response of prices to a given wage response) may be lower in the recession regime than in the expansion regime.

This is illustrated further in Figures 3 and 4. For reasons of comparability in Figure 3 the responses of all variables to the one standard deviation demand shocks are normalised to correspond to the same magnitude of the response of compensation per employee (namely one) in the first quarter of the shock. Figure 3 shows that this implies also a broadly similar path of the wage response in the subsequent quarters. The median responses of the GDP deflator and the HICPX, which now show the price responses to a broadly comparable wage path and, hence, comparable developments for the wage-price pass-through, are lower in the recession regime and for both regimes outside the confidence bands of the respective other regime for a number of quarters. This provides some evidence of differences in the wage-price pass-through between the two regimes for both the price stage of domestic cost pressures represented by the GDP deflator as well as for that of core consumer prices represented by the HICPX and suggests, as indicated above, that the wage-price pass-through of a typical demand shock appears to be lower in recession than expansion periods.

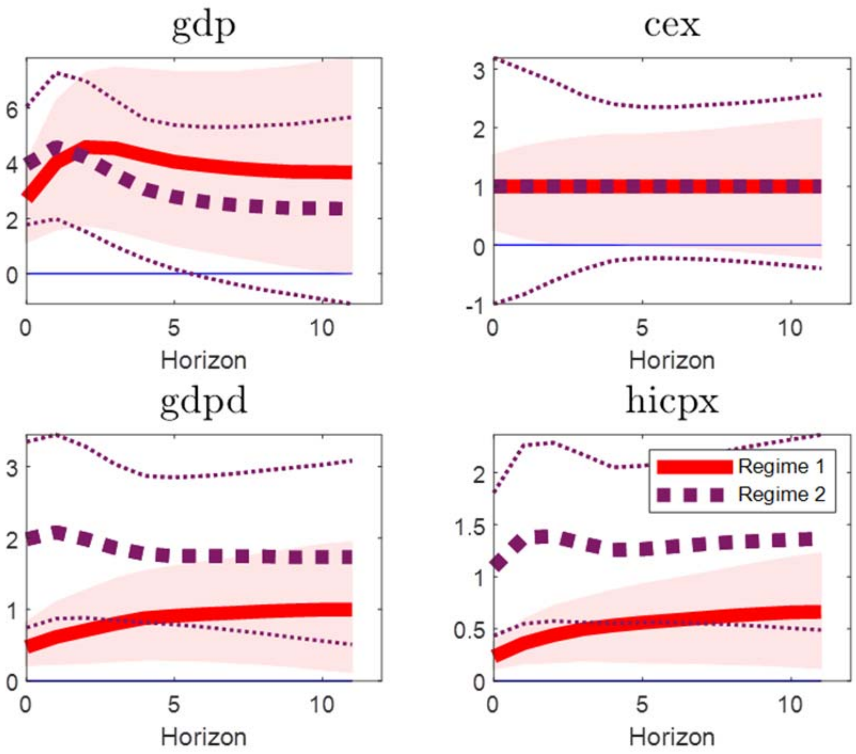
These results are confirmed in Figure 4 which shows the cumulated impulse response functions for all variables which are for reasons of comparability of the wage-price pass-through between regimes normalised to a value of one for compensation per employee in both regimes over the whole horizon. While the calculations in Figure 3 provide a proxy for the wage-price pass-through (as wages are only normalised to exactly the same value in the first period), the normalisation of compensation per employee to exactly the same value for all periods allows for an exact comparison of the differences in the wage-price pass-through between the two regimes. The results show a much smaller median response of the two price variables relative to that of wages to a demand shock in recessions than expansions which is significantly different between the two regimes for the first few quarters.

Figure 3: Impulse responses to a demand shock normalised to a one percent increase in compensation per employee on impact in each regime
(log differences)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

Figure 4: Cumulated impulse responses to a demand shock normalised to a one percent increase in compensation per employee in all periods in each regime
(log)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

3.2.2 Which variables account for the differences in the wage-price pass-through of a demand shock between regimes?

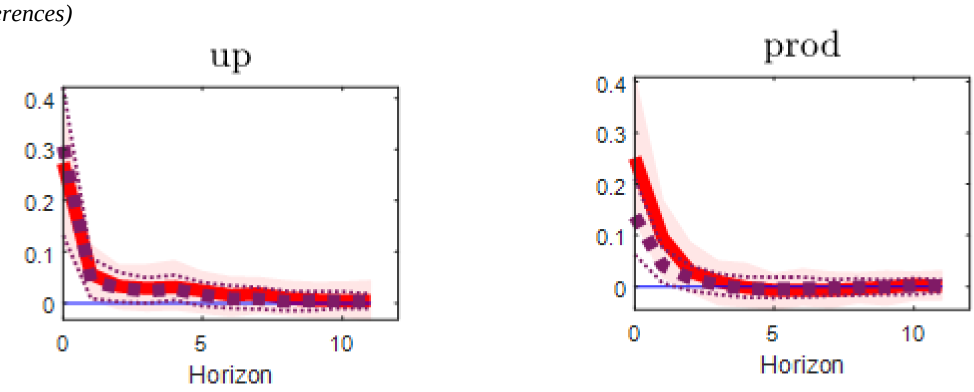
The above results provide evidence on differences in the pass-through of demand shocks from wages to prices between expansion and recession periods. They do not provide insights on the origin of these differences though. To understand what accounts for the differences in the wage-price pass-through between the two regimes, the responses of all variables that affect the wage-price pass-through along the cost side of the economy have to be analysed. Besides the wage and price variables considered above, these variables include profit margins, calculated here as profits per unit of output (or more precisely gross operating surplus per unit of real GDP), and labour productivity. To examine the responses of these two variables two slightly modified versions of the baseline model are estimated. To avoid increasing the size of the model, in the alternative models the two additional variables are individually included in the model replacing the HICPX. That is, the first alternative model includes as variables real GDP, compensation per employee, unit profits and the GDP deflator and the second alternative model is composed of the variables real GDP, compensation per employee, labour productivity and the GDP deflator.

Figure 5 shows the median impulse responses and 68% credibility intervals for unit profits and labour productivity from the two alternative models transformed in the same way as the responses of the variables of the baseline model shown in Figures 2 to 4. Figure 5a illustrates that for a typical demand shock, similar to the results for the price variables, unit profits respond in a broadly comparable way in both regimes, while similar to the results for real GDP and compensation per employee, the median response of labour productivity is larger in the recession regime. When normalised relative to the response of wages in the first quarter (Figure 5b) or in cumulated terms to the response of wages for all horizons (Figure 5c) to get insights into whether the variables contribute to the differences in the wage-price pass-through between the regimes, the normalised response of unit profits is lower in the recession regime and significantly different between the regimes in the short-term again in line with the results for the price variables, while the corresponding normalised response of labour productivity is broadly comparable between the regimes. This suggests that differences in the responses of profit margins relative to that of compensation per employee are the origin of the differences and lower wage-price pass-through in recessions compared to expansions.

Figure 5: (Cumulated) impulse responses to a demand shock

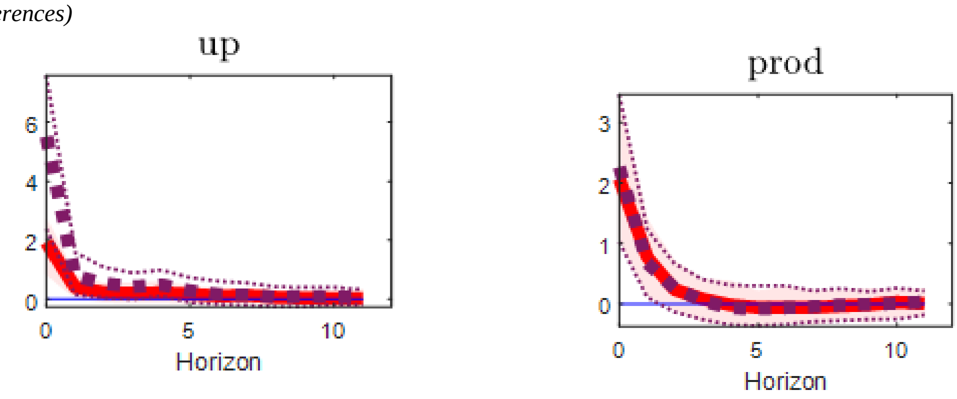
(a) Demand shock of one standard deviation in each regime

(log differences)



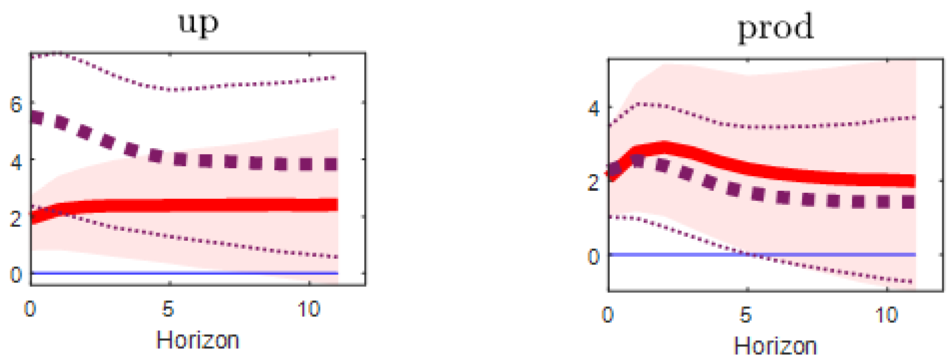
(b) Demand shock normalised to a one percent increase in compensation per employee on impact in each regime

(log differences)



(c) Demand shock normalised to a one percent increase in compensation per employee in all periods in each regime

(log)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: up refers to unit profits and prod to labour productivity.

3.2.3 Integrated representations of the wage-price pass-through of a demand shock for the two regimes

Integrated representations of the responses of all variables involved in the pass-through of the demand shocks along the cost side of the economy to the GDP deflator help to illustrate and understand the transmission mechanism of the shocks and the differences between the two regimes further. The combined representation of the impulse responses of all involved variables allows examining the dynamic interaction of the variables in the transmission mechanism of the shocks between wages and prices. In line with the above analysis, the results are reported for both the absolute responses of the variables to the respective typical demand shocks in the two regimes and the relative responses of all variables compared to the same wage response in both regimes (i.e. the wage-price pass-through), as both sets of results are instructive. Figure 6 and 7 provide such integrated representations of the transmission mechanism for the typical one-standard deviation demand shocks for the recession and expansion regimes, respectively. As shown above the magnitude of the one-standard deviation demand shocks differs between the two regimes and is about twice as large in the recession than in the expansion regime. Figures 8 and 9 provide corresponding representations of the transmission mechanism for the two regimes where the wage responses are normalised to comparable magnitudes such that the differences in the wage-price pass-through between the two regimes become visible. The results shown in these Figures refer to the median responses of the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator and, hence, the full set of variables based on which the transmission mechanism to the GDP deflator can be fully decomposed.[5]

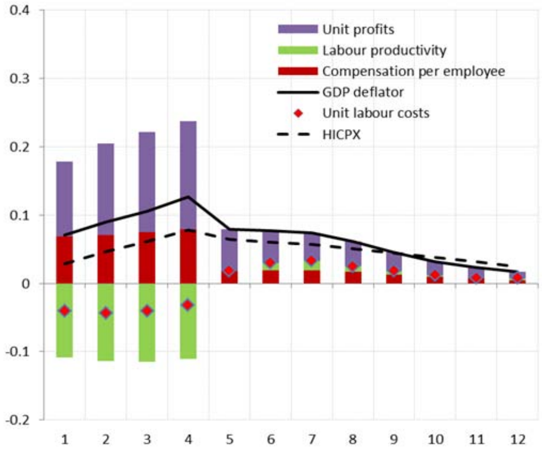
Figures 6 and 7 illustrate the above finding that the absolute price responses that are observed to the respective typical demand shocks in the two regimes are similar. This applies to the magnitude of the price response (shown in the Figures in terms of year-on-year inflation rates) as well as its persistence and evolution over time. The magnitude of the response to the shocks is also similar in both regimes for the contribution of profit margins to the price response. Differences are visible with respect to the contributions of compensation per employee and labour productivity to the price responses. These are both larger (in absolute terms) in the

[5] The response of labour productivity shown in the Figures is derived as a residual of the responses of the other variables.

recession regime than in the expansion regime. The differences in the responses of these two variables between the regimes are, however, broadly proportional such that their effects on prices, which work in opposite directions, broadly offset each other, leading to the comparable price response. The broadly offsetting differences in the responses of the variables are also visible in the similar responses of unit labour costs, which combine the impact from compensation per employee and labour productivity.

Figure 6: Pass-through of a one standard deviation demand shock between wages and the GDP deflator in the recession regime

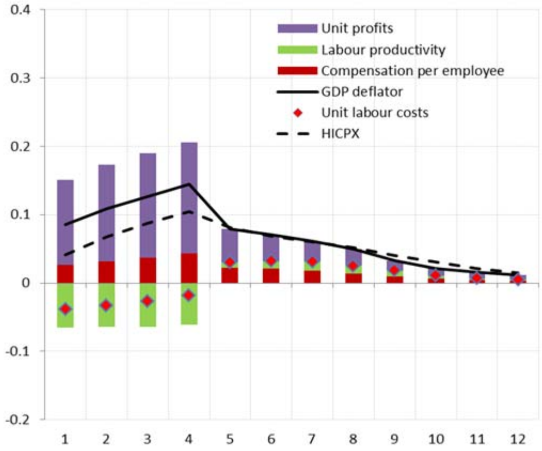
(annual percentage change, p.p. contributions)



Note: The x-axis refers to the horizon of the impulse responses in quarters. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

Figure 7: Pass-through of a one standard deviation demand shock between wages and the GDP deflator in the expansion regime

(annual percentage change, p.p. contributions)



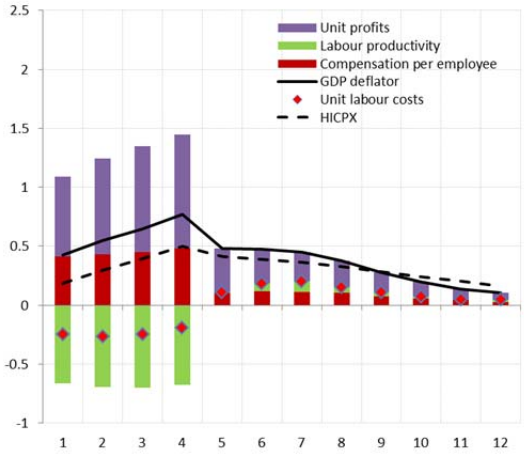
Note: The x-axis refers to the horizon of the impulse responses in quarters. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

While the results highlight that the relative magnitude of the contributions of some of the variables to the price response differ between the regimes, they also show that the general response patterns of the variables in the transmission mechanism to the demand shocks are stable across growth regimes. A stylised description of the transmission mechanism for demand shocks between wages and prices is as follows (see also Hahn (2019)): Following a positive demand shock prices are rising triggered for instance by a situation of excess demand with increased pricing power of companies and, hence, facilitated price increases. Given the increase in demand companies tend to also increase their production which is reflected in the model in an increase in real GDP. The associated higher demand for labour input triggers an increase in wages and employment. As employment, however, tends to respond more slowly than output labour productivity picks up and dampens the cost pressures. As the downward impact from labour productivity is for a number of quarters stronger than the upward price pressures from compensation per employee, unit labour costs are declining in the short term following a positive demand shock. In a situation of more favourable demand, companies will take advantage of this dampening impact and expand their profit margins. Vice versa developments are observed for a negative demand shock for which, as explained above, estimates show comparable effects. Overall, the broadly unchanged patterns of the transmission mechanism of the demand shocks across regimes suggest that these processes develop in a similar manner in both regimes.

Figures 8 and 9 provide the comparison of the wage-price pass-through of a demand shock in the two growth regimes. The integrated representations of the transmission of a demand shock between wages and prices normalised to the same wage response (in this case a 1% increase in compensation per employee over the first four quarters) in both regimes show a much smaller relative price response for recession than expansion periods. The Figures also highlight again the role of profit margins in accounting for the lower wage-price pass-through in recessions. So while profit margins and prices do not respond differently in absolute terms to the typical shocks observed in the two growth regimes, they do so in relative terms in relation to compensation per employee. But as the results above have shown what actually seems to differ between the two regimes in absolute terms appears to be the response of the real variables (GDP and labour productivity) and that of compensation per employee, which are affected by the differences in the relative magnitude of the typical demand shocks, and the latter leads to the differences in the wage-price pass-through for demand shocks between growth regimes.

Figure 8: Wage-price pass-through of a demand shock normalised to a one percent increase in compensation per employee over the first four quarters in the recession regime

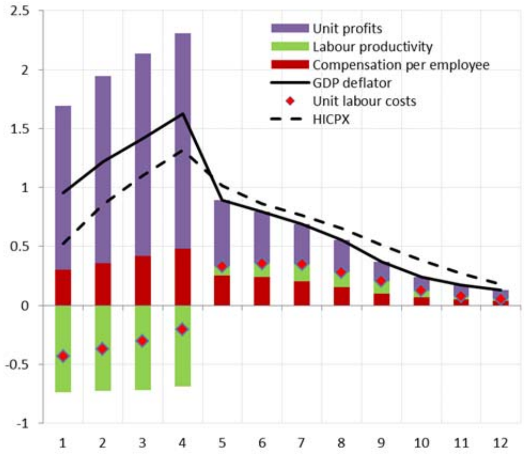
(annual percentage change, p.p. contributions)



Note: The x-axis refers to the horizon of the impulse responses in quarters. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

Figure 9: Wage-price pass-through of a demand shock normalised to a one percent increase in compensation per employee over the first four quarters in the expansion regime

(annual percentage change, p.p. contributions)



Note: The x-axis refers to the horizon of the impulse responses in quarters. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

Overall, the results suggest that one should not expect a very different absolute price response to typical demand shocks in recession than in expansion periods but broadly similar absolute price responses across regimes. Even though according to the median results the typical demand shocks are of different size and larger in recessions, the typical price response should not be expected to be larger in these periods. This is, however, what is likely to have been the expectation of many economists for instance in the period of the double dip recession in the euro area which was characterised by systematic forecast errors for inflation. As mentioned above, in this period inflation was declining by less than what was generally expected, a feature referred to as “missing disinflation”. Forecasters tended to persistently under-predict inflation in this period. The current results help to explain these developments. Forecasters may have expected a stronger decline in inflation in line with the observed stronger changes in economic activity and wages assuming a stable relationship between the variables across expansions and recessions. The results have, however, shown that the relative responses between the variables and the associated elasticities may differ between growth regimes. For the economist that tries to assess and forecast price developments taking into account the observed developments in compensation per employee it is important to know that the relationship between the variables differs between growth regimes and that a different price response should be inferred from an observed change in compensation per employee of a certain magnitude in recessions than in expansions. The results indicate that the price signal from a certain magnitude of a change in compensation per employee is smaller in recessions than expansions as the wage-price pass-through is growth regime-dependent and lower in recessions.

Finally, it is worth noting that the results for the wage-price pass-through of the demand shock for the two growth regimes are consistent with those of Hahn (2019) based on a standard BVAR model estimated over the whole period from 1999 to 2018. The magnitude of the wage-price pass-through estimated jointly for both recession and expansion periods lies in between those found for the two growth regimes estimated in the TVAR model and also the transmission patterns for the demand shock are consistent across the different models.

3.2.4 What explains the differences in the response of compensation per employee between growth regimes?

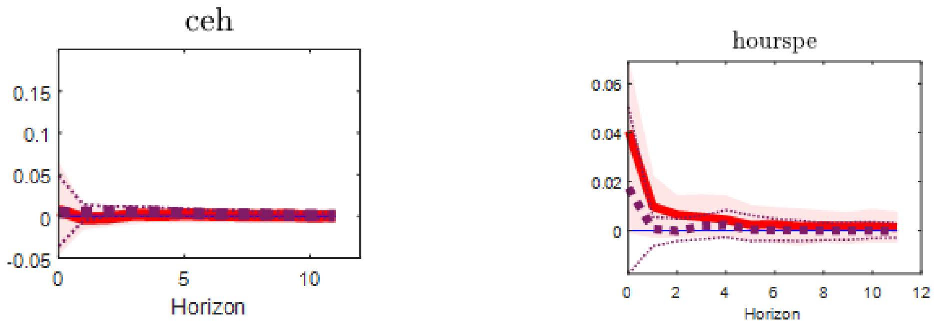
The above results have shown that the wage-price pass-through of demand shocks differs between growth regimes and that the variable that accounts for these differences as it responds differently in absolute terms in the two regimes (besides GDP and other activity variables) is compensation per employee. The question is why compensation per employee responds differently in the two growth regimes. Surprising about the differences in the responses of compensation per employee in the two regimes is that these differences are not aligned with those of the price variables but rather with those of the activity variables. Surprising is also that the response of compensation per employee is larger in recessions than expansions. Downward nominal wage rigidities would have rather pointed in the opposite direction. Recession periods are likely to be dominated by negative demand shocks for which downward nominal wage rigidities should apply, while expansion periods are to a larger extent characterised by positive demand shocks for which these are not binding. One might therefore have expected the median response of compensation per employee to be rather smaller in the recession than in the expansion regime. The simulations suggest, however, also that the results do not hinge on the sign of the shocks. As mentioned above the empirical results do not point to asymmetries in the responses of compensation per employee to positive and negative demand shocks but only to differences in the responses between the two growth regimes such that other sources than nominal downward wage rigidities must be at play.

Insights into the sources of the differences of the responses of compensation per employee in the two regimes are gained by analysing the behaviour of its two components, compensation per hour and average hours worked per employee. To that aim, the responses of these two components to a demand shock in the two growth regimes are estimated. This is done by substituting in the baseline model (which includes as variables real GDP, compensation per employee, the GDP deflator and HICPX) the variable compensation per employee by compensation per hour and average hours worked per employee, respectively.

The median impulse responses to typical demand shocks in the two regimes show that compensation per hour responds little to the demand shocks and develops similarly in the two regimes, while average hours worked per employee appear to respond more strongly in recessions than in expansions (see Figure 10). The responses of compensation per hour are not significantly different between the two regimes. At the same time, there is some but weak evidence of significant differences in the responses of average hours worked per employee between the regimes. At the horizons 1 to 3 quarters following the shock, the responses are close to the edge or outside the credibility intervals of the respective other regime.

In sum, the results suggest that the source of the differences in the responses of compensation per employee between expansions and recessions to typical demand shocks appears to be the response of average hours worked per employee. The typical demand shock is associated with a stronger change in average hours worked per employee in recessions than expansions. This finding explains also why compensation per employee responds more in line with the activity than the price variables in the two regimes. This is the case as its activity-related component accounts for the differences across regimes and behaves in line with the other activity variables.

Figure 10: Impulse responses of compensation per hour and average hours worked to a demand shock of one standard deviation in each regime
(log differences)

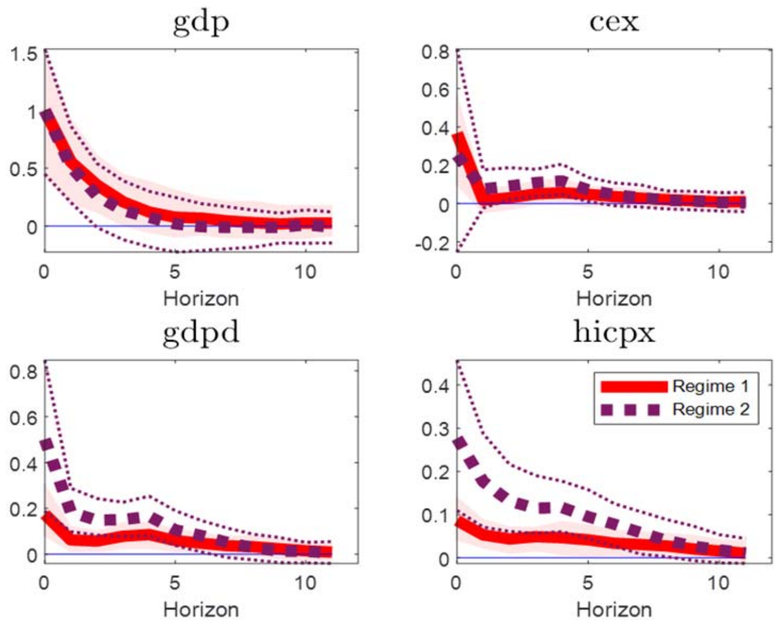


Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: ceh refers to compensation per hour and hourspe to average hours worked per employee. The results for compensation per hour are from the model that includes as variables real GDP, compensation per hour, the GDP deflator and the HICPX. The results for average hours worked per employee are from the model that includes as variables real GDP, average hours worked per employee, the GDP deflator and the HICPX.

3.2.5 Implications for the price and wage Phillips curves

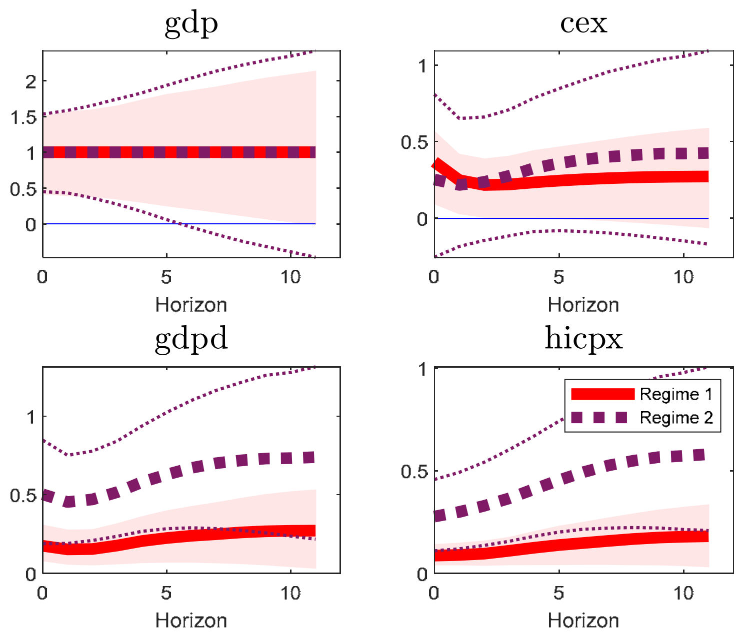
The results show differences in the relative responses of the variables between growth regimes for compensation per employee and prices, i.e. the wage-price pass-through. The results indicate that such differences between growth regimes apply also to the relationship between the activity and price variables. The results, hence, also provide insights into the Phillips curve relationship in the euro area with different implications for the wage and price Phillips curves. The broadly proportional responses of real GDP and compensation per employee across the two regimes suggest that the wage Phillips curve, which is typically analysed in the euro area in terms of compensation per employee, is about stable across growth regimes. The differences in the relative responses between the activity and price variables, by contrast, hint at differences in the slope of the price Phillips curve between recessions and expansions with a decrease in the slope coefficient during recessions on account of the lower wage-price pass-through. This is illustrated in Figures 11 and 12 in which the responses of all variables in the model are normalised on those of GDP on impact or for all horizons, correspondingly to what has been done above in the analysis of the wage-price pass-through for compensation per employee. Figures 13 and 14, moreover, provide corresponding integrated representations on the link between the activity, wage and price variables for comparable magnitudes of GDP shocks in the two regimes highlighting again the stability of the wage Phillips curve across the two growth regimes and the flattening of the price Phillips curve on account of the lower relative response of profit margins in the recession regime. The finding of a flatter price Phillips curve in recessions than expansions is consistent with the results of Gross and Semmler (2017) based on estimates of a series of singe equation regime-switching Phillips curve models for the euro area and individual countries.

Figure 11: Impulse responses to a demand shock normalised to a one percent increase in real GDP on impact in each regime
(log differences)



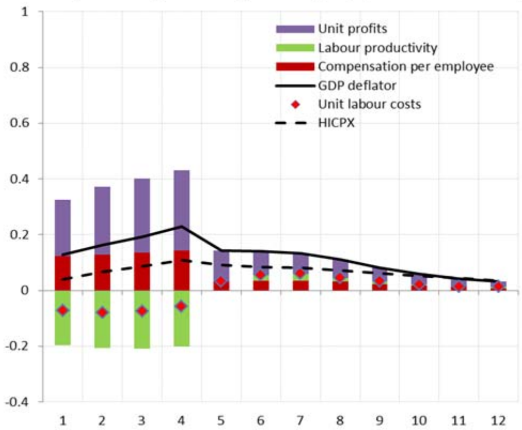
Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

Figure 12: Cumulated impulse responses to a demand shocks normalised to a one percent increase in real GDP in all periods in each regime
(log)



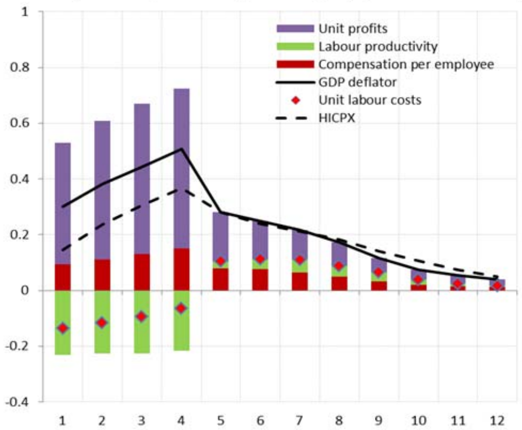
Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

Figure 13: Pass-through of a demand shock (normalised to a one percent increase in real GDP over the first four quarters) to wages and the GDP deflator in the recession regime
(annual percentage change, p.p. contributions)



Note: The x-axis refers to the quarters following the shock. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

Figure 14: Pass-through of a demand shock (normalised to a one percent increase in real GDP over the first four quarters) to wages and the GDP deflator in the expansion regime
(annual percentage change, p.p. contributions)

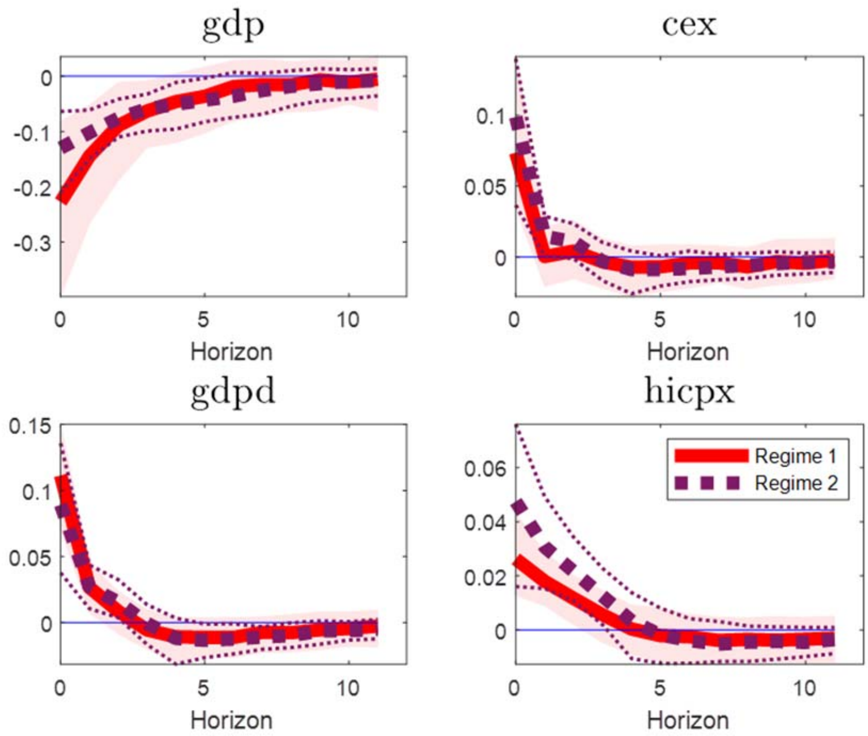


Note: The x-axis refers to the quarters following the shock. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

3.3 The wage-price pass-through of a wage mark-up shock in the two growth regimes

This section presents the results on the wage-price pass-through of the wage mark-up shock in the two growth regimes. Figure 15 displays the estimated impact of a positive one standard deviation wage mark-up shock on the four variables of the baseline model in the two growth regimes. Note again that while the results are shown for a positive wage mark-up shock, as for the demand shock, the generalised impulse responses to the wage mark-up shock in the two regimes did not provide empirical evidence of clearer disproportional effects with regard to the sign or the size of the shock.

Figure 15: Impulse responses to a wage mark-up shock of one standard deviation in each regime
(log differences)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

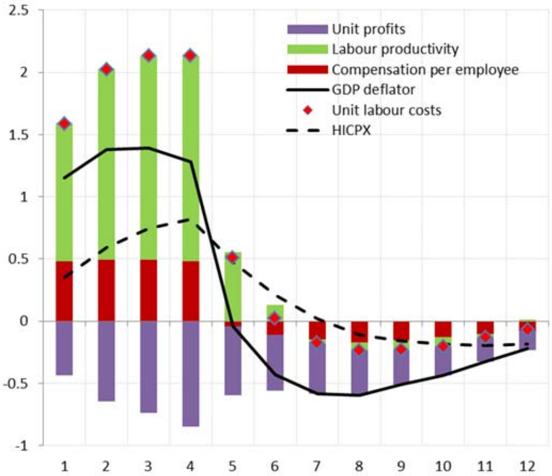
Figure 15 illustrates that the positive wage mark-up shock decreases GDP and lifts compensation per employee as well as the two price variables as imposed by the sign restrictions for the first quarter. Different to the demand shock, the typical wage mark-up shock is of comparable magnitude in the two growth regimes and slightly larger in the expansion than the recession regime. There are some differences in the median responses of all variables between the two regimes. However, in contrast to the results found for the demand shock, none of them appear significant even though the typical wage mark-up shocks in the two regimes are of comparable size. The results, hence, do not point to differences in the wage-price pass-through of the wage mark-up shock in the two growth regimes. This is highlighted further in the Figures A1 and A2 in Appendix 1, where for reasons of comparability the responses of all variables have been normalised to those of compensation per employee in the first quarter and over the whole horizon, respectively, as has been done for the demand shock before.

As for the demand shock, the additional models including unit profits and labour productivity were used to assess the impact of the wage mark-up shock also on these variables which are part of the wage-price transmission mechanism along the cost side of the economy. The results for these two variables were likewise not found to be significantly different in the two growth regimes for the wage mark-up shock (see Figure A3 in Appendix 1). Although the differences in the responses of the two variables for the two growth regimes are not significant, the transmission patterns of the wage mark-up shock found in the integrated representations for the two growth regimes are interesting and worth looking at (see Figures 16 and 17). Hahn (2019) found based on estimates for the whole period of 1999 to 2018 that profit margins buffer part of the labour cost pressures in case of a wage mark-up shock. The median responses for the two growth regimes suggest that this appears to be mainly the case in the recession regime where the upward price pressures from the loss in labour productivity appear larger, while in the expansion regime the labour cost pressures seem to be initially fully passed through to prices and only with some delay buffered somewhat by profit margins.

Finally, for completeness the responses of compensation per hour and average hours worked per employee from the alternative models developed above were explored. As for the other variables also the results for these two variables were not found to be significantly different in the two growth regimes for the wage mark-up shock (see Figure A4 in Appendix 1).

Figure 16: Wage-price pass-through of a wage mark-up shock normalised to a one percent increase in compensation per employee over the first four quarters in the recession regime

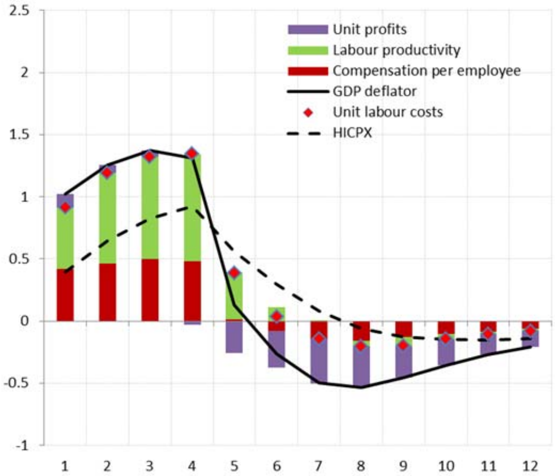
(annual percentage change, p.p. contributions)



Note: The x-axis refers to the horizon of the impulse responses in quarters. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

Figure 17: Wage-price pass-through of a wage mark-up shock normalised to a one percent increase in compensation per employee over the first four quarters in the expansion regime

(annual percentage change, p.p. contributions)



Note: The x-axis refers to the horizon of the impulse responses in quarters. It is assumed that indirect taxes net of subsidies respond proportionally to real GDP such that this component does not contribute to the changes in the GDP deflator. The decomposition is based on the results from the model which includes as variables real GDP, compensation per employee, unit profits and the GDP deflator. The results for the HICPX are from the baseline model.

4. CONCLUSIONS

Since the great financial crisis inflation developments have posed major puzzles to economists as inflation declined by less than was widely expected during the past recessions and rose by less during the subsequent recoveries. This paper analyses whether the wage-price pass-through may have contributed to these inflation puzzles. Previous analyses have shown that the wage-price pass-through relationship is highly complex. The relationship is shock-dependent, it seems to have changed over time and appears to depend on certain states of the economy. The present paper adds to the analyses of state-dependence of the wage-price pass-through and explores whether the transmission mechanism between wages and prices in the euro area is affected by the growth regime and differs between recessions and expansions. The state-dependence of the wage-price pass-through on the growth regime is examined by applying the TVAR model proposed by Alessandri and Mumtaz (2017) to the link between wages and prices in the euro area. As in Hahn (2019) demand and wage mark-up shocks are identified based on sign restrictions. The TVAR model then allows analysing the wage-price pass-through of these types of shocks for different levels of GDP growth, i.e. for expansions and recessions.

The main results of the paper can be summarized as follows: The TVAR model provides estimates of two growth regimes in the euro area, a recession and an expansion regime, for the period of the European monetary union. The estimated recession periods correspond closely to those identified by the CEPR. The empirical results point to differences in the wage-price pass-through between expansions and recession for demand shocks but not for wage mark-up shocks. For demand shocks, the response to a typical one standard deviation shock, which differs in magnitude across regimes and is larger in recessions, is found to be bigger in recessions than expansions for real GDP and compensation per employee but to be similar for the considered price variables. In terms of the relative movements of the variables, the results show a much smaller response of prices relative to wages, i.e. a smaller wage-price pass-through, for demand shocks in recessions than expansions. This is accounted for by a smaller relative response of profit margins in recessions.

Both the absolute responses of the variables to typical demand shocks and the relative responses of the variables in the two regimes are instructive. The results suggest that one should not expect a very different, i.e. stronger, absolute price response in recessions than expansions despite the much larger typical demand shock in recessions. Such expectations appear, however, to have prevailed and may have led to the expectation of a stronger disinflation than observed in the context of the great financial crisis and sovereign debt crisis and, hence, to the notion of "missing disinflation". The results, however, indicate that important elasticities change between recessions and expansions. The price signal of a certain magnitude of change in compensation per employee, i.e. the wage-price pass-through, is smaller in recessions than in expansions and, hence, prices should be expected to recede by less relative to compensation per employee in a recession.

The analysis, moreover, provides insights into why compensation per employee responds more strongly in absolute terms in recessions than in expansions, similarly to the activity variables and in contrast to the price variables, and thereby induces the lower wage-price pass-through. This behaviour is at first glance surprising in the context of the notion of downward nominal wage rigidity. More detailed analyses highlight that the behaviour of compensation per employee reflects that of its activity component, average hours worked, while the response of compensation per hour is consistent with that of prices and similar across regimes.

Finally, similar differences between growth regimes appear to apply also to the price and activity variables and, hence, the Phillips curve relationship in the euro area but there are different implications for the price and the wage Phillips curves. Broadly proportional responses of activity variables and compensation per employee across regimes suggest that the wage Phillips curve is about stable across regimes, while differences in the responses of activity variables and prices between regimes suggest that the slope of the price Phillips curve depends on the growth regime and flattens in recessions compared to expansions on account of the lower wage-price pass-through.

All in all, the analysis contributes to solve or diminish the puzzle of the "missing disinflation" in the past two recessions. A lower wage-price pass-through of demand shocks in recessions than expansions inducing a flattening of the price Phillips curve in recessions may have been the source of these developments. Differences in the elasticities between real and price variables for demand shocks between recessions and expansions account for the lower relative response in inflation in recessions than expansions. More generally, there appears to be a kind of dichotomy between the developments in real and price variables in response to demand shocks in recessions compared to expansions as real variables respond much more strongly in these periods consistent with the larger demand shocks while price variables show rather similar absolute responses to those in expansions. With regard to the current situation, the results should help in forecasting inflation in the unfolding 2020 recession. Although each recession is different and with regard to the current situation in particular the mix of supply and demand shocks may be peculiar, the results suggest that inflation should be expected to recede by less than indicated by standard linear models.

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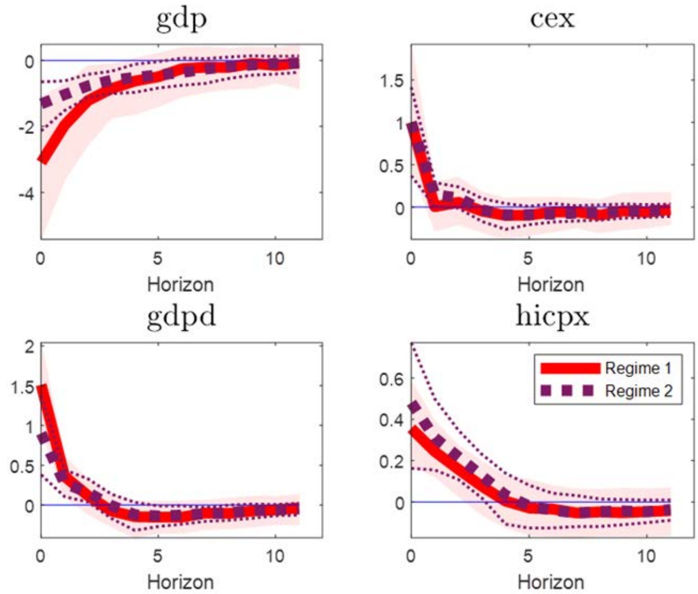
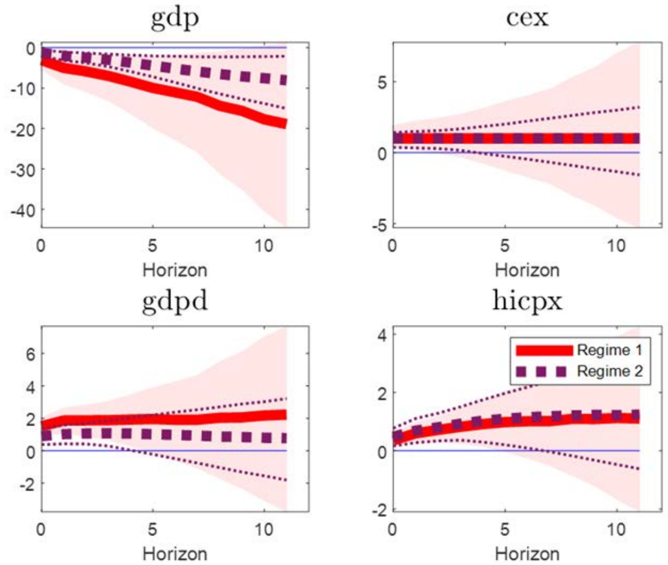
Appendix 1:

Figure A1: Impulse responses to a wage mark-up shock normalised to a one percent increase in compensation per employee on impact in each regime
(log differences)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

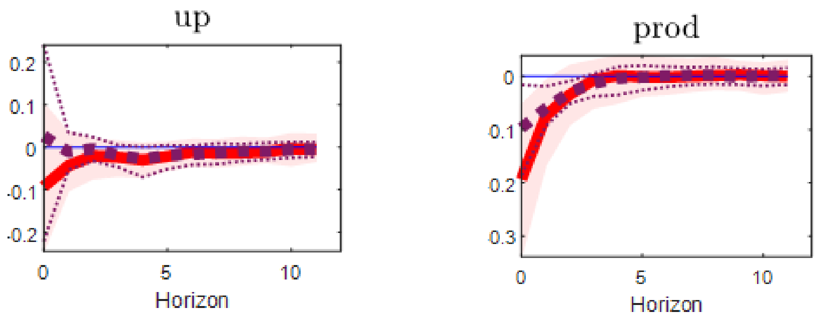
Figure A2: Cumulated impulse responses to a wage mark-up shock normalised to a one percent increase in compensation per employee in all periods in each regime
(log)



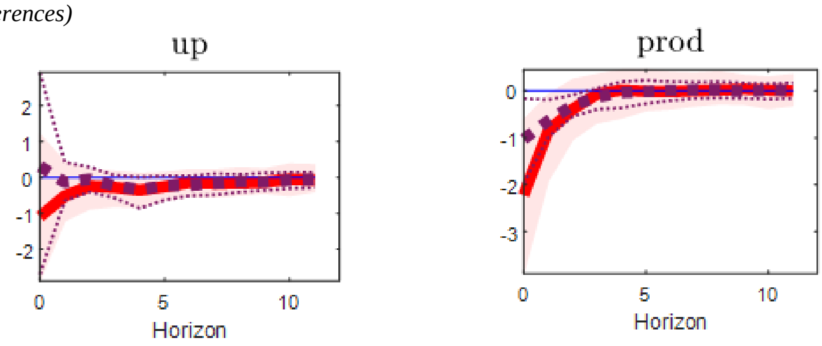
Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: gdp refers to real GDP, cex to compensation per employee, gdpd to the GDP deflator and hicpx to the HICPX.

Figure A3: (Cumulated) impulse responses to a wage mark-up shock

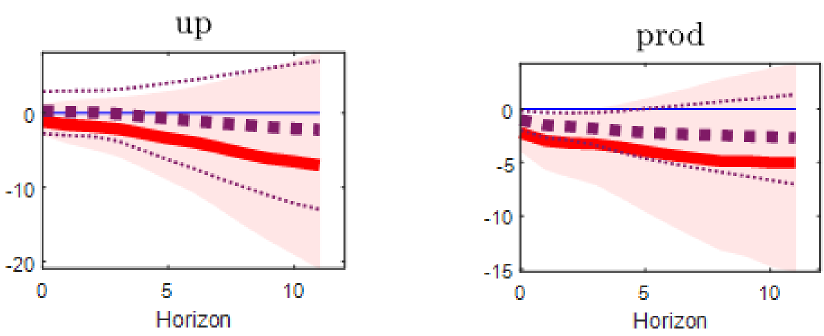
(a) Wage mark-up shock of one standard deviation in each regime
(log differences)



(b) Wage mark-up shock normalised to a one percent increase in compensation per employee on impact in each regime
(log differences)

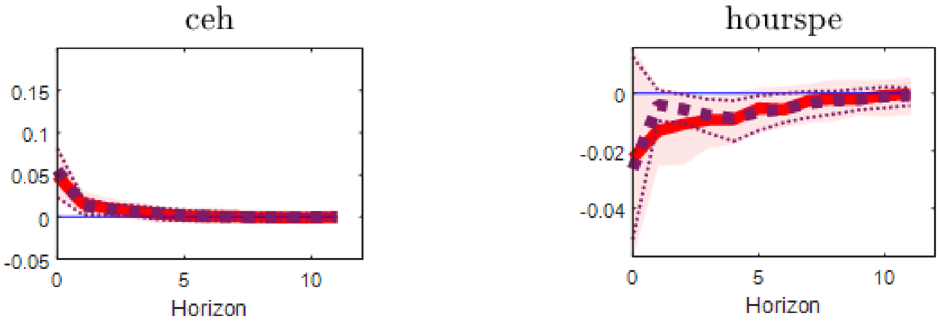


(c) Wage mark-up shock normalised to a one percent increase in compensation per employee in all periods in each regime
(log)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: up refers to unit profits and prod to labour productivity.

Figure A4: Impulse responses of compensation per hour and average hours worked to a one standard deviation wage mark-up shock in each regime
(log differences)



Notes: The x-axis refers to the horizon of the impulse responses in quarters. Note the following abbreviations in the Figures: ceh refers to compensation per hour and hourspe to average hours worked per employee. The results for compensation per hour are from the model that includes as variables real GDP, compensation per hour, the GDP deflator and the HICPX. The results for average hours worked per employee are from the model that includes as variables real GDP, average hours worked per employee, the GDP deflator and the HICPX.

Appendix 2:

The estimation of the TVAR model follows the approach applied by Alessandri and Mumtaz (2017). As described in Alessandri and Mumtaz (2017), a natural conjugate prior is imposed on the TVAR parameters of equation (1) via dummy observations as proposed by Sims and Zha (1998) and Banbura et al. (2010):

$$Y_{D,1} = \begin{pmatrix} diag(\gamma_1\sigma_1 \dots \gamma_N\sigma_N)/\tau \\ 0_{N(P-1)\times N} \\ \dots\dots\dots\dots\dots\dots\dots\dots \\ diag(\sigma_1 \dots \sigma_N) \\ \dots\dots\dots\dots\dots\dots\dots\dots \\ 0_{1\times N} \end{pmatrix}, \text{ and } X_{D,1} = \begin{pmatrix} J_P \otimes diag(\sigma_1 \dots \sigma_N)/\tau & 0_{NP\times 1} \\ \dots\dots\dots\dots\dots\dots\dots\dots & \\ 0_{N\times NP} & 0_{N\times 1} \\ \dots\dots\dots\dots\dots\dots\dots\dots & \\ 0_{1\times NP} & c \end{pmatrix} \quad \text{(A1)}$$

where $\gamma_1 \; to \; \gamma_N$ represent the prior means for the coefficients on the first lag, $\sigma_1 \; to \; \sigma_N$ denote the scaling factors, τ is the tightness of the prior on the TVAR coefficients, c is the tightness of the prior on the constant term and $J_P = diag(1, 2 \dots, P)$. The prior means are the OLS estimates of the coefficients of an AR(1) regression which is estimated for each endogenous variable using a training sample and the scaling factors correspond to the standard deviation of the error terms from these AR(1) regressions. In line with Alessandri and Mumtaz (2017) the tightness of the prior on the TVAR coefficients is set to $\tau = 0.1$ and a flat prior is chosen for the constant setting c$= 1/10000$.

A prior is set also on the sum of the lagged dependent variables by adding the following dummy observations:

$$Y_{D,2} = (diag(\gamma_1\mu_1 \dots \gamma_N\mu_N)/\lambda, \text{ and } X_{D,2} = ((1_{1\times P}) \otimes diag(\gamma_1\mu \dots \gamma_N\mu_N)/\lambda \;\; 0_{N\times 1}) \quad \text{(A2)}$$

where μ_i is the sample means of the endogenous variables calculated based on the training sample and the tightness of the sum of coefficients prior is chosen to be $\lambda = 10\tau$ as in Alessandri and Mumatz (2017) and Banbura et al (2010). The priors on the TVAR parameters are set to be identical for the two regimes, which ensures that any differences between regimes reflect the data and not the prior.

A flat prior is chosen for the delay d and the maximum delay is set to 4. Finally, a normal prior is applied for the threshold $z^* \sim N(\bar{z}, \bar{v})$, where $\bar{z} = 1/T \sum_{t=1}^{T} z_t$ and $\bar{v} = 10$, which is rather loose considering the scale of real GDP.

The Gibbs sampling algorithm of Chen and Lee (1995) is used to estimate the TVAR model. To that aim, the data are split into regime specific observations. Given an initial value for

z^* and d, the conditional posterior distribution for the VAR parameters $B = vec([c, B_1; B_2 \dots; B_P])$ and Ω in the two regimes is standard in view of the applied natural conjugate prior and given by $G(B|\Omega) \sim N\left(B^*, \Omega \otimes \left(X^{*\prime} X^*\right)^{-1}\right)$ and $G(\Omega|\mathrm{B}) \sim IW(S^*, T^*)$. The posterior means are $B^* = \left(X^{*\prime} X^*\right)^{-1} \left(X^{*\prime} Y^*\right)$ and $S^* = (Y^* - X^*)\,\tilde{B}'\left(Y^* - X^* \tilde{B}\right)$, where $Y^* = \left[Y; Y_{D,1}; Y_{D,2}\right]$ and $X^* = \left[X; X_{D,1}; X_{D,2}\right]$ and $\tilde{B}$ is the draw of the VAR coefficient B reshaped to conform with X^* and T^* denotes the number of rows of Y^* (see Alessandri and Mumtaz (2017)).

Given a draw for the VAR parameters and a value for d, the threshold value z^* can be drawn from its non-standard posterior in a random walk Metropolis Hastings step. A candidate value of z^*_{new} is drawn from $z^*_{new} = z^*_{old} + \psi^{1/2}\epsilon$, $\epsilon \sim N(0,1)$. The acceptance probability is $f(Y_t|z^*_{new}, \Xi)/f(Y_t|z^*_{old}, \Xi)$. $f(.)$ represents the posterior density and Ξ includes all other parameters in the model. The scaling factor ψ is chosen such that the acceptance rate lies between 20% and 40%.

Following Chen and Lee (1995) the conditional posterior of the delay parameter d is a multinomial distribution with probability $L(Y_t|d, \Xi)/\sum_{d=1}^{4} L(Y_t|d, \Xi)$, where $L(.)$ represents the likelihood function. The model is estimated based on 20000 iterations of the Gibbs sampler with a 15000 iterations burn-in phase.

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