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Sources of post-pandemic inflation in Germany and the euro area: An application of Bernanke and Blanchard (2023)

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Non-technical summary

Research Question

Over the past two years, the rate of inflation has risen exceptionally sharply worldwide, which has come as a surprise to academics, market participants and central banks alike. In order to avoid similar surprises in the future, it is very important to better understand the reasons for this rise. Our paper makes a contribution to this.

Contribution

We use a stylised macroeconomic model recently proposed by Bernanke and Blanchard (2023) in which inflation, wages and inflation expectations influence each other. We estimate the model originally developed for the US for Germany and in a panel approach for the euro area. Based on the estimates, we calculate impulse-response functions, historical decompositions and conditional projections of future inflation and wage developments.

Results

According to our results, the rise in the inflation rate in Germany and the euro area since the outbreak of the COVID19-pandemic is largely attributable to energy price shocks, food price shocks and supply bottlenecks. The tightness of labour markets reinforced this effect indirectly via wage dynamics, although the overall impact was less pronounced. Inflation expectations, particularly in the short term, were also influenced by commodity prices and shortages, but overall showed no signs of deanchoring. We find no evidence so far for a wage-price spiral as measured by an additional influence of high inflation rates in the past on current wage settlements. Assuming a gradual decline in labour market shortages and no further commodity price shocks, the model suggests a gradual decline in inflation in the future.

Nichttechnische Zusammenfassung

Fragestellung

In den letzten zwei Jahren ist die Inflationsrate weltweit außergewöhnlich stark gestiegen, was sowohl für Wissenschaftler, Marktteilnehmer und Zentralbanken überraschend kam. Um in der Zukunft ähnliche Überraschungen zu vermeiden, ist es von großer Wichtigkeit, die Gründe für diesen Anstieg besser zu verstehen. Hierzu liefert unser Papier einen Beitrag.

Beitrag

Wir verwenden ein kürzlich von Bernanke and Blanchard (2023) vorgeschlagenes stilisiertes makroökonomisches Modell, in dem sich Inflation, Löhne und Inflationserwartungen gegenseitig beeinflussen. Wir schätzen das ursprünglich für die USA entwickelte Modell für Deutschland und in einem Panelansatz für den Euroraum. Basierend auf den Schätzungen berechnen wir Impuls-Antwort-Folgen, historische Zerlegungen und konditionierte Projektionen über den zukünftigen Verlauf der Inflations- und Lohnentwicklung.

Ergebnisse

Basierend auf unseren Schätzungen ist der Anstieg der Inflationsrate in Deutschland und im Euroraum seit Ausbrauch der Corona-Pandemie zum Großteil auf Energiepreisschocks, Nahrungsmittelpreisschocks und Lieferengpässe zurückzuführen. Die hohe Auslastung auf den Arbeitsmärkten verstärkte diesen Effekt indirekt über die Lohndynamik, allerdings war der Einfluss insgesamt geringer. Die Inflationserwartungen, insbesondere in der kurzen Frist, wurden zwar ebenfalls von Rohstoffpreisen und Knappheiten beeinflusst, zeigten aber insgesamt keine Anzeichen einer Entankerung. Wir finden bisher keine Evidenz für eine Lohn-Preis-Spirale gemessen an einem zusätzlichen Einfluss von hohen Inflationsraten in der Vergangenheit auf die gegenwärtigen Lohnabschlüsse. Unter der Annahme eines schrittweisen Rückgangs der Arbeitsmarktknappheiten sowie ohne weitere Rohstoffpreisschocks suggeriert das Modell einen graduellen Rückgang der Inflationsrate in den der Zukunft.

Sources of Post-Pandemic Inflation in Germany and the Euro Area: An Application of Bernanke and Blanchard (2023)*

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Abstract

We use a simple macroeconomic model proposed by Bernanke and Blanchard (2023) to investigate the reasons for the recent sharp rise in inflation. Applied to Germany and the euro area, the model suggests that the surge in inflation has mainly been caused by commodity price shocks and supply bottlenecks, rather than shortages in the labour market. Inflation expectations were found to be well-anchored and evidence for a wage-price spiral is scarce. The model predicts a gradual decline in future inflation rates. However, this prediction is based on the assumption that there will be no commodity price shocks and that the labour market will cool down.

Keywords: Inflation, wages, inflation expectations, Phillips curve.

JEL codes: E3, J3, D84, C33

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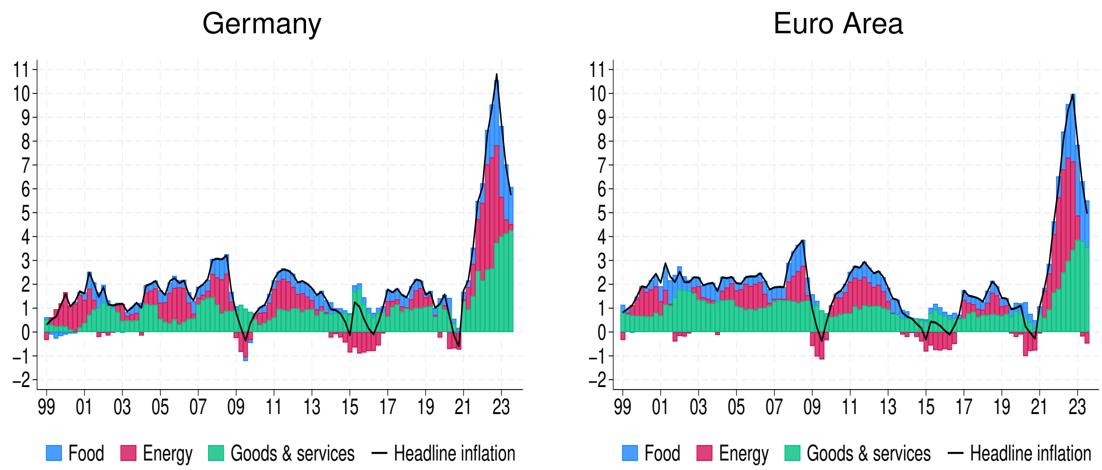
1 Introduction

In the fourth quarter of 2019, on the eve of the COVID-19 pandemic, the German inflation rate was 1.2%, slightly below its pre-pandemic average of 1.5%. Similarly, euro area inflation was 1.0%, 0.7 percentage points below average. When the crises hit, headline inflation fell below zero mainly as a result of the collapse in oil prices. Then, starting already in 2021 and reinforced by Russia's invasion of Ukraine in early 2022, inflation gradually declined, reaching an unprecedented peak of 10.8% in Germany and 10.0% in the euro area in the fourth quarter of 2022. Initially, this increase was driven by energy prices, followed by goods and services prices and food prices (see figure 1). More recently, the impact of the energy subcomponent has diminished, but price pressures, particularly from food and the core components, are still considerable.

Figure 1: Headline inflation and major subcomponents



Note: The figure shows the year-on-year inflation rates (% change) of the unadjusted quarterly HICP together with the contributions of the three main sub-components in Germany and the euro area.

This paper aims to identify the main drivers of inflation in Germany and the euro area since the pandemic. The impact of the pandemic and the war is evident, but it is unclear which transmission channels were most important. Explanations range from supply chain bottlenecks (Di Giovanni, Kalemli-Özcan, Silva, and Yildirim, 2022; Neri, Busetti, Conflitti, Corsello, Delle Monache, and Tagliabraccci, 2023) to loose monetary policy (Gagliardone and Gertler, 2023; Reis, 2022) and fiscal stimulus packages to cope with COVID-19 (Di Giovanni, Kalemli-Özcan, Silva, and Yildirim, 2023; De Soyres, Santacreu, and Young, 2022). Some companies have been accused of 'greedflation', attempting to overcompensate for losses incurred during the pandemic (DePillis, 2022; Storm, 2023, Weber and Wasner, 2023). Others mention commodity price shocks (Gagliardone and Gertler, 2023; Ball, Leigh, and Mishra, 2022), reallocation of demand from services to goods (Ferrante, Graves, and Iacoviello, 2023) and tight labour markets (Benigno and Eggertsson, 2023, 2024).

We contribute to this literature by using an approach recently proposed by Bernanke and Blanchard (2023).[1] They build a simple model consisting of four equations for wages, inflation, and short-term and long-term inflation expectations. When applied to the US, the model fits inflation very well, suggesting that it was first been driven by commodity prices followed by a slow but persistent impact of labour market tightness.

The contribution of this paper is twofold. First, we fit the model to Germany, keeping the model structure and data as close as possible to the original specification used by Bernanke and Blanchard (2023). In contrast to the US, and despite an ongoing trend towards de-unionisation, the wage-setting process in Germany is still highly institutionalised. As a result, we focus mainly on negotiated wages, but the results are similar for compensation measures. Second, we apply the model to the euro area. Since the wage-setting process largely depends on national institutional frameworks and practices, we estimate the model at the country level within a panel setup. Due to data limitations, we have used the unemployment rate instead of the vacancy-unemployment ratio. We have also focused on compensation measures in addition to negotiated wages and have used inflation expectations as a proxy in some countries. Of course, this simple panel approach neglects many country-specific issues that are important for explaining inflation, wages and inflation expectations. These features are analysed in great detail in Aldama, Le Bihan, and Le Gall (2024) for France, Pisani and Tagliabracci (2024) for Italy, Ghomi, Hutardo, and Manuel (2024) for Spain, and De Walque and Lejeune (2023) for Belgium.[2] Arce, Ciccarelli, Kornprobst, and Montes-Galdón (2024) also provide evidence for the euro area by estimating the model directly at the aggregate level. This has the advantage that they do not have to deal with the problem of how to combine country results derived from different specifications and do not face data limitations in some countries. By contrast, using a panel approach for the euro area can be useful in two way. First, it allows for the impact of country-specific changes in the underlying variables that are ignored when the model is estimated directly at the euro area aggregate. Second, a key conclusion from the various country studies is that wage growth is largely determined by country-specific characteristics, while inflation has behaved rather similarly across member states. Therefore, we believe that estimating a euro area panel is a good compromise between specifying an elaborate model for each country, which makes it difficult to aggregate to the euro area and estimating a single model for the euro area which neglects the country dimension.

The main results of this exercise can be summarised as follows:

1. Since the pandemic, inflation in Germany and the euro area has been driven mainly by energy price shocks, food price shocks and supply bottlenecks. The impact of commod-

[1] Assessing the full set of explanations is beyond the scope of this paper. For instance, quantifying the impact of greedflation would require the use of firm-level data, which are not available in Germany. Recent studies for Canada (Bouras, Bustamante, Guo, and Short, 2023; Bilyk, Grieder, and Khan, 2023) and Belgium (Bijnens, Duprez, and Jonckheere, 2023) have found no evidence of greedflation. For more details on this debate, see De Loecker, Eeckhout, and Unger (2020) and Conlon, Miller, Otgon, and Yao (2023).

[2] The model has also been applied by Haskel, Martin, and Brandt, 2023 to the United Kingdom, by Bounajm, Junior Roc, and Zhang (2024) to Canada and by Nakamura, Nakano, Osada, and Yamamoto, 2024 to Japan. Bernanke and Blanchard (2024) offer a short summary of comparing the model results across the different countries.

ity prices has been large but rather temporary, while the impact of shortages is more permanent.

2. The tightness of the labour market has little direct impact on inflation, but indirectly through wages. Rising unemployment and falling job vacancies due to the outbreak of the pandemic weighed heavily on wage growth in 2021. In line with the recovery, tighter labour markets contribute significantly to higher wage growth from 2022 onwards. The wage effect is larger in Germany than in the euro area, but this may be due to data limitations.

3. Inflation expectations showed little sign of de-anchoring. Short-term expectations rose sharply in 2022 in response to the commodity price hikes and supply bottlenecks, but remained linked to long-term expectations. Although the latter also increased somewhat, they remained close to 2%. This applies to both Germany and the euro area.

4. According to our estimates, we find little evidence of a wage-price spiral. In Germany, allowing wages to react to past inflation surprises has almost no effect, and in the euro area the effect tends to be rather small.

5. The COVID pandemic and subsequent structural breaks have some impact on the stability of the model estimates, but less than one might think. In Germany and the euro area, negotiated wage growth becomes slightly more persistent after 2020 and less dependent on short-term expectations. Moreover, in the euro area, wages are less dependent on the labour market. Inflation is more influenced by energy prices and shortages, but less by food prices. In Germany, the impact of wages on inflation has increased somewhat.

6. According to the model, inflation in Germany is projected to gradually reach 2% by the end of 2026, provided that there are no additional shocks to commodity prices and scarcity and that the tightness of the labour market begins to ease. In the euro area, inflation is projected to reach 2% already by the end of 2024. It is important to note that these projections should be treated with caution, as the model is not intended for forecasting purposes.

In addition, the exercise suggests the following conclusions regarding the usefulness of the model for Germany and the euro area:

1. Overall, the model performs well for Germany and also for the euro area. Compared to the US, the wage equation poses some challenges due to the higher degree of institutionalised wage bargaining in Europe.

2. The choice of wage and labour market measures is important for fitting the wage equation but not for explaining inflation. In Germany, using basic salaries and the vacancy-unemployment ratio suggests an important labour market effect on wage growth, but not when the model is estimated using total negotiated wages and the unemployment rate.

3. Estimating the model for the euro area is complicated by data limitations on wages, vacancies and inflation expectations. Fitting a panel model that at least partly accounts for country-specific differences in the wage-setting process performs much better than estimating the model at the euro area aggregate.

2 Model and data

2.1 The model

The model proposed by Bernanke and Blanchard (2023) consists of four equations, one for wages, one for inflation, one for short-term inflation expectations and one for long-term inflation expectations. In this section, we briefly sketch the ingredients of the model and refer the interested reader to the original paper for more details.

Starting from the wage equation (1), the annualised growth rate of wages Δw_t is regressed on four lags in addition to four explanatory variables. More specifically, wage growth depends on short-term inflation expectations $CF1_t$, the vacancy/unemployment ratio VU_t which captures labour market tightness, the trend labour productivity growth $magpty$ and a catch-up term CU_t which allows for the effect of inflation surprises on wages. Finally, the equation includes two dummy variables for the lockdown periods in 2020Q2 and 2020Q3.

If workers or trade unions expect higher inflation in the near future, this will be reflected in higher wage demands to maintain real incomes. A tighter labour market, indicated by a rising vacancy/unemployment ratio, should have a positive impact on wages. The same is true if workers become more productive. Catch-up is defined as the difference between the average inflation over the past year and the expected inflation one year ago. Therefore, if inflation has been higher than expected, this would also be reflected in higher wage claims to compensate for the loss in purchasing power.

$$\Delta w_t = \alpha_0 + \sum_{i=1}^{4} \alpha_{1,i} \Delta w_{t-i} + \sum_{i=1}^{4} \alpha_{2,i} CF1_{t-i} + \sum_{l=i}^{4} \alpha_{3,i} VU_{t-i} + \sum_{l=i}^{4} \alpha_{4,i} CU_{t-i} \tag{1}$$

$$+ \alpha_{5,1} mapty_{t-1} + \alpha_{6,1} D20Q2_t + \alpha_{7,1} D20Q3_t + \varepsilon_{1,t},$$

$$s.t. \sum_{i=1}^{4} \alpha_{1,i} + \sum_{i=1}^{4} \alpha_{2,i} = 1 \text{ (long-run vertical wage Phillips curve)}$$

Δw_t	wages, annualised growth rate, $400ln(WAGE_t/WAGE_{t-1})$
$CF1_t$	short-term inflation expectations
VU_t	vacancy/unemployment-ratio
CU_t	catch-up term, $0.25\Sigma_{i=0}^{3}\Delta p_{t-i} - CF1_{t-4}$ with inflation $\Delta p_t = 400ln(CPI_t/CPI_{t-1})$
$mapty_t$	productivity, moving average of annualised growth rate $0.125\Sigma_{i=0}^{7}\Delta pty_{t-i}$
$D20Q2_t, D20Q3_t$	dummy variables for 2020Q2 and 2020Q3

Next, the price equation (2) models inflation, expressed as the annualised growth rate of the consumer price index as a linear function of wage growth Δw_t, the ratio of energy prices to wages ΔRPE_t, the ratio of food prices to wages ΔRPF_t, supply side constraints $SHORTAGE_t$ and trend productivity growth $magpty_t$. Inflation is expected to rise with higher wages, and if food and energy prices rise faster than wages. In addition, inflation is expected to rise if firms face difficulties in accessing raw materials or if consumer goods face supply shortages. This term also captures the effect of higher profit margins. Higher productivity growth should reduce inflation through a negative impact on unit labour costs.

$$\begin{aligned}\Delta p_t = \beta_0 + \sum_{i=1}^{4}\beta_{1,i}\Delta p_{t-i} + \sum_{i=0}^{4}\beta_{2,i}\Delta w_{t-i} + \sum_{i=0}^{4}\beta_{3,i}\Delta RPE_{t-i} + \sum_{i=0}^{4}\beta_{4,i}\Delta RPF_{t-i} \\ + \sum_{i=0}^{4}\beta_{5,i}SHORTAGE_{t-i} + \beta_{6,1}\Delta mapty_t + \varepsilon_{2,t}, \\ s.t. \sum_{i=1}^{4}\beta_{1,i} + \sum_{i=0}^{4}\beta_{2,i} = 1\end{aligned} \tag{2}$$

RPE_t	energy prices/wages $400(ln(ENERGY_t/WAGE_t) - ln(ENERGY_{t-1}/WAGE_{t-1}))$
RPF_t	food prices/wages $400(ln(FOOD_t/WAGE_t) - ln(FOOD_{t-1}/WAGE_{t-1}))$
$SHORTAGE_t$	supply shortages

In equation (3), short-term inflation expectations $CF1_t$ are assumed to depend on long-term inflation expectations $CF10_t$ and on inflation. Both explanatory variables are expected to have a positive impact on short-term expectations. This equation can also be used to test whether expectations are anchored. If they are, they should depend mainly on long-term expectations and less on past movements in actual inflation.

$$CF1_t = \sum_{i=1}^{4} \gamma_{1,i} CF1_{t-i} + \sum_{i=0}^{4} \gamma_{2,i} CF10_{t-i} + \sum_{i=0}^{4} \gamma_{3,i} \Delta p_{t-i} + \varepsilon_{3,t}, \tag{3}$$
$$s.t. \sum_{i=1}^{4} \gamma_{1,i} + \sum_{i=0}^{4} \gamma_{2,i} + \sum_{i=0}^{4} \gamma_{3,i} = 1$$

$CF1_t$	short-term inflation expectations
$CF10_t$	long-term inflation expectations

Finally, long-term inflation expectations $CF10_t$ are modelled as a function of past long-term inflation expectations and actual inflation in equation (4). Again, if expectations are strongly anchored, we should not find a significant effect of past inflation.

$$CF10_t = \sum_{i=1}^{4} \delta_{1,i} CF10_{t-i} + \sum_{i=0}^{4} \delta_{2,i} \Delta p_{t-i} + \varepsilon_{4,t}, \tag{4}$$
$$s.t. \sum_{i=1}^{4} \delta_{1,i} + \sum_{i,0}^{4} \delta_{2,i} = 1$$

The model comprises four endogenous variables - wage growth, inflation, short-term inflation expectations and long-term inflation expectations - and five exogenous variables - labour market tightness, productivity growth, energy and food price inflation, and supply constraints. Additionally, the catch-up term is a predetermined variable that consists of past inflation and inflation expectations. In brief, short-term inflation expectations impact wages, which then influence inflation, and subsequently affect short- and long-term inflation expectations. Therefore, the model can give rise to a wage-price-spiral, particularly if wage negotiators account for previous losses in real purchasing power.

The model is estimated equation by equation using OLS, with the identifying assumption that inflation reacts immediately to changes in its determinants, while wages are affected with one-quarter lag. Inflation expectations also react within the same quarter but only gradually affect inflation via wages. These identifying assumptions take account of the fact that firms adjust prices more quickly than wages in response to shocks. In Germany, as in the euro area, wages are largely determined by wage negotiations between trade unions and employers' associations. We include four lags of each variable in the model, as there are no compelling theoretical arguments to exclude certain lags of a given variable. In this sense, the model reflects a structural VAR with exogenous variables. It is important to note that the model is estimated under four constraints. First, in the wage equation, we assume that the sum of the coefficients on lagged wage growth plus the sum of the coefficients on short-term expectations equals one, implying a long-run vertical wage Phillips curve. Similarly, in the price equation, we restrict the sum of the coefficients on lagged inflation and the sum of the coefficients on wages to equal one. In the equation modelling short-term expectations, the restriction applies to the sum of the coefficients on lagged expectations, long-run expectations and inflation; in the equation modelling long-run expectations, it applies to lagged expectations and inflation.

2.2 The data

Next, this section provides a detailed description of how the model was fitted for both Germany and the euro area. For further information on the various data sources used, please refer to Appendix A.

Germany Starting with the inflation rate, the choice of the appropriate consumer price index in Germany is by no means obvious. Despite the existence of the Harmonised Index of Consumer Prices (HICP), the national CPI is still used as the central price measure in collective wage bargaining. However, the CPI has a drawback in that it is revised every five years with the introduction of a new consumption basket. In general, the revisions are not substantial, but in the current period of high inflation, they are significant, reaching 1 percentage point in 2022. Therefore, it would be more appropriate to use the CPI inflation rate calculated with the old basket until 2022Q4, just before the new index is published.[3] However, for monetary policy purposes and for comparisons within the euro area, the HICP is more useful, so we also use it as our benchmark price measure. HICP inflation has been significantly higher than CPI inflation since 2021, as shown in figure B1 in the Annex.

For wages, the choice of the appropriate measure is even more important because the differences between the individual series are much larger than for inflation. Table 1 describes the composition of German wages in detail combining data for negotiated wages collected by the Bundesbank and compensation measures provided by Destatis.

First, trade unions and employers' associations agree on basic salaries (*Grundvergütungen*, **NEGB**) which form the basis of the regular monthly wage payments. In a second step, the negotiated wages can be supplemented with wealth-related benefits or with lump-sum payments such as holiday pay. Thirdly, these regular salaries (*Tabellenwirksame Leistungen*, **NEGR**) can include additional one-off payments such as the inflation bonus 2023, which will apply from October 2022: if companies decide to pay their employees up to 3,000s euros on top of their regular salaries, this money will be tax-free.[4] Importantly, these additional payments can be split into several tranches which will increase the volatility of the negotiated wage series. Next, negotiated wages can be increased with bonus payments or overtime pay, or reduced if firms decide to cut working hours (and thus total wages) in times of crisis. As it can be seen in figure B2, these differences matter a lot, especially for the period since 2019. Finally, the resulting effective wages (*Bruttolöhne und -gehälter*, **EFFW**) can be supplemented by non-financial benefits and social contributions to obtain compensation of employees. To correct for composition

[3] See Destatis for more information.
[4] See Federal Government of Germany.

Table 1: German wage composition

	NEGB	**Negotiated wages, basic salaries (*Grundvergütungen*)**
+ + +		lump-sum payments (e.g., holiday pay) capital accumulation benefits employer-funded pension schemes
=	**NEGR**	**Negotiated wages, regular salaries (*Tabellenwirksame Leistungen*)**
+		one-off payments (e.g., inflation bonus 2023)
=	**NEGT**	**Negotiated wages, total**
+ -		bonuses, overtime pay short-time payment
=	**EFFW**	**Effective wages (*Bruttolöhne und -gehälter*)**
+ +		benefits in kind employers' social contributions
=		Compensation of employees (*Arbeitnehmerentgelte*)
	COMPE **COMPH**	**Compensation per employee** **Compensation per hour**

effects, total compensation is expressed either relative to the number of employees (**COMPE**) or relative to the number of hours worked (**COMPH**). As shown in figure B2, growth in compensation per employee fell dramatically in 2022Q2 while growth in compensation per hour was largely unaffected by the pandemic. In contrast, the latter series was much more volatile in the following years.

We estimate the model for Germany using all of the six wage series (NEGB, NEGR, NEGT, EFFW, COMPE, COMPH). To provide a more detailed analysis, we focus on the two extremes of the different wage measures. Basic salaries are the smoothest series and should also be more closely related to more persistent, medium-term changes in the underlying determinants such as productivity, inflation and inflation expectations. On the other hand, compensation measures take into account many short-term related effects, making them more comprehensive but also more volatile. Nevertheless, they tend to track negotiated wages because of the large sectoral coverage[5] and because of the fact that many non-unionised workers use the agreed wages as a benchmark in their individual wage negotiations.

Labour market tightness is measured using the vacancy-unemployment ratio, as this should be a better indicator than using the unemployment rate alone (Elsby, Michaels, and Ratner, 2015). As shown in figure B3, the standardised vacancy-unemployment rate has been on an upward trend since the mid-2000s, interrupted only by the sharp decline during the pandemic. Disentangling the two parts of the ratio shows both a gradual increase in vacancies over time and a continuous decrease in the number of unemployed. Note that we use the national definition of unemployment, which is significantly higher than the ILO definition due to the inclusion

[5]Despite the steady decline in unionisation, about 40% of employers still have an employment contract that is part of a collective bargaining agreement, see IAB.

of refugees. Looking at the Beveridge curve in figure B3, there was some reduction in labour market tightness after the pandemic, but this was only temporary and the labour market does not start to loosen until 2023. Finally, it should be noted that the German labour market has been characterised by a steady increase in the number of part-time workers, in addition to the pronounced increase of the number of short-term workers during the Great Recession and the COVID19-pandemic. In Germany, firms try to avoid laying off workers during recessions but instead reduce their working hours and the associated wage payments.[6]

For inflation expectations, we use the forecasts of professional forecasters surveyed by Consensus Economics. For short-term expectations, we compute a one-year-ahead expectations series as a weighted average of the professional forecasters' predictions for the current and next calendar year. As a proxy for long-term expectations, we use forecasts for five calendar years ahead. Figure B4 shows the corresponding series together with the catch-up term, defined as the average headline inflation over the current and the previous three quarters minus the one-year-ahead inflation expectations one year ago. While short-term inflation expectations fluctuated quite strongly, peaking at around 7% in 2022Q4, long-term expectations proved to be much more stable but still increased by around 0.5 percentage points between the end of 2019 and the end of 2022. Note also that the expectations five years ahead are very similar to those two years ahead.

Figure B5 then shows the annualised growth rate of the ratio between the HICP subcomponents energy and food relative to the six different wage measures. Both series increased markedly during the pandemic, although the food ratio is more sensitive to the use of a particular wage series. Figure B6 also shows three different measures of supply bottlenecks, the number of Google searches for the term "Lieferengpässe" (supply bottlenecks), the New York Fed's Global Supply Chain Pressure Index (GSCPI), and the proportion of firms citing "shortage of materials" as a factor limiting production in the European Commission's Business Survey. Overall, the three series behave rather similarly, with two peaks in early 2020 and summer 2021. We follow Bernanke and Blanchard (2023) and use the number of Google searches as our benchmark series. Finally, we include two measures of real labour productivity. In the version using compensation per employee, we also use productivity per employee, while for the remaining wage series we use productivity per hour. Overall, the two series are quite similar, with two large peaks in productivity growth per employee in 2020Q2 and 2022Q2.

Euro area Data availability is more limited within the euro area compared to Germany. We will consider the euro area in its changing country composition as shown in Table 2, i.e. we only include data for a given country after it has become a member of the euro area.

[6] During the pandemic, this instrument was also widely used in France, Italy and Spain, in contrast to the US (Fitzenberger and Walwei, 2023).

Table 2: Countries joining the euro area since 1999

Year	Aggregate	Countries
1999	EA11	AT, BE, DE, FR, IT, ES, NL, LU, IE, FI, PT
2001	EA12	GR
2007	EA13	SI
2008	EA15	CY, MT
2009	EA16	SK
2011	EA17	EE
2014	EA18	LV
2015	EA19	LT
2023	EA20	HR

AT: Austria, BE: Belgium, DE: Germany, FR: France, IT: Italy, ES: Spain, NL: Netherlands, LU: Luxembourg, IE: Ireland, FI: Finland, PT: Portugal, GR: Greece, SI: Slovenia, CY: Cyprus, MT: Malta, SK: Slovakia, EE: Estonia, LV: Latvia, LT: Lithuania, HR: Croatia, EA: Euro Area.

Regarding wages, there are only three available measures. For the nine largest countries (AT, BE, DE, FR, IT, ES, NL, FI, and PT) there are indicators for negotiated wages, which account for approximately 92% of the euro area inflation rate. In contrast to Germany, we cannot extract lump-sum payments or or one-time payments, so the data refers to total negotiated wages. Additionally, data on compensation per employee and per hour are available for all euro area countries. In the following, we divide the countries into two groups based on the availability of negotiated wages and plot the different series in the appendix C. Starting with the annualised wage in growth in figure C1, the picture is clearly dominated by the large volatility since the pandemic in most countries, except for Finland and the Netherlands – and for some smaller member states – where the series already showed large fluctuations in the past.

Inflation is measured by the Harmonised Index of Consumer Prices and inflation expectations are sourced from Consensus Economics. For the latter, the data availability is more limited. Only for Germany, France, Italy, Spain and the Netherlands are expectations available at a quarterly frequency since 1999, while the euro area aggregate starts only in 2003. For Austria, Belgium, Greece, Ireland, Finland and Portugal, experts providing a forecast are surveyed only once a year from 1999 to 2017, so we have to assume that expectations have remained constant throughout the year. Expectations for Estonia, Latvia, Lithuania, Slovenia and Croatia are only available biannually from 2007 until 2014. Similarly, data for Slovakia is also biannual but starts in 1999. To fill in the gaps, we carry forward the expectations from the previous quarter, and use data from neighbouring countries before 2014.[7] Expectations for Cyprus are available on a quarterly frequency since 2019; for the years before, we use the forecasts for Greece. Finally, there are no available expectations for Malta, which we proxy with Italy, and Luxembourg, for which we use the expectations series for the Netherlands. To construct an average expectation series for the euro area aggregate before 2003, we have weighted the available country series by the HICP country weights. Comparing the resulting series with the aggregate series since 2003, they are quite close. In figure C2, we plot the country-specific inflation rates

[7] We use Italy for Slovenia and Croatia, and Finland for the Baltic countries.

expressed as annualised quarterly growth rates, along with the corresponding expectation series. Short-term inflation expectations move more in line with actual inflation, while long-term expectations are more stable. The corresponding series for energy price inflation and food price inflation relative to wage growth are shown in figures C6 and C7.

For most euro area countries, data on job vacancies is either unavailable or only available for a very short sample. Therefore, we use the unemployment rate as defined by the ILO to measure labour market tightness. Figure C3 shows that unemployment decreased in many countries from 1999 until the great financial crisis, increased again until the pandemic and then decreased once one. However, there are important exceptions, such as in Germany, where the unemployment rate has been falling since the mid-2000s, or in Austria, where the unemployment rate has slightly trended upwards throughout the entire sample. Labour productivity is measured both per person employed and per hour worked, with the exception of Belgium, where hourly productivity does not exist (see Figure C4).

Finally, supply shortages are measured by the proportion of enterprises that cite "shortage of material" as an important factor limiting their production, according to the European Commission's Business Survey. Due to data gaps, we have to use the first available observation for the earlier periods. This is the case for Ireland, where data is only available from 2016Q3 onwards, as well as for Croatia and Cyprus (2008Q3), Latvia (2004Q1) and Malta (2003Q1). Figure C5 illustrates that supply shortages were not usually a major problem before the pandemic.

3 Results for Germany

In the following section, we present in detail the estimation results of the model proposed by Bernanke and Blanchard (2023) for Germany. The model is estimated on two subsamples. In order to have as many observations as possible, we start in 1996Q1, which rules out the possibility that the results are influenced by the reunification boom. We then estimate the model until 2019Q4, the last quarter before the COVID-19 pandemic hit the world. The second sample ends in 2023Q3, the last quarter for which we have data on wages and productivity available.

To account for the lockdown effects on employment and wages, in the second estimation sample, we add two dummy variables for 2020Q2 and 2020Q3 to the wage equation. Inflation was also affected by extraordinary policy measures related to the pandemic and to Russia's invasion of the Ukraine. As we discuss in detail in Beck, Carstensen, Menz, Schnorrenberger, and Wieland (2023), the German government temporarily reduced the VAT rate from 19% to 16% for the regular rate and from 7% to 5% for the reduced rate between 1 July 2020 and 31 December 2020. In addition, the price of public transport was reduced to 9 euro per month between June and August 2022, and households received a one-off emergency package for natural gas and heating in December 2022. The impact on inflation was quite pronounced: in each of the three months when the measure was in place, the monthly inflation rate fell by more than one percentage point, followed by an even larger increase when the measure was withdrawn. In our baseline estimation, since we want to stay as close as possible to the original model specification, we refrain from adding dummies for these periods, but we do so in the robustness section.[8]

Besides of the estimation results, we will also present impulse-response functions that take into account the feedback effects between the endogenous variables, historical decompositions that highlight the contributions of the exogenous variables and conditional forecasts that provide an outlook for the future path of inflation.

3.1 Estimation results

Table 3 summarises the estimation results for the wage equation (1) fitted to six different wage measures: compensation per employee (COMPE), compensation per hour (COMPH), effective wages (EFFW), total negotiated wages (NEGT), regular salaries (NEGR) and basic salaries (NEGB). For each of the explanatory variables, the long-run coefficients, calculated as the sum of the individual coefficients, are reported in the rows labelled $\sum$. In addition, we test the statistical significance of the long-run coefficients by testing whether the sum of the individual coefficients is non-zero, e.g. $H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$, and whether the individual coefficients are jointly different from zero, e.g. $H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$. The p-values of these tests are reported in the rows p(sum) and p(joint), respectively.

First, we find that wage growth mostly depends negatively on its own lags, except for basic salaries, reflecting the higher volatility of the wage series. Second, we find a large positive and statistically significant effect of short-term inflation expectations, which is larger for compensation per hour than for basic salaries. Next, we also find a positive and statistically significant effect of labour market tightness on wages, again, larger for compensation per hour than for basic salaries. According to our estimates, we generally do not find that workers demand higher wages in response to higher-than-expected inflation. The sign of the estimated effect is positive in the pre-COVID sample and negative in the full sample, but the effect is mostly not significantly different from zero. This result fits well with a series of telephone interviews conducted by the Bundesbank among trade unions and employers' associations between July and October 2022. Compared with a previous round of the survey in 2016, participants said they were more focused on expected inflation than on the ECB's inflation target. However, they generally did not plan to demand an additional increase in wages due to high inflation in the past (Deutsche Bundesbank, 2023b). Next, the effect of labour productivity is not statistically different from zero, although the long-run effect is positive for regular and basic salaries, as expected. Finally, the lockdown dummies are only significant for compensation per employee.

[8] In addition, the Statistical Office decided to impute the prices of goods and services that could not be consumed because of the lockdown restrictions. In April 2020, 27% of the HICP was imputed. The share then fell to zero in August 2020, but between November 2020 and August 2021, prices had to be imputed again, reaching 23% in January and February 2021. For more details see Eurostat. As we cannot add dummy variables over such a long period, we ignore this issue.

Table 3: Estimation results for the wage equation in Germany

	COMPE		COMPH		EFFW		NEGT		NEGR		NEGB	
WAGES												
Σ	-0.156	-0.200	0.079	-0.579	0.161	-0.466	-0.495	-1.306	-0.083	-0.063	0.284	0.336
p(sum)	0.527	0.422	0.741	0.024	0.480	0.066	0.077	0.000	0.713	0.754	0.191	0.076
p(joint)	0.633	0.292	0.283	0.003	0.304	0.001	0.009	0.000	0.894	0.857	0.000	0.000
CF1												
Σ	1.156	1.200	0.921	1.579	0.839	1.466	1.495	2.306	1.083	1.063	0.716	0.664
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
p(joint)	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.012	0.009
VU												
Σ	0.747	0.809	0.551	1.030	0.410	0.885	0.854	0.830	0.505	0.365	0.234	0.232
p(sum)	0.023	0.005	0.187	0.010	0.316	0.026	0.002	0.003	0.039	0.039	0.295	0.132
p(joint)	0.001	0.048	0.014	0.000	0.042	0.000	0.000	0.006	0.003	0.008	0.098	0.133
CATCH-UP												
Σ	0.149	-0.315	0.313	-0.540	0.264	-0.529	0.096	-1.147	0.149	-0.323	0.216	-0.019
p(sum)	0.629	0.188	0.448	0.133	0.519	0.136	0.757	0.000	0.552	0.099	0.356	0.917
p(joint)	0.188	0.019	0.368	0.329	0.277	0.326	0.773	0.002	0.573	0.339	0.621	0.619
PRODUCTIVITY												
Σ	-0.257	-0.189	-0.212	-0.465	-0.167	-0.489	-0.001	-0.089	0.023	0.088	0.125	0.188
pval	0.124	0.234	0.490	0.161	0.589	0.146	0.997	0.711	0.896	0.566	0.439	0.176
DUMMIES												
Σ	0.000	-7.218	0.000	3.020	0.000	1.796	0.000	-0.954	0.000	1.252	0.000	-0.576
p(sum)	.	0.086	.	0.635	.	0.778	.	0.834	.	0.665	.	0.825
p(joint)	.	0.000	.	0.795	.	0.518	.	0.717	.	0.848	.	0.803
R2	0.243	0.621	0.245	0.399	0.268	0.436	0.372	0.453	0.242	0.213	0.309	0.273
Start	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3

Note: Measures are computed using different wage series: COMPE - compensation per employees, COMP - compensation per hour, EFFW - effective wages, NEGT - total negotiated wages, NEGR - negotiated wages excluding arrangements, NEGB - negotiated wages excluding arrangements and lump-sum payments. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

In general, the coefficients tend to be fairly stable across the two estimation samples.

The results for the price equation (2) are summarised in table 4. First, and perhaps most importantly, the estimated coefficients are quite similar regardless of which wage measure we use as the explanatory variable. Inflation depends positively on past inflation and also positively on wage growth. Here, the effect is somewhat larger when using basic salaries instead of compensation per hour. At 0.1 to 0.4, the long-run impact of wages on inflation is quite close to the estimated impact provided by Bobeica, Ciccarelli, and Vansteenkiste (2019) in a VAR model and to the elasticity in the macroeconomic model of the Bundesbank (Deutsche Bundesbank, 2019). The impact of energy and food price shocks on inflation is also statistically significant and positive, although the impact of food prices is larger. In addition, supply shortages also lead to an increase in inflation, but only when the estimation sample includes the post-COVID period. This is not surprising, given that supply bottlenecks were note an important issue before the pandemic. Similar to the wage equation, we do not find a significant role for labour productivity.

Table 4: Estimation results for the price equation in Germany

	COMPE		COMPH		EFFW		NEGT		NEGR		NEGB	
INFLATION												
Σ	0.591	0.664	0.762	0.894	0.771	0.895	0.634	0.607	0.713	0.631	0.702	0.657
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.005	0.000	0.005
WAGES												
Σ	0.409	0.336	0.238	0.106	0.229	0.105	0.366	0.393	0.287	0.369	0.298	0.343
p(sum)	0.001	0.021	0.076	0.480	0.065	0.468	0.021	0.026	0.054	0.034	0.061	0.062
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENERGY PRICES / WAGES												
Σ	0.044	0.045	0.028	0.022	0.028	0.022	0.039	0.054	0.034	0.049	0.034	0.047
p(sum)	0.009	0.023	0.114	0.312	0.104	0.290	0.035	0.015	0.067	0.030	0.071	0.043
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FOOD PRICES / WAGES												
Σ	0.205	0.101	0.201	0.064	0.199	0.064	0.233	0.178	0.174	0.126	0.196	0.121
p(sum)	0.015	0.299	0.024	0.517	0.020	0.505	0.014	0.072	0.052	0.207	0.032	0.245
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SHORTAGES												
Σ	-0.539	0.217	-0.495	0.153	-0.505	0.152	-0.317	0.205	-0.299	0.270	-0.274	0.261
p(sum)	0.120	0.097	0.193	0.240	0.174	0.247	0.404	0.109	0.429	0.052	0.489	0.074
p(joint)	0.282	0.009	0.343	0.001	0.323	0.001	0.474	0.002	0.336	0.001	0.441	0.003
PRODUCTIVITY												
Σ	0.061	0.068	0.014	0.100	-0.004	0.092	0.062	0.122	0.046	0.096	0.068	0.100
p(pval)	0.239	0.250	0.878	0.273	0.960	0.323	0.460	0.160	0.577	0.276	0.423	0.258
R2	0.853	0.917	0.839	0.914	0.844	0.913	0.842	0.920	0.846	0.914	0.838	0.912
Start	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3

Note: Measures are computed using different wage series: COMPE - compensation per employees, COMP - compensation per hour, EFFW - effective wages, NEGT - total negotiated wages, NEGR - negotiated wages excluding arrangements, NEGB - negotiated wages excluding arrangements and lump-sum payments. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

Finally, the results for short-term and long-term inflation expectations are shown in table 5. Short-term expectations depend positively on past expectations and on long-term expectations, as well as on past inflation. Interestingly, the long-term impact of each of these three variables is between 0.3 and 0.4. Long-term expectations are quite persistent and are also influenced by past inflation, albeit to a very small extent. Overall, inflation expectations remain well anchored, although there is some degree of backward-looking expectation formation, especially in the case of short-term inflation expectations.

Table 5: Estimation results for inflation expectations in Germany

SHORT-TERM EXPECTATIONS		
Σ	0.325	0.289
p(sum)	0.001	0.003
p(joint)	0.006	0.005
LONG-TERM EXPECTATIONS		
Σ	0.330	0.388
p(sum)	0.000	0.000
p(joint)	0.001	0.000
INFLATION		
Σ	0.345	0.324
p(sum)	0.000	0.000
p(joint)	0.000	0.000
R2	0.696	0.906
Start	1996q1	1996q1
End	2019q4	2023q3

LONG-TERM EXPECTATIONS		
Σ	0.960	0.988
p(sum)	0.000	0.000
p(joint)	0.000	0.000
INFLATION		
Σ	0.040	0.012
p(sum)	0.000	0.031
p(joint)	0.011	0.405
R2	0.841	0.829
Start	1996q1	1996q1
End	2019q4	2023q3

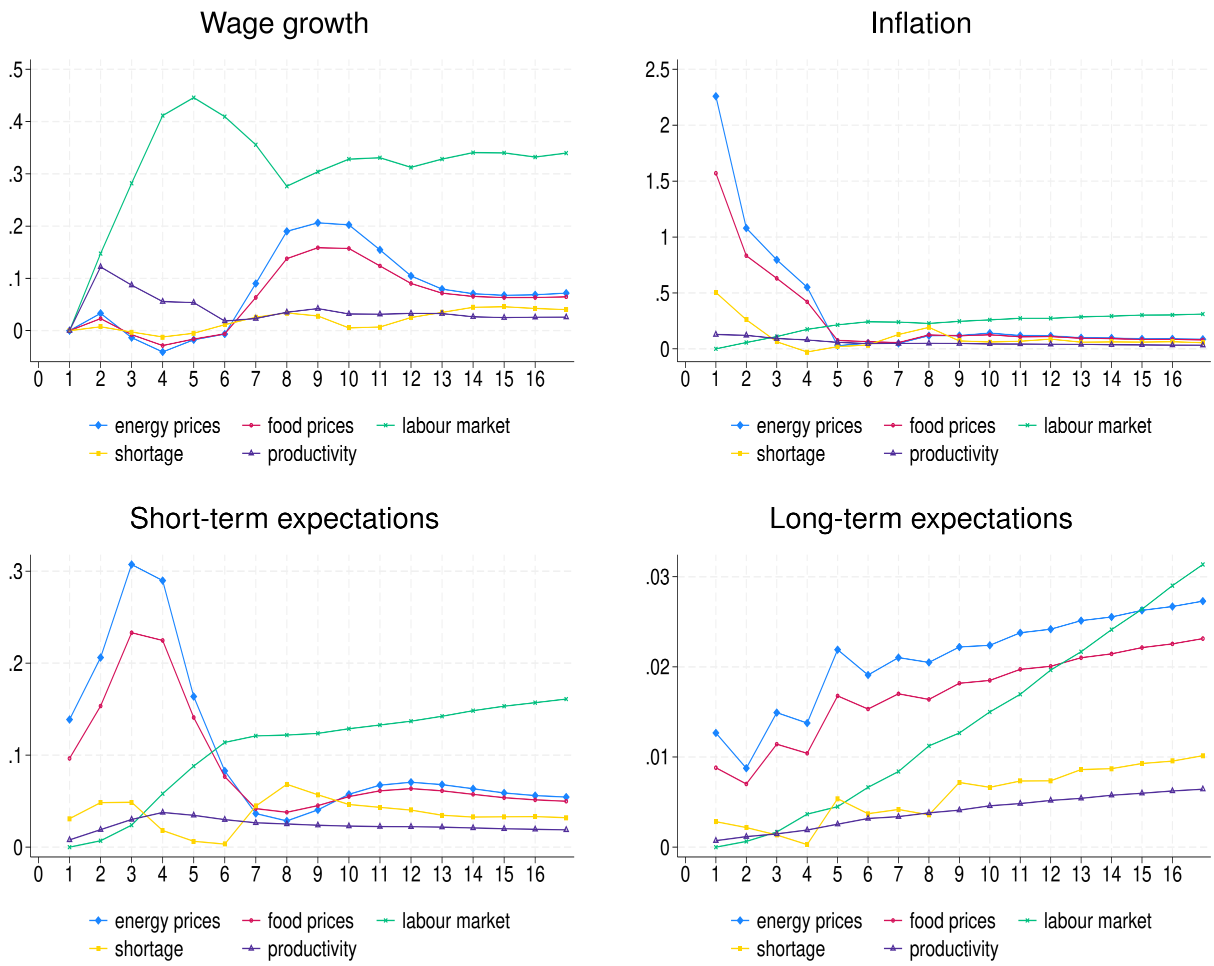
Note: $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

3.2 Impulse response functions

Looking at the size and statistical significance of the estimated coefficients in each of the four equations separately does not take into account the feedback effects that exist between the endogenous variables in our model. For example, an exogenous energy price shock will have a direct effect on inflation, which will then affect inflation expectations, which will affect wages and, ultimately, inflation. These feedback effects can be accounted for by computing impulse response functions, which allow us to quantify the overall impact of the five exogenous variables in the model. The exogenous variables are increased by one standard deviation calculated over the period 2020Q1-2023Q3. We assume that the shocks to energy prices, food prices, bottlenecks and productivity are temporary, i.e., lasting only one quarter. In contrast, the labour market shock is assumed to be permanent, taking into account that structural changes in the labour market take more time to take effect. For illustrative purposes, we have transformed the resulting impulse response functions into annual rates defined as the sum of the quarterly rates such that $\pi_t^{yoy} = 100(ln(P_t/P_{t-4}) = 1/4\sum_{i=0}^{3} 400ln(P_t/P_{t-1})$.

The results are shown in figure 2 using basic salaries (NEGB) as the model's wage variable and in figure 3 using compensation per hour. A persistent tightening of the labour market leads to persistently higher wage increases. For compensation per hour, the effect is negative in the first two quarters after the shock, but becomes positive in the following quarters. The impact of the other shocks on wages tends to be small. Energy and food price shocks have almost no impact in the short run, but become effective after six quarters due to the feedback effects in the model. Productivity is found to have a small positive but permanent effect on basic salaries. In terms of inflation, we find that a one-standard-deviation shock to energy prices raises annual inflation by about 2.2 percentage points at the time of impact, and by 1.5 percentage points for food prices.

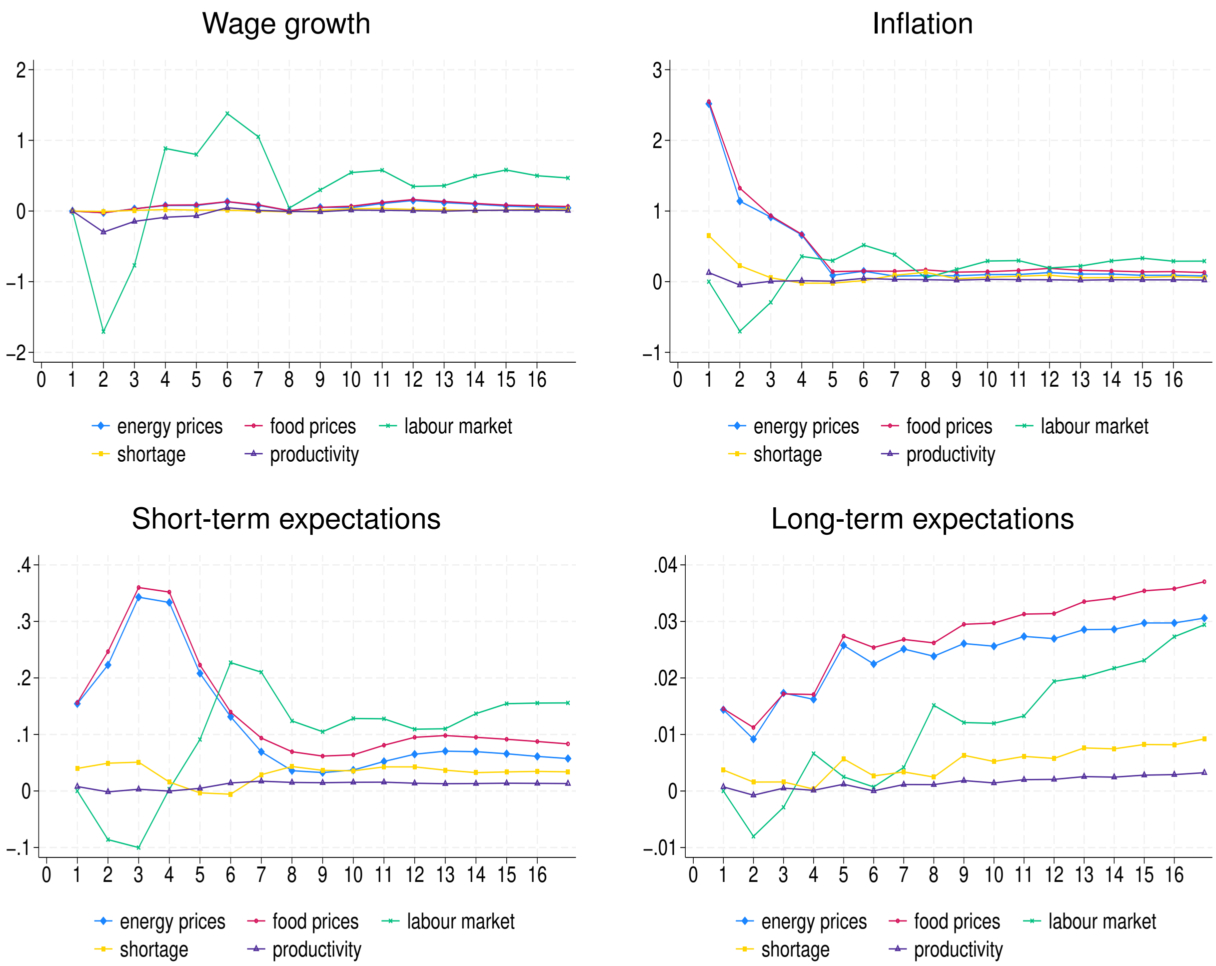
Figure 2: Impulse-response functions using basic salaries as wage variable



Note: The figures show the total responses of wage growth, inflation, and inflation expectations to one-standard-deviation shocks to five exogenous variables. The responses of wage growth and inflation are transformed into annual growth rates. Basic salaries have been used as the wage variable in the model. Estimation sample: 1996Q1-2023Q3.

After that, the effect disappears quite quickly and is zero after one year. Using compensation per hour as the wage variable, both commodity shocks lead to an almost identical inflation response. An increase in supply bottlenecks leads to an increase of inflation of around 0.5 percentage point at the time of the shock, and the effect also disappears within a year. This is the case regardless of which wage measure is used. By contrast, a permanent tightening of the labour market leads to a small but long-lasting impact on inflation of around 0.4 percentage point. This rather modest response of inflation to labour market slack results from the small size of the estimated coefficients of the vacancy-unemployment ratio in the wage equation, but also from the small feedback effects given by the impact of wages on inflation and the catch-up effect. Inflation expectations do amplify the impact of exogenous shocks, but only to a small extent. According to the impulse response functions, energy price and food price shocks increase the short-term inflation expectations by a maximum of 0.3 and 0.2 percentage points after three quarters, respectively, while labour market shocks have a long-lasting impact of around 0.15 percentage points. As long-term inflation expectations are very persistent, the exogenous shocks have very long-lasting effects, but only of a very small magnitude.

Figure 3: Impulse-response functions using compensation per hour as wage variable

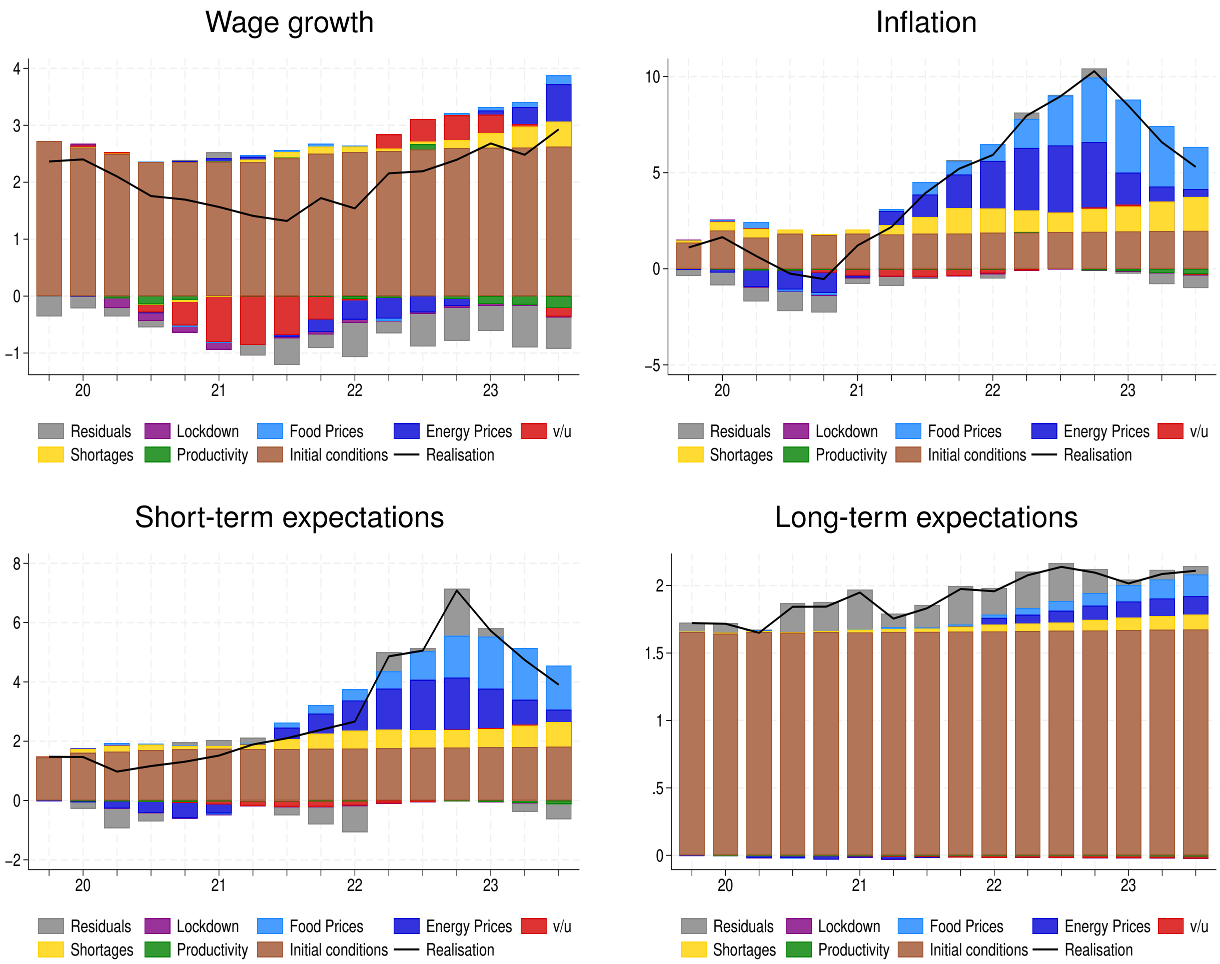


Note: The figures show the total responses of wage growth, inflation, and inflation expectations to one-standard-deviation shocks to five exogenous variables. The responses of wage growth and inflation are transformed into annual growth rates. Compensation per hour has been used as the wage variable in the model. Estimation sample: 1996Q1-2023Q3.

3.3 Decomposing post-pandemic developments

We then use the model to decompose the post-pandemic developments in inflation, wages and inflation expectations into the relative contributions of different explanatory variables. We start in 2020Q1 and run the historical decompositions of the full model until 2023Q3 thus taking into account the feedbacks between the endogenous variables. The shocks to energy prices, food prices, supply shortages and the lockdown period are constructed as deviations from zero, so that if these shocks had not occurred during the pandemic, the variables of interest would not have been affected by these determinants. The productivity shock is constructed as a deviation from its long-run average, implying that in the absence of this shock, inflation and wages would have increased in line with long-run productivity. Finally, the labour market shock is defined as the deviation from its pre-pandemic value. Taken together, the decomposition yields a term called ”initial conditions”, which is a combination of the estimated constants, the pre-pandemic shocks, the long-run productivity growth and the pre-pandemic labour market tightness. As with the impulse response functions, we transform the annualised quarterly growth rates for wages and inflation into annual rates.

Figure 4: Decompositions using basic salaries as wage variable

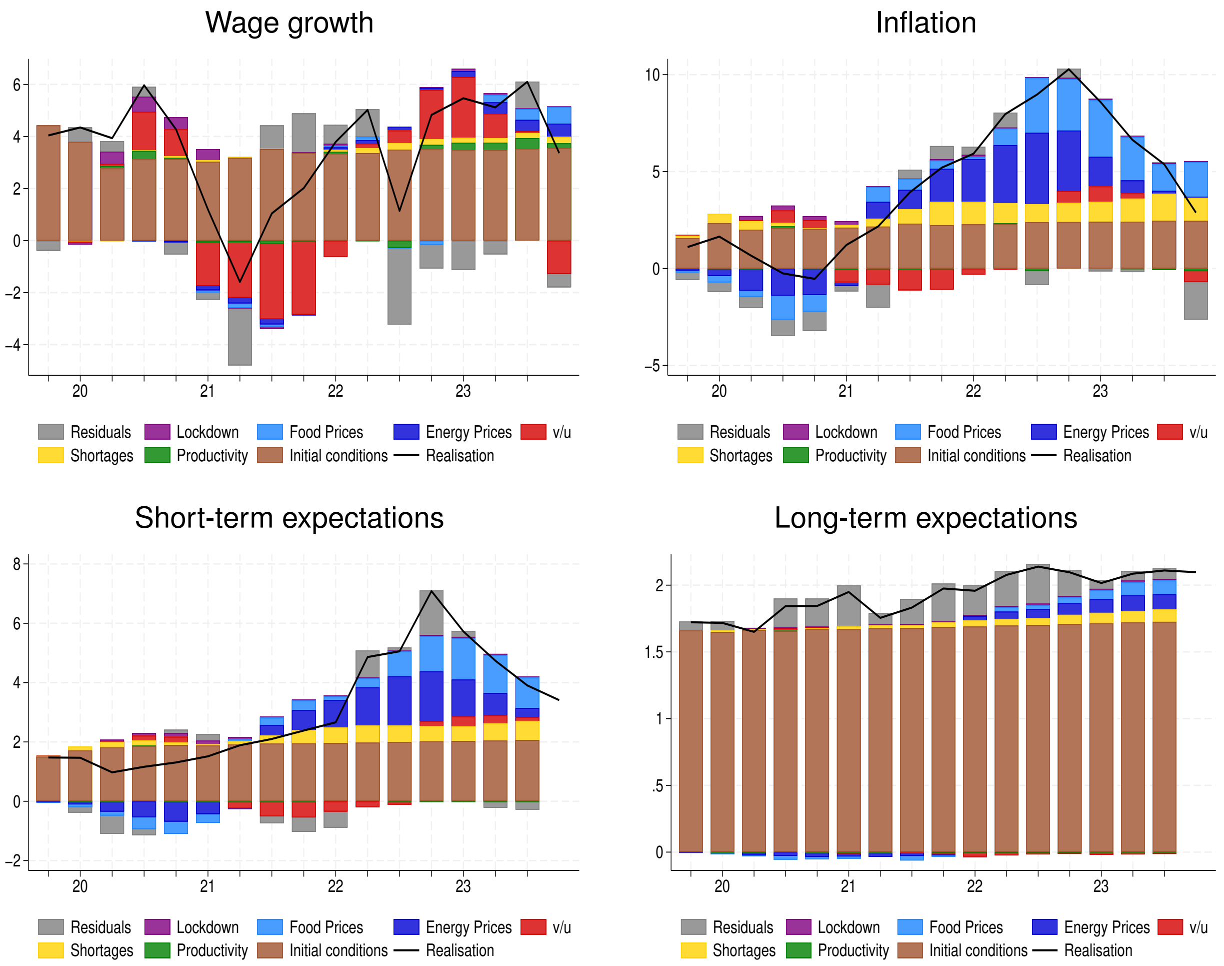


Note: The figure shows as black solid lines actual values for wage growth (NEGB) and inflation, expressed in year-over-year rates, and for short-term and long-term inflation expectations. The coloured bares denote the contributions of the different exogenous variables in addition to the residuals and the initial conditions of each equations. Estimation sample: 1996Q1-2023Q3.

According to the results for basic salaries shown in figure 4, in the absence of shocks, we find that basic salaries would have grown by about 2.8%, inflation and short-term expectations by about 2% and long-term expectations by about 1.7%. When the pandemic hits, the lockdown and the deterioration of the labour market in particular lead to slower growth in basic salaries. This changes at the beginning of 2022, when improving labour market conditions lead to higher wage increases again. From 2023 onwards, supply shortages and energy price shocks contribute positively to wage growth, and the labour market effects fade and even turn negative in 2023Q3. Inflation is first been reduced by negative energy price shocks and, in 2021, is also held down by negative labour market shocks. The unprecedented burst of inflation from 2021 onwards was been driven by energy price shocks and supply shortages. Food price shocks also start to have an impact from the summer of 2021 and replace energy shocks as the main driver of inflation by the end of 2022. The recent slowdown in inflation ins mainly been due to the phasing out of energy shocks. The labour market has almost no impact on inflation, apart from indirect effects working via the wage channel. The picture is very similar for short-term inflation expectations, which were first pushed down somewhat by negative energy shocks and then boosted by positive commodity shocks and supply shortages. Since 2022, long-term expectations have also been driven up by commodity price shocks which raises some risks of a possible deanchoring.

When basic salaries are replaced by compensation per hour, the results shown in figure 5 are broadly similar. In the absence of shocks, the steady-state wage growth would have been around 4%, for inflation and short-term expectations about 2% and for long-term expectations approximately 1.7%. In 2020, wages, as measured by compensation per hour, actually increased more than before, mainly due to a positive impact from the labour market. Then, in 2021, wage growth turns negative in response to a large negative labour market impact. From summer 2022 onwards, positive labour market shocks lead to above-average wage growth. More recently, the impact of of the labour market has diminished, but commodity price shocks, supply constraints and labour productivity have made positive contributions to higher wage growth. The story for inflation and for inflation expectations is quite similar compared to the basic salary version of the model, except that we now find a significant direct labour market effect. Negative labour market outcomes contribute negatively to inflation and short-term expectations in 2021 and positively from 2022 onwards.

Figure 5: Decompositions using compensation per hour as wage variable

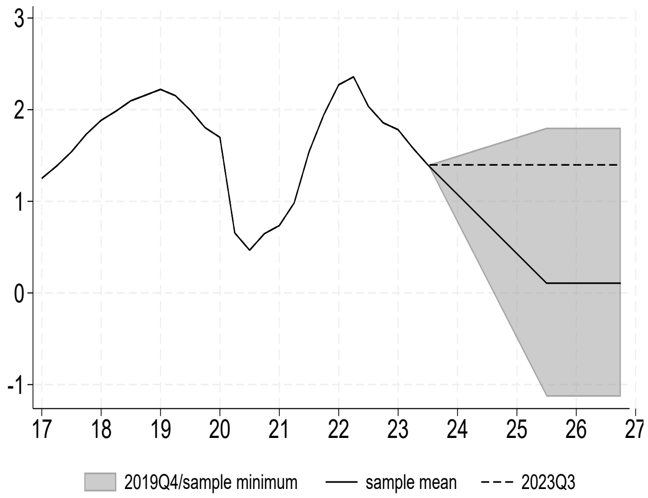


Note: The figure shows as black solid lines actual values for wage growth (COMPH) and inflation, expressed in year-over-year rates, and for short-term and long-term inflation expectations. The coloured bares denote the contributions of the different exogenous variables in addition to the residuals and the initial conditions of each equations. Estimation sample: 1996Q1-2023Q3.

3.4 Conditional forecasts

Finally, we use the estimated model to provide an outlook for the future path of inflation, wage growth, and inflation expectations. It is beyond the scope of this paper to develop a full forecasting exercise. Instead, we derive conditional projections based on different scenarios for the exogenous variables. Our forecasting exercise starts in 2023Q4. We set the shortage variable, the energy price growth and the food price growth to zero, assuming that there will be no commodity price shocks over the forecast period. Productivity growth is assumed to follow its long-run average. Most importantly, we use four different scenarios for labour market tightness, as shown in figure 6.

Figure 6: Labour market scenarios used for conditional forecasts

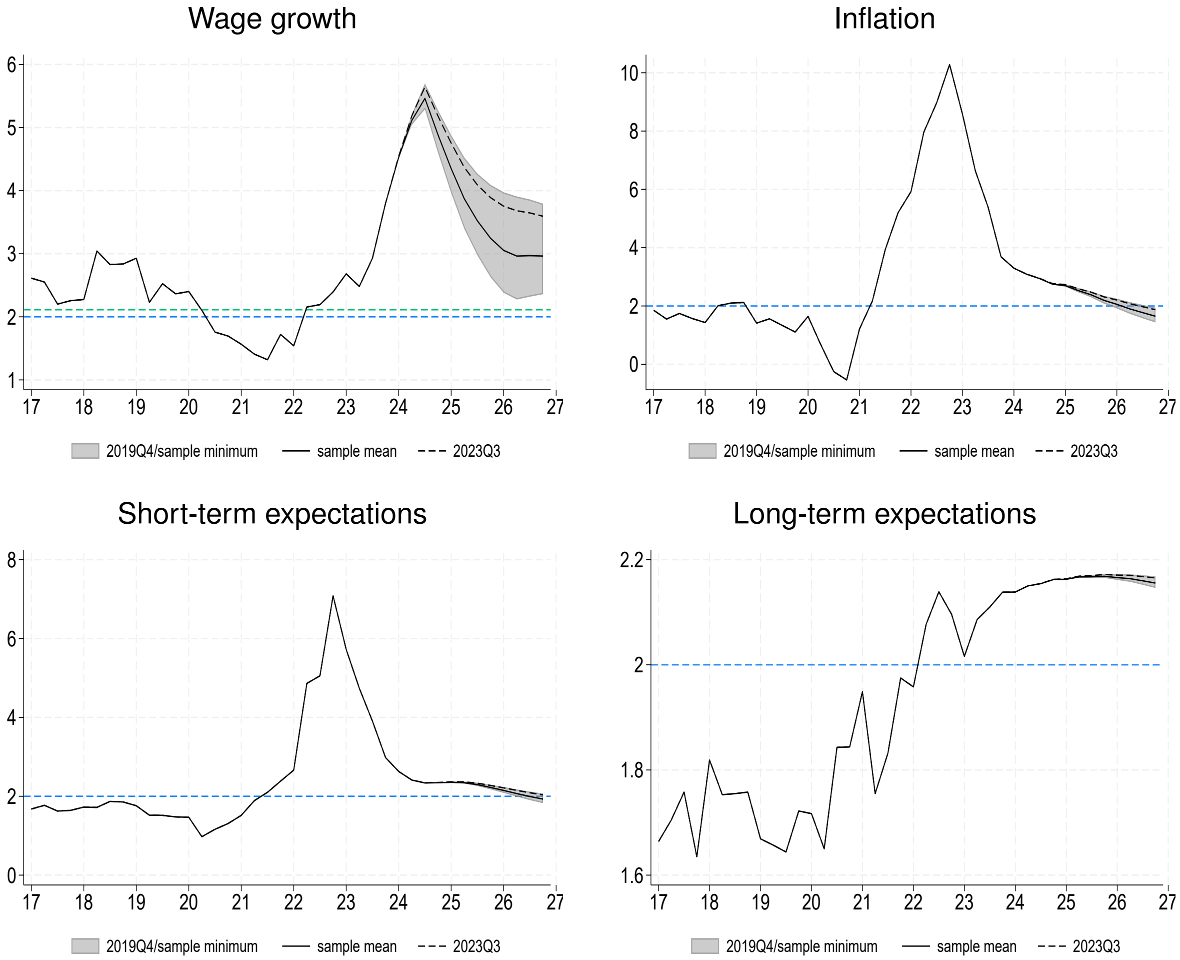


Note: The figure shows four scenarios on the future path of the vacancy-unemployment ratio used as inputs in the conditional forecasting exercise.

First, we simply carry forward the vacancy-unemployment ratio from 2023Q3, assuming that the labour market situation remains unchanged. Second, we assume that the vacancy-unemployment ratio converges over the next eight quarters to its pre-pandemic value of 2019Q4, to its sample mean and to its minimum value. These four scenarios cover a very wide range of possible labour market constellations that we use as an input in the forecasting exercise. Finally, note that we need to adjust the constant term in the wage equation to ensure that the steady-state value of the vacancy-unemployment ratio is equal to its value in 2019Q4. Again, we convert the projected annualised growth rates into annual rates of change.

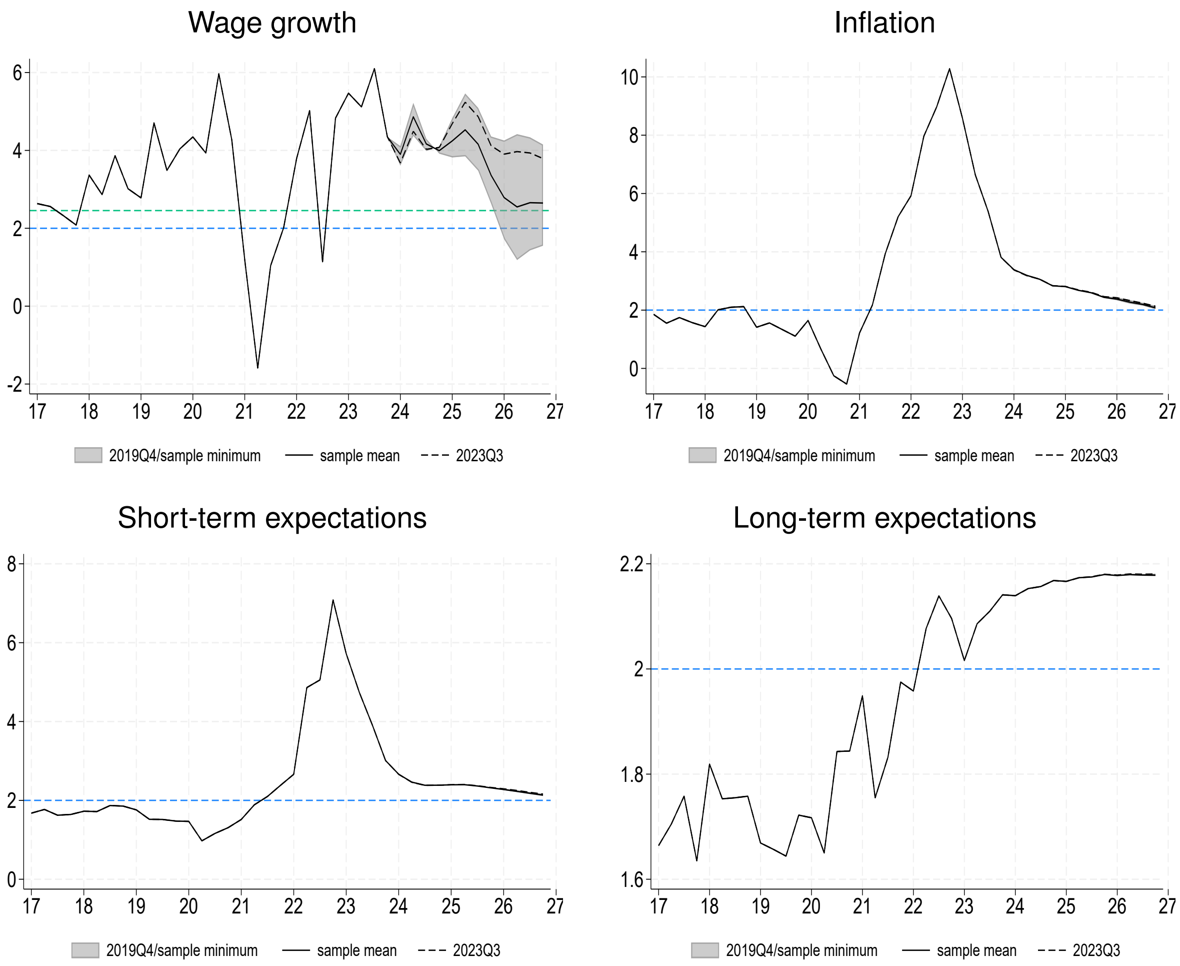
The resulting projections shown in figure 7 using basic salaries and in figure 8 using compensation per hour send a clear message. Irrespective of the assumed path for the labour market and the choice of the wage measure, the model predicts that it will take almost two years to bring inflation below the ECB's target of 2%. This is because it will take a very long time for wages to grow at a rate close to the post-1999 average. For basic salaries, this will take until 2028, even under the extreme scenario of very negative labour market developments, while for compensation per hour, the process will be faster, leading to average growth rates in 2026. Similarly, inflation expectations, especially in the long term, will adjust very slowly. Therefore, in the absence of any additional negative shocks, there is still some way to go to bring inflation back to target. Interestingly, the conditional forecast is fairly close compared to the most recent Bundesbank inflation forecast for Germany published in December 2023 (Deutsche Bundesbank, 2023a). The Bundesbank predicted inflation to fall to 2.7% in 2024, followed by 2.5% in 2025 and 2.2% in 2026, which is about 0.3 percentage points higher in 2024 and almost equal to our model projections in 2025 and 2026 conditional on a high degree of labour market pressure. The gap in 2024 should be mostly due to the fact that the model projection is derived under the assumption of no commodity price shocks, *inter alia*.

Figure 7: Conditional forecasts using basic salaries as wage variable



Note: The figures show the conditional forecasts of wage growth measured as basis salaries (NEGB), inflation, short-term and long-term inflation expectations. The projections are derived under four different scenarios for the vacancy-unemployment ratio shown in Figure 6 giving rise to the projection intervals highlighted as gray shaded ares. Variables are expressed in annual growth rates. The blue dotted line shows the 2% inflation target and the green dotted line shows the average wage growth rate since 1999Q1. Estimation sample: 1996Q1-2023Q3.

Figure 8: Conditional forecasts using compensation per hour as wage variable



Note: The figures show the conditional forecasts of wage growth measured as compensation per hour (COMPH), inflation, short-term and long-term inflation expectations. The projections are derived under four different scenarios for the vacancy-unemployment ratio shown in Figure 6 giving rise to the projection intervals highlighted as gray shaded ares. Variables are expressed in annual growth rates. The blue dotted line shows the 2% inflation target and the green dotted line shows the average wage growth rate since 1999Q1. Estimation sample: 1996Q1-2023Q3.

3.5 Alternative specification

In the basic model specification presented so far, we have stuck as closely as possible to the original framework offered by Bernanke and Blanchard (2023). While this has the advantage of allowing a direct comparison of estimation results across economies, it certainly neglects some important country-specific characteristics. We have therefore extended the model in two directions that may be important for Germany. First, we augment the wage equation with two additional variables, following earlier arguments presented by Deutsche Bundesbank (2018) on wage formation before the pandemic. As Germany is a very open economy that relies heavily on the export of final manufactured goods, while at the same time relying on the import of intermediate goods, the terms of trade could play a role. If German firms become more competitive, i.e. if the terms of trade rise, workers could be rewarded with higher wages. The terms of trade are defined as the ratio of the export deflator to the import deflator. As shown in figure B7, the terms of trade deteriorate sharply between 2020 and mid-2022, but then recover. It should also be noted that Germany experienced a huge increase in net immigration from countries within the European Union as a result of the great financial crisis, see figure B7. This effect might have dampened the upward pressure on wage growth from the tight labour market. We standardise both series and include them in the model with four lags.

Second, we also adjust the price equation, mainly to account for the fiscal measures introduced to dampen the inflationary surge. As already discussed, we add a dummy variable with the value of -1 in 2020Q3 and +1 in 2021Q1 to take into account the effect of the temporary VAT reduction from 19% to 16% for the regular rate and from 7% to 5% for the reduced rate. Similarly, we add a dummy with a value of -1 in 2022Q2 and +1 in 2022Q3 due to the large temporary reduction in public transport fares ("9-euro ticket"). And then we add another dummy with a value of -1 in 2022Q4 and +1 in 2023Q1 to account for the emergency package for natural gas and heating. We also include terms of trade in the price equation to test whether they have an additional effect on domestic consumer prices.

We show the estimation results of this alternative model specification in tables D1 and D2 in the appendix. Overall, the impact of the adjustments is small. First, for all wage measures, the estimated effect of the terms of trade on wages has the wrong sign, implying that an improvement in the terms of trade would lead to lower wage growth. Moreover, for the negotiated wage measures, the effect is not statistically significantly different from zero. Similarly, the effect of net immigration is not statistically significant, although the estimated coefficient is negative, in particular for compensation per hour. In the price equation, the terms-of-trade are again of no importance, either in terms of statistical significance or in terms of the size of the coefficient. Instead, the inclusion of the terms of trade obscures the effect of the shortage variable, which is no longer significant. The only difference worth mentioning is found for the dummy variables capturing the fiscal measures introduced to mitigate the effects of high inflation rates. The joint effect of the reduction and increase in VAT rates is statistically and economically significant, which is also the case for the dummy measuring the joint effect of the emergency aid related to the high gas and electricity prices in 2022Q4. The 9-euro ticket, on the other hand, does not play much of a role. Overall, we take these results as evidence that the baseline model specification is already able to capture the main drivers of wages and inflation in Germany since the pandemic.

4 Results for the Euro Area

Finally, we apply the model to the euro area, which poses several challenges. First, data availability is more limited than in Germany, especially with respect to wages and the labour market. Second, when deriving insights into the behaviour of wages, inflation and expectations at the euro area aggregate, it is important to take into account institutional differences at the country level. For this reason, we choose to estimate the model within a panel framework, which can be seen as a compromise between developing elaborate versions of the model for each member state and estimating the model at the euro area level. For the country-specific versions of the model, we refer to the studies prepared by the various national central banks cited in the introduction. Arce et al. (2024) have estimated the model for the euro area aggregate that allows the use of variables not available at the country level. However, this approach excludes the potential impact of country-specific determinants on the wage and price-setting process.

As we have previously discussed in the data section, we need to make some adjustments in order to adapt the model to the euro area. The estimation sample begins in 1999Q1 and only includes countries from the their entry into the euro area. As the number of job vacancies is not available for most countries and only starts in 2006 for the euro area aggregate, we use the unemployment rate according to the harmonised ILO definition to measure labour market slack. It is important to note that inflation expectations are not available for all countries or only with some gaps, so we use data from neighbouring countries as a proxy. Finally, the model is estimated using three different wage measures: compensation per employee, compensation per hour and negotiated wages.

Regarding the estimation strategy, we estimate the model in two ways. First, we include country-specific fixed effects to account for the institutional and national characteristics that determine the wage and price-setting process in each member state. In addition, we weight the observations by applying HICP country weights. This controls for the fact that developments in larger countries will have a greater impact on euro area inflation. Second, we allow the lockdown dummies in 2020Q2 and 2020Q3 in the wage equation to differ across countries, as the impact of COVID19 and the countermeasures varied considerably among member states. We have also estimated the model with time-fixed effects, which yields results that are qualitatively very similar to the benchmark estimates. However, the inclusion of time-fixed effects somewhat picks up the impact of common shocks, particularly from supply shortages and energy prices. Therefore, we prefer to measure the impact of these shocks directly through the relevant variables.

In this section, we present the estimation results of the euro area panel regressions. We compare the estimated long-run coefficients of each equation with those obtained by estimating the same model at the euro area aggregate and with the results provided by Arce et al. (2024). Second, we evaluate the explanatory power of the various model specifications by generating in-sample forecasts of the endogenous variables using the realised data of the exogenous variables. Third, we decompose the post-pandemic evolution of wages, inflation and expectations at both the country and euro area levels. Finally, we provide conditional forecasts based on country-specific scenarios for the unemployment rate.

4.1 Estimation results

The results of the panel regressions for the euro area are shown in tables 6 to 9. It is important to note tat the results are dependent on the wage series used, namely compensation per employee (COMPE), compensation per hour (COMPH) or total negotiated wages (NEGT), as well as whether the model includes only country fixed-effects (FE) or also HICP country weights (FE+CW).

Table 6: Estimation results for the wage equation in the euro area

	COMPE				COMPH				NEGT			
	FE		FE+CW		FE		FE+CW		FE		FE+CW	
WAGES												
Σ	-0.387	-0.342	-0.185	0.144	-0.544	-0.643	-0.307	-0.489	0.260	0.233	0.060	0.113
p(sum)	0.000	0.000	0.008	0.011	0.000	0.000	0.000	0.000	0.000	0.002	0.445	0.131
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
CF1												
Σ	1.387	1.342	1.185	0.856	1.544	1.643	1.307	1.489	0.740	0.767	0.940	0.887
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U												
Σ	-0.368	-0.393	-0.268	-0.198	-0.415	-0.473	-0.290	-0.310	-0.066	-0.070	-0.098	-0.074
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.012	0.000	0.001
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
CATCH-UP												
Σ	-0.264	-0.209	-0.626	-0.276	0.088	0.008	-0.074	-0.066	0.039	0.093	0.039	-0.038
p(sum)	0.062	0.037	0.000	0.002	0.607	0.946	0.610	0.557	0.569	0.127	0.581	0.512
p(joint)	0.094	0.000	0.000	0.000	0.804	0.487	0.156	0.169	0.000	0.000	0.000	0.000
PRODUCTIVITY												
Σ	0.355	0.216	0.243	-0.004	0.148	0.082	0.161	0.066	0.119	0.090	0.080	0.007
pval	0.000	0.003	0.000	0.941	0.113	0.348	0.058	0.421	0.009	0.067	0.086	0.873
R2	0.055	0.277	0.063	0.311	0.054	0.353	0.067	0.361	0.210	0.320	0.161	0.269
Start	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3
N	1,183	1,471	1,183	1,471	1,183	1,471	1,183	1,471	692	827	692	827

Note: The table summaries the estimation results from fitting the wage equation to the euro area using a panel regression with fixed effects (column FE) and with HICP country weights (column $FE + CW$). The model is estimated using three different wage series: COMPE - compensation per employees, COMP - compensation per hour, and NEGT - total negotiated wages. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$). Models estimated until 2023Q3 include country-specific dummy variables for 2020Q2 and 2020Q3.

Starting with the wage equation in table 6, we find a negative impact of past wage growth when using any of the compensation measures.[9] Negotiated wages, on the other hand, depend positively on their own history. Short-term inflation expectations have a positive impact on wages, ranging from 0.8 for negotiated wages to a maximum of 1.6 for compensation per hour. Overall, these magnitudes are very similar to the German results. The tightness of the labour market, as measured by the unemployment rate, also has a statistically significant effect on

[9] Except for the model with compensation per employees and country weights using the full sample.

wage growth in the euro area. Again, the effect is smallest for negotiated wages at around -0.1 and largest for compensation per hour at around -0.5. The results for the catching-up variable are less clear. For compensation per employee, the effect is highly statistically significant but has the wrong sign. For compensation per hour, the effect is also negative but statistically insignificant. Only for negotiated wages, we found a positive and statistically significant catch-up effect, but not in full sample estimate using country weights. Again, these unstable results are similar to the German estimates. In contrast, we tend to find a positive and also statistically significant effect of labour productivity, at least in the pre-pandemic sample.

Examining the price equation in table 7, it is evident that inflation is positively influenced by its own lags, which exhibit a high degree of persistence. Wages have a positive and significant impact on inflation, ranging from 0.2 for compensation per hour to 0.4 for negotiated wages.

Table 7: Estimation results for the price equation in the euro area

	COMPE				COMPH				NEGT			
	FE		FE+CW		FE		FE+CW		FE		FE+CW	
INFLATION												
Σ	0.761	0.704	0.759	0.811	0.787	0.763	0.801	0.827	0.599	0.574	0.562	0.575
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WAGES												
Σ	0.239	0.296	0.241	0.189	0.213	0.237	0.199	0.173	0.401	0.426	0.438	0.425
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENERGY PRICES / WAGES												
Σ	0.029	0.042	0.022	0.030	0.027	0.041	0.018	0.034	0.043	0.070	0.039	0.059
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FOOD PRICES / WAGES												
Σ	0.142	0.151	0.142	0.106	0.134	0.135	0.133	0.095	0.149	0.151	0.189	0.145
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SHORTAGES												
Σ	0.070	0.015	0.111	0.002	0.071	0.049	0.116	0.037	0.063	0.112	0.088	0.174
p(sum)	0.309	0.731	0.063	0.948	0.303	0.281	0.054	0.326	0.433	0.024	0.238	0.001
p(joint)	0.501	0.000	0.398	0.000	0.570	0.000	0.263	0.000	0.528	0.000	0.485	0.000
PRODUCTIVITY												
Σ	0.022	0.022	0.018	0.006	0.023	0.014	0.027	-0.007	-0.003	-0.032	0.033	-0.001
p(pval)	0.140	0.137	0.223	0.667	0.132	0.368	0.098	0.661	0.902	0.131	0.155	0.957
R2	0.824	0.880	0.801	0.857	0.819	0.879	0.800	0.855	0.838	0.904	0.829	0.898
Start	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3
N	1,183	1,471	1,183	1,471	1,183	1,471	1,183	1,471	692	827	692	827

Note: The table summaries the estimation results from fitting the price equation to the euro area using a panel regression with fixed effects (column FE) and with HICP country weights (column $FE + CW$). The model is estimated using three different wage series: COMPE - compensation per employees, COMP - compensation per hour, and NEGT - total negotiated wages. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

The impact of energy prices on inflation is similar to that in Germany, while the impact of food prices is slightly larger. Finally, supply shortages play a smaller role for inflation in the euro area than in Germany.

Table 8: Estimation results for the short-term expectations equation in the euro area

	COMPE/COMPH				NEGT			
	FE		FE+CW		FE		FE+CW	
SHORT-TERM EXPECTATIONS								
Σ	0.559	0.538	0.432	0.415	0.506	0.476	0.386	0.376
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LONG-TERM EXPECTATIONS								
Σ	0.195	0.227	0.250	0.288	0.216	0.258	0.275	0.310
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INFLATION								
Σ	0.246	0.235	0.318	0.296	0.278	0.266	0.338	0.314
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2	0.796	0.853	0.778	0.844	0.794	0.857	0.770	0.844
Start	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3
N	1,183	1,471	1,183	1,471	692	827	692	827

Note: The table summaries the estimation results from fitting the short-term expectations equation to the euro area using a panel regression with fixed effects (column FE) and with HICP country weights (column $FE+CW$). The model is estimated using two different panels based on the availability of the wage series. $COMPE/COMPH$ includes all euro area member states, $NEGT$ includes only nine countries. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

Table 9: Estimation results for the long-term expectations equation in the euro area

	COMPE/COMPH				NEGT			
	FE		FE+CW		FE		FE+CW	
LONG-TERM EXPECTATIONS								
Σ	0.983	0.995	0.982	0.993	0.983	0.994	0.980	0.993
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INFLATION								
Σ	0.017	0.005	0.018	0.007	0.017	0.006	0.020	0.007
p(sum)	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000
R2	0.876	0.869	0.876	0.869	0.876	0.871	0.876	0.870
Start	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3
N	1,183	1,471	1,183	1,471	692	827	692	827

Note: The table summaries the estimation results from fitting the long-term expectations equation to the euro area using a panel regression with fixed effects (column FE) and with HICP country weights (column $FE+CW$). The model is estimated using two different panels based on the availability of the wage series. $COMPE/COMPH$ includes all euro area member states, $NEGT$ includes only nine countries. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1}+\alpha_{1,2}+\alpha_{1,3}+\alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

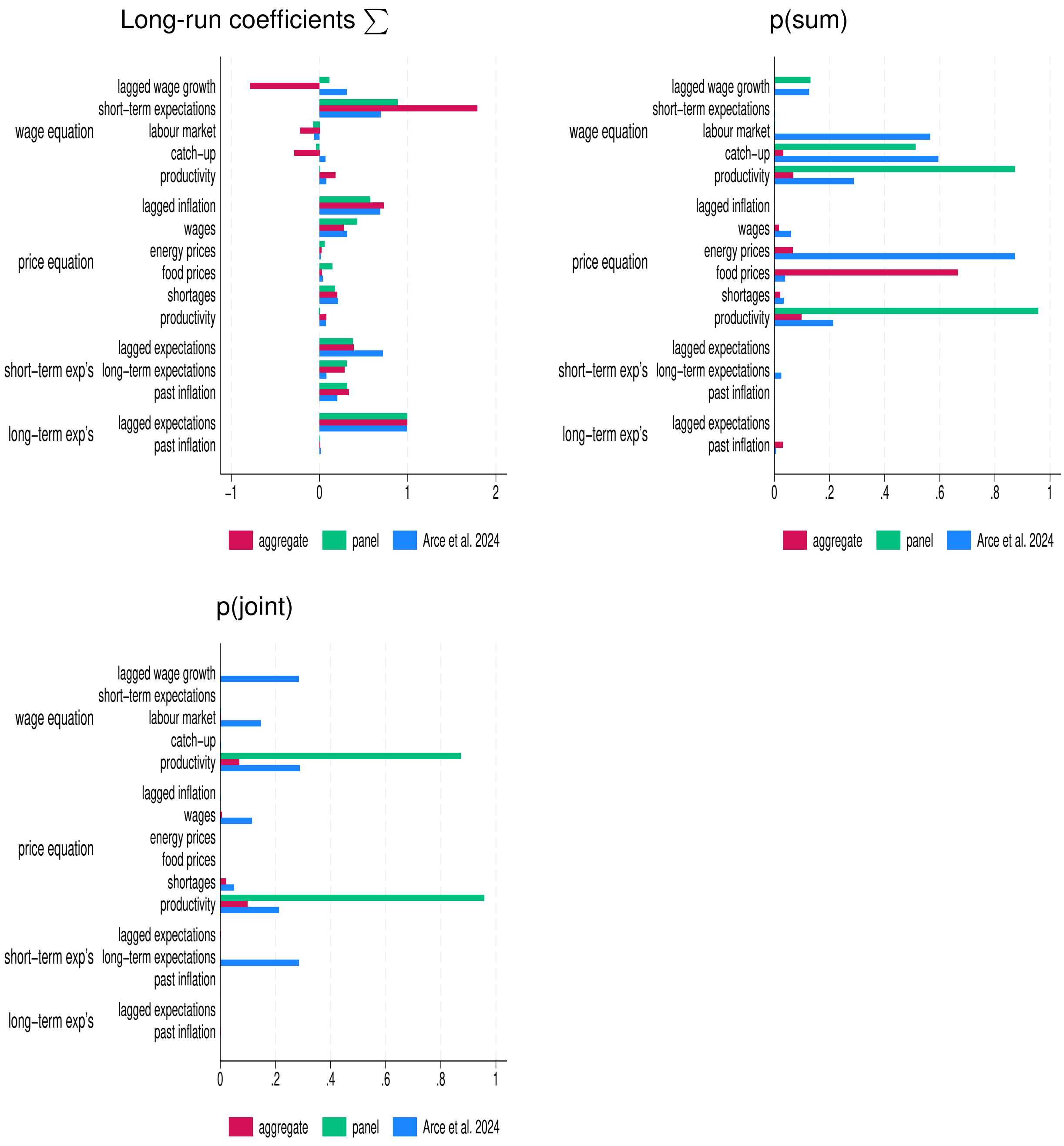
Regarding inflation expectations, the results in table 8 suggest that short-term expectations are much more persistent in the euro area than in Germany. Moreover, short-term expectations are less closely linked to long-term expectations and the impact of past inflation is found to be somewhat smaller. For long-term expectations, the results for the euro are very close to those for Germany. Expectations are very persistent and depend only marginally on past inflation.

Fitting the model to the euro area by using a panel framework has the advantage of taking into account country-specific features in the wage and price-setting process. To see how the results differ when estimating the model using aggregate euro area time series, figure 9 shows the resulting long-run coefficients of the panel regression with fixed effects and country weights compared to the single equation estimates for the euro area. Both models use the same set of variables, i.e. the unemployment rate and total negotiated wages. In addition, the figures show the estimation results of Arce et al. (2024) also for the euro area aggregate, but with a different set of variables. Specifically, for labour productivity, they use gross value added per employee instead of productivity per hour as in our setting. For long-run expectations, they use the predictions from the Survey of Professional Forecasts (SPF) instead of Consensus Economics, and for the shortage variable, they use the New York Fed's Global Supply Chain Pressure Index (GSCPI) instead of the survey responses on factors limiting production. Most importantly, they use a back-cast version of the vacancy-unemployment ratio instead of the unemployment rate used in our approach. Also note that the results shown in figure 9 use negotiated wages, as this is the main variable used by Arce et al. (2024). We provide the full set of estimation results for the euro area aggregate also using compensation per employee and compensation per hour in Appendix E.

Starting with the wage equation, we find that short-term inflation expectations have a positive and statistically significant effect in each of the three models, with the size of the effect being largest for the aggregate equation and smallest for Arce et al. (2024). A tighter labour market leads to higher wage growth in all models[10], but is only statistically significant in the panel and aggregate regressions. Arce et al. (2024) find a small positive and statistically significant catch-up effect, while the effect is negative in the panel and aggregate models. Productivity tends to have no significant impact on wages in any of the three approaches. For inflation, we find a positive and statistically significant wage effect throughout, which is largest for the panel regression. In contrast, energy and food prices have a larger larger impact in the panel, while supply shortages behave very similarly. Regarding short-term inflation expectations, the results are quite close whether we use a panel or an aggregate equation, but differ more from Arce et al. (2024). According to their estimates, short-term expectations are more persistent and less dependent on long-term expectations and past inflation. The results of estimating the long-run expectations equation are virtually the same in all specifications.

[10]The sign of the coefficient provided by Arce et al. (2024) is reversed for illustrative purposes

Figure 9: Estimation results for the euro area: panel framework vs. single equation vs. Arce et al. (2024)



Note: The figures show the long-run coefficients $\sum$, the p-values of testing whether the sum of the individual coefficients equals zero $p(sum)$ and the p-values of testing whether the individual coefficients are jointly equal to zero $p(joint)$. $Panel$ denote the results from running panel regressions including fixed effects and country weights, $aggregate$ gives the results estimating the equations using aggregate euro area time series and Arce et al. (2024) shows the results using aggregate time series with different specifications. All models use the total negotiated wage series. The long-run coefficient for the labour market effect on wages provided by Arce et al. (2024) is multiplied by -1 for sake of comparison. Estimation sample: 1999Q1-2023Q3.

Overall, there are four main differences between the three approaches. First, the labour market effect on wages is only statistically significant when using the unemployment rate instead of the vacancy-unemployment ratio, but of a similar magnitude. Second, the catch-up effect has the wrong sign in the panel and aggregate regressions. Third, wages and commodity prices are more important for inflation in the panel framework. And fourth, short-term expectations are less persistent and more sensitive to long-term expectations and past inflation in our approach.

4.2 Model fit

Next, we take a closer look at the model fit for the euro area. We compute in-sample forecasts for the four endogenous variables wage growth, inflation, short-term expectations and long-term expectations. We estimate the panel model including country fixed effects and also including HICP country weights for each of the three different wage series over the full sample 1999Q1 to 2023Q3. We then derive in-sample forecasts conditional on the realised path of the exogenous variables and taking into account the feedback effects between the endogenous variables. Annualised quarterly growth rates of wages and inflation are transformed into annual rates. The use of the panel regressions allows us to compute in-sample forecasts for each country, which we then aggregate to the euro area level by applying HICP country weights.[11]

Table 10 shows for each equation the root mean squared forecast error of the predictions over the sample from 2010Q1 to 2023Q3.

Table 10: RMSE of in-sample forecasts for the euro area using different models

	FE			FE+CW			AGG		
	COMPE	COMPH	NEGT	COMPE	COMPH	NEGT	COMPE	COMPH	NEGT
WAGE	1.13	0.78	0.29	1.06	0.77	0.27	1.06	0.66	0.47
INFLATION	0.65	0.60	0.35	0.66	0.38	0.24	0.60	0.42	0.45
SHORT EXP	0.42	0.31	0.34	0.43	0.27	0.26	0.54	0.40	0.46
LONG EXP	0.10	0.06	0.06	0.08	0.06	0.06	0.07	0.06	0.05

Note: Numbers denote the root mean squared forecast error (RMSE) of in-sample forecasts from panel regressions using country fixed effects (FE) or country fixed-effects and HICP country weights (FE+CW), as well as different wage measures, compensation per employees (COMPE), compensation per hour (COMPH) and total negotiated wages (NEGT). Column AGG reports results from fitting the model to the euro area aggregate. RMSEs are computed over the period 2010Q1 to 2023Q3.

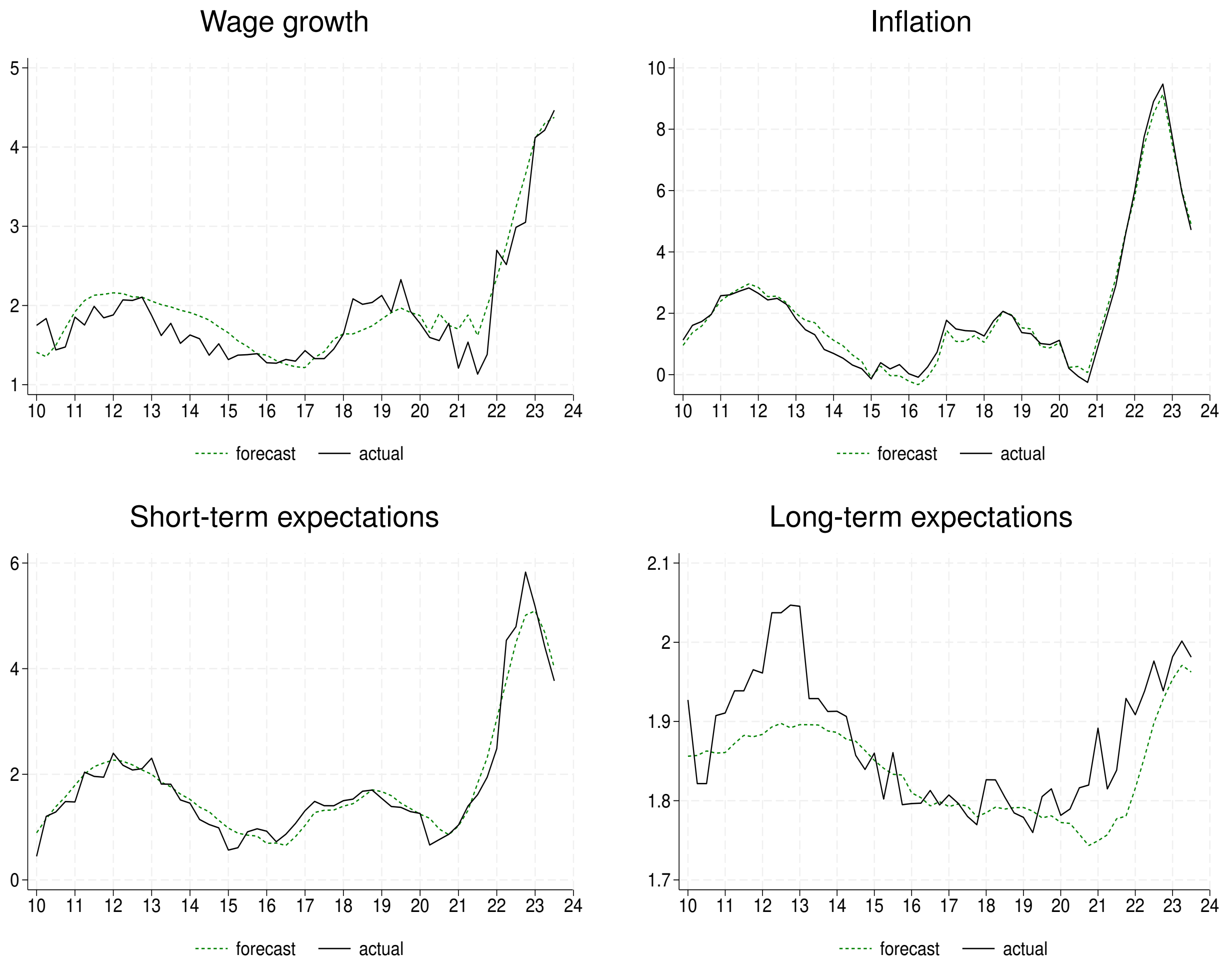
Comparing the panel regressions, we find that adding HICP country weights to the country fixed effects reduces the in-sample forecast errors for all equations and wage series, except for the inflation equation estimated with compensation per employee. Moreover, in both panels and for all equations, compensation per hour always outperforms compensation per employee, and negotiated wages outperform compensation per hour. Therefore, the best model fit for the euro area is obtained by estimating a panel with country fixed effects and HICP country weights

[11] The aggregation of wage growth and inflation expectations using HICP country weights does not exactly match the official euro area series. While the differences are negligible for wages, they are more relevant for inflation expectations. With regard to the latter, it should be noted that calculating a weighted average of country-specific expectations does not necessarily provide a good proxy for expected inflation for the euro area. Therefore, comparisons between panel and aggregate results for the expectations equation should be made with caution.

and using negotiated wages. Finally, estimating a panel pays off: except for the wage equation using compensation per hour, the model fit is lower when the model is estimated directly at the euro area level.

Figure 10 plots the in-sample forecasts of this benchmark model against the realised values. Overall, the model performs very well. For wages, the predicted wage growth was too high from 2010 to 2016, and too low in 2018 and 2019. Thereafter, the predicted wage growth was again too high, but the model was successful in predicting rising wage growth. Given the different scale, the model also performed well with regard to inflation, again overestimating until 2015, followed by underestimating until the start of the pandemic. Short-term expectations are also predicted reasonably well, except for the large spike at the end of 2022. Finally, the model has some difficulties in predicting long-term expectations, but here one has to take into account the different scale and the fact that we had to proxy missing expectations in some countries.

Figure 10: In-sample forecasts for the euro area



Note: The figure shows as green dotted lines the in-sample forecasts for wage growth (NEGT) and inflation, expressed in year-over-year rates, and for short-term and long-term inflation expectations. Predictions are derived from a panel model including country fixed-effects and HICP country weights estimated from 1999Q1 to 2023Q3. The black solid lines show realised values computed as weighted average of the country data.

4.3 Decomposing post-pandemic developments

We then use the estimated model to decompose euro area developments in wages, inflation and expectations since the pandemic. We follow exactly the same procedure as for the German case, except that we first derive country-specific decompositions before aggregating them to the euro area level. We start the decomposition in 2020Q1 and construct the shocks from energy prices, food prices, supply shortages and lockdown measures as deviations from zero. The productivity shock is constructed relative to the country-specific sample averages and the unemployment shock is defined relative to its pre-pandemic values in each country.

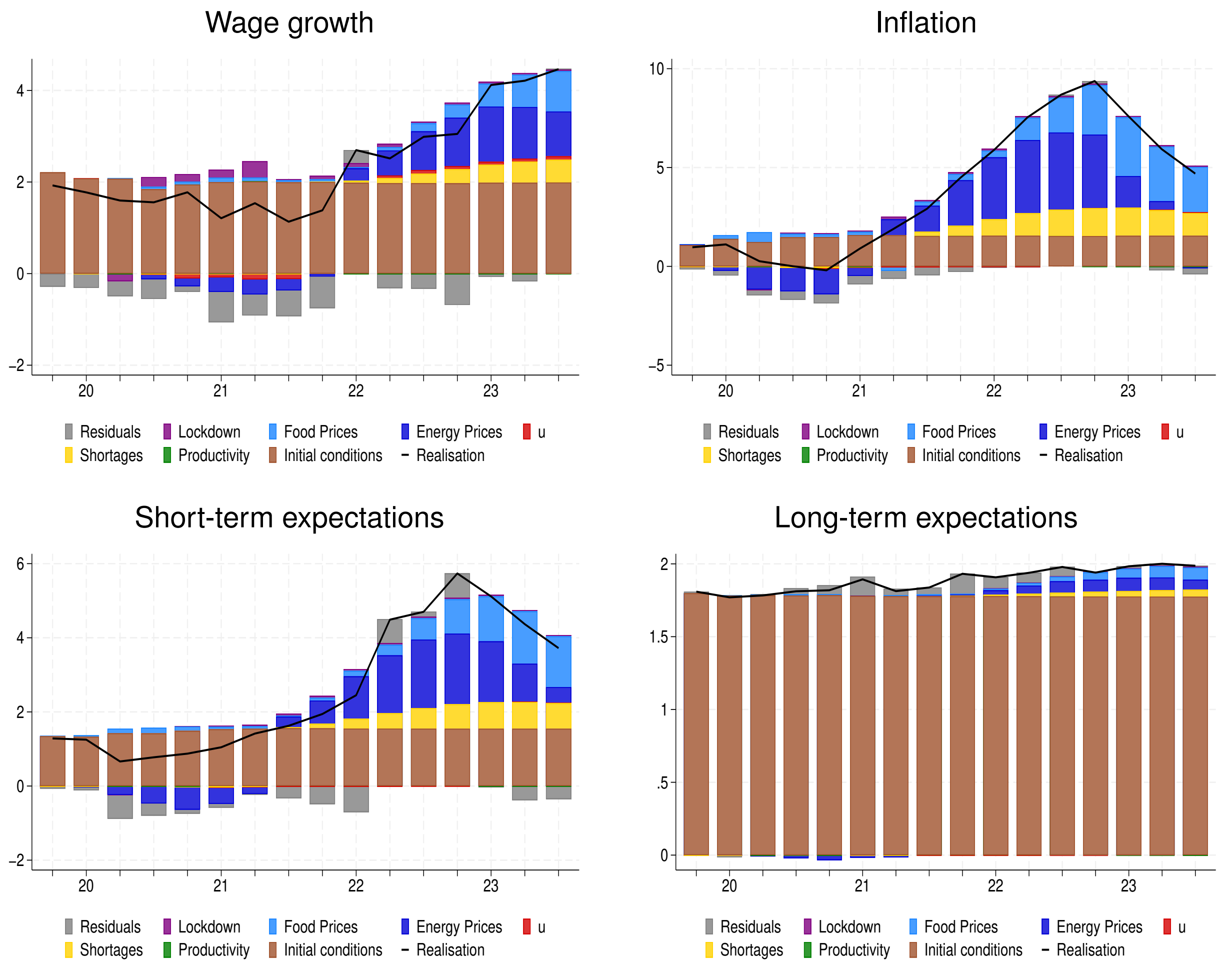
In the appendix, we show the decompositions for wage growth and inflation (figure F1) and for inflation expectations (figure F2) for the nine countries of the euro area panel with negotiated wages. For wages, energy prices are the main driver in all countries, with the lowest impact in Portugal, followed by Austria and France, and the highest contribution in Italy. Foods prices and supply shortages are also responsible for rising wage growth in some countries. The impact of the unemployment rate is very small and most relevant in Spain, Italy and France. The decomposition of the inflation rate is more homogeneous across countries. The energy price shock has the largest impact, followed by food price shocks and supply shortages, while the unemployment rate plays no role. The picture is similar for short-term and long-term expectations.

Comparing the results of the panel decompositions for Germany with the results of the individual estimations for Germany highlights two important points. First, it matters which wage variable we use and how labour market slack is measured. According to the decompositions for Germany in figure (4) using basic salaries and in figure (5) using compensation per hour, labour market tensions measured by the vacancy-unemployment ratio contributed significantly to wage growth. In contrast, the decomposition of inflation yields rather similar results according to both approaches. This finding therefore suggests that the wage equation should be estimated at the country level, taking into account the institutional features of the wage-setting process in each country, even if this limits the comparability of results within the euro area. Similarly, estimating a wage equation for the euro area aggregate can only serve as a crude compromise of the underlying wage equations at the national level.

Figure 11 shows the country-specific decompositions aggregated to the euro area level. In general, we find that the acceleration in wage growth from the beginning of 2022 onwards is mainly driven by positive energy price shocks and, from the end of 2022 onwards, by an increasing impact of food price shocks. Labour market tightness also makes a positive contribution from 2022 onwards, but only to a small extent. Inflation is also mainly driven by energy price shocks, but also by food price shocks and supply shortages. The same applies to short- and long-term inflation expectations.

Comparing the results with those of Arce et al. (2024), there are some differences. According to their evidence, the acceleration in wage growth has been driven more by the labour market and less by energy prices. In contrast, the picture for inflation is rather similar.

Figure 11: Decomposition of euro area developments using negotiated wages as wage variable



Note: The figure shows as black solid lines actual values for wage growth (NEGT) and inflation, expressed in year-over-year rates, and for short-term and long-term inflation expectations. The coloured bares denote the contributions of the different exogenous variables in addition to the residuals and the initial conditions of each equations. The decompositions are computed as weighted averages from country-specific contributions derived from a panel regression. Estimation sample: 1999Q1-2023Q3.

4.4 Conditional forecasts

Finally, the model can be used to gains some insights into the future path of inflation in the euro area. We again use the panel regression with country fixed effects and HICP country weights. For robustness, we use both negotiated wages and compensation per hour as wage variables. As before, we assume that supply shortages, energy price growth and food price growth return to zero and that labour productivity grows at its long-run average across countries. For the unemployment rate, we use four scenarios depending on the values in each country: the sample minimum, the sample mean, the value in 2019Q4 and the value in 2023Q3. Finally, we repeat the same exercise using our estimates for the euro area aggregate.

Based on the projections, inflation in the euro area will return rather quickly to the 2% target.

The panel estimates suggest that inflation will then gradually decrease in the absence of any further shocks. Importantly, it does not matter whether we use negotiated wages or compensation per hour to project inflation. Estimating the model at the euro area aggregate level also predicts declining inflation rates. However, these estimates suggest that inflation will decrease to nearly zero by the end of 2024 before recovering. Note that the results of the aggregate estimation using compensation per hour are not as meaningful as the sign of the estimated impact of wages, energy prices and food prices is negative (see table E2).

Compared with the Eurosystem's most recent inflation forecast for the euro area, published in December 2023 (European Central Bank, 2023), our model projections suggest a faster decline in inflation. Note that this difference may be due to a number of issues that are relevant for forecasting but are not included in our model. For example, our projection is based on the assumption that the impact of commodity prices is zero, that the unemployment rate correctly captures labour market pressures in all countries, and that the estimated panel coefficients are a good compromise for estimating a more detailed model version at the country level. The conditional forecasts should therefore be interpreted with caution.

5 Conclusion

In this paper we have applied the model proposed by Bernanke and Blanchard (2023) to Germany and the euro area. Overall, the model has proved to be very useful for analysing the joint behaviour of inflation, wages and inflation expectations. According to the model, inflation has been driven mainly by commodity price shocks and supply shortages and much less by the labour market. Applying the model to the euro area is challenging because of the large impact of country-specific characteristics, in particular on wage-setting. We believe that the use of a panel approach can be a promising way to derive insights for the euro area while taking into account the country dimension.

The model and analysis presented in this paper could be extended along the following lines. First, both in Germany and in the other euro area countries, the wage equation deserves further attention, as its empirical fit is relatively low compared to the other equations. Second, for the euro area, some of the data limitations could be addressed, in particular with respect to missing inflation expectations in some countries. The construction of a vacancy series could be done by following the idea of Arce et al. (2024), who used the responses from the European Commission's firm survey. In addition, it might be worthwhile to include some important country-specific characteristics in the panel regression or to allow the coefficients on some variables, such as the unemployment rate, to vary across countries. Third, one could estimate the model using monthly data and assess its forecasting ability in an out-of-sample forecasting exercise. And fourth, one could consider extending the model, e.g. by splitting headline inflation into a core and a volatile component (Hasenzagl, Pellegrino, Reichlin, and Ricco, 2022) or by explicitly modelling labour market slack.

As regards the outlook for future inflation, the projected decline in price pressures clearly depends on the assumption that no further major commodity shocks hit the European economies. Given the additional tensions in global markets, exacerbated by the terrorist attack in Israel, the likelihood of this scenario does not seem too high. This, together with other factors discussed by Reis (2023), points to the high degree of uncertainty surrounding the current and future inflation situation.

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A Description of the data set

Variable	Source	Description
		GERMANY
		Wages
COMPE	Destatis	Compensation per employee, seasonally and calendar adjusted, total economy
COMPH	Destatis	Compensation per hour, seasonally and calendar adjusted, total economy
EFFW	Destatis	Effective wages (*Bruttolöhne und -gehälter*), per hour, seasonally and calendar adjusted
NEGT	Bundesbank	Negotiated wages including all arrangements and lump-sum payments, per hour, seasonally adjusted
NEGR	Bundesbank	Negotiated wages, including arrangements (e.g., company pension scheme) and excluding one-time payments (e.g., inflation compensation premium 2023) (*Tabellenwirksame Leistungen*), hourly basis, seasonally adjusted
NEGB	Bundesbank	Negotiated wages, basic salaries, excluding lump-sum payments (e.g., vacation pay) (*Grundvergütungen*), hourly basis, seasonally adjusted
		Labour Market
PRODE	Destatis	Real labour productivity per employee, seasonally adjusted, total economy
PRODH	Destatis	Real labour productivity per hour, seasonally adjusted, total economy
VAC	FEA	Total number of posted jobs, seasonally and calendar adjusted
USGB	FEA	Total number of unemployed persons, national definition (e.g., including refugees) seasonally adjusted
UILO	Destatis	unemployment, ILO definition
URATE	Destatis	unemployment rate, seasonally adjusted
EMPFULL	IER	Number of full-time workers, seasonally and calendar adjusted
EMPPART	IER	Number of part-time workers, seasonally and calendar adjusted
EMPSHORT	IER	Number of short-term workers, seasonally and calendar adjusted
		Consumer Prices and Inflation Expectations
CPI15	Destatis	National consumer price index, base year 2015, seasonally and calendar adjusted
CPI20	Destatis	National consumer price index, base year 2020, seasonally and calendar adjusted
HICP	Destatis	Harmonised index of consumer prices, seasonally and calendar adjusted
ENERGY	Destatis	HICP subcomponent energy, seasonally and calendar adjusted
FOOD	Destatis	HICP subcomponent food, seasonally and calendar adjusted

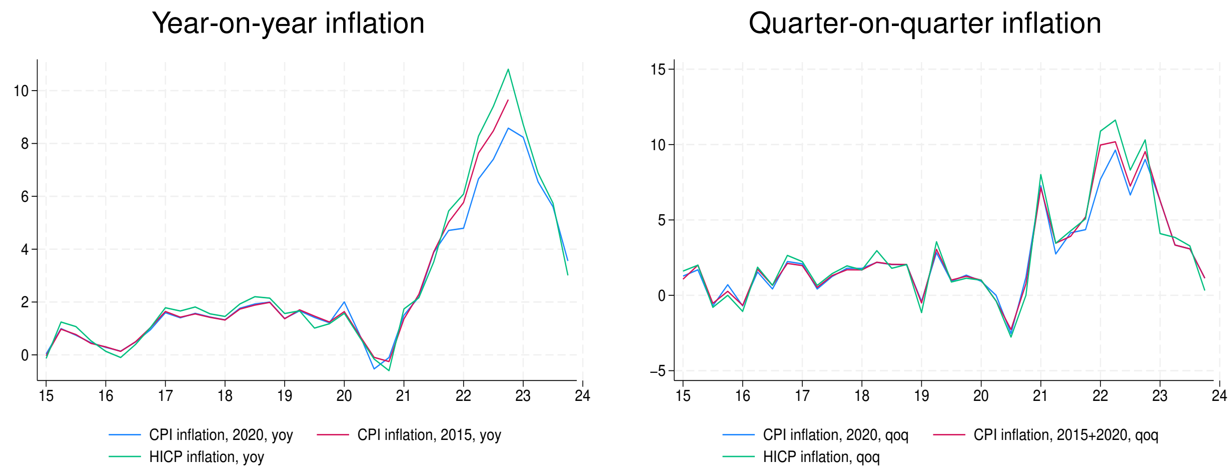
Variable	Source	Description
Consumer Prices and Inflation Expectations (continued)		
EXPCY	CE	Inflation expectations of professional forecasters, current calendar year
EXPNY	CE	Inflation expectations of professional forecasters, next calendar year
EXP5Y	CE	Inflation expectations of professional forecasters, 6 to 10 years ahead
Additional Data		
SHORTAGE1	FED	New York Fed global supply chain pressure index (GSCPI)
SHORTAGE2	Google	Number of Google search requests for the term "Lieferengpässe"
SHORTAGE3	EC	Factors limiting production, fraction of firms mentioning shortage of material and/or equipment, seasonally adjusted
EURO AREA		
Wages		
COMPE	ECB	Compensation per employee, seasonally and calendar adjusted, all activities except activities of public administration, defence, education, human health and social work
COMPH	ECB	Compensation per hour, seasonally and calendar adjusted, all activities except activities of public administration, defence, education, human health and social work
NEGT	ECB	Negotiated wages including all arrangements and lump-sum payments, per hour, seasonally adjusted, total economy
Labour Market		
PRODE	ECB	Real labour productivity per employee, seasonally adjusted, all activities except activities of public administration, defence, education, human health and social work
PRODH	ECB	Real labour productivity per hour, seasonally adjusted, all activities except activities of public administration, defence, education, human health and social work. No data available for Belgium.
UILO	Bundesbank	unemployment rate, ILO definition, seasonally adjusted
Consumer Prices and Inflation Expectations		
HICP	ECB	Harmonised index of consumer prices, seasonally and calendar adjusted
ENERGY	ECB	HICP subcomponent energy, seasonally and calendar adjusted. Unadjusted data used if seasonally adjusted series are not available.
FOOD	ECB	HICP subcomponent food, seasonally and calendar adjusted. Unadjusted data used if seasonally adjusted series are not available.

Variable	Source	Description
		Consumer Prices and Inflation Expectations (continued)
EXPCY	CE	Inflation expectations of professional forecasters, current calendar year. No data available for Luxembourg and Malta.
EXPNY	CE	Inflation expectations of professional forecasters, next calendar year. No data available for Luxembourg and Malta.
EXP5Y	CE	Inflation expectations of professional forecasters, 6 to 10 years ahead. No data available for Luxembourg and Malta.
		Additional Data
SHORTAGE3	EC	Factors limiting production, fraction of firms mentioning shortage of material and/or equipment, seasonally adjusted

Note: *Destatis*: Statistical Office of Germany, *FEA*: Federal Employment Agency, *ECB*: ECB Data Portal, *CE*: Consensus Economics, *IAB*: Institute for Employment Research, *Google*: Google Trends, *EC*: European Commission Business Survey, *FED*: Federal Reserve Bank of New York

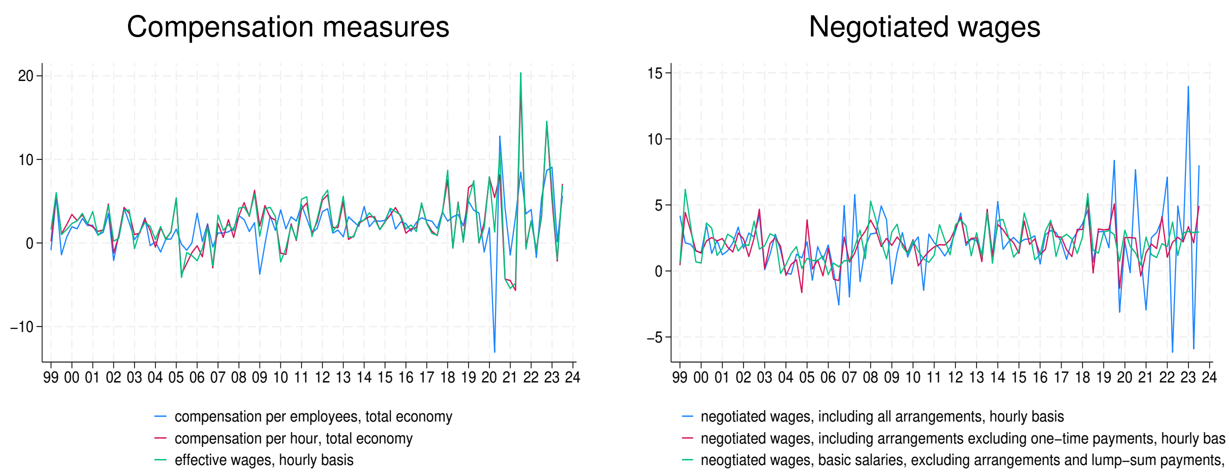
B Data plots for Germany

Figure B1: HICP and CPI inflation rates



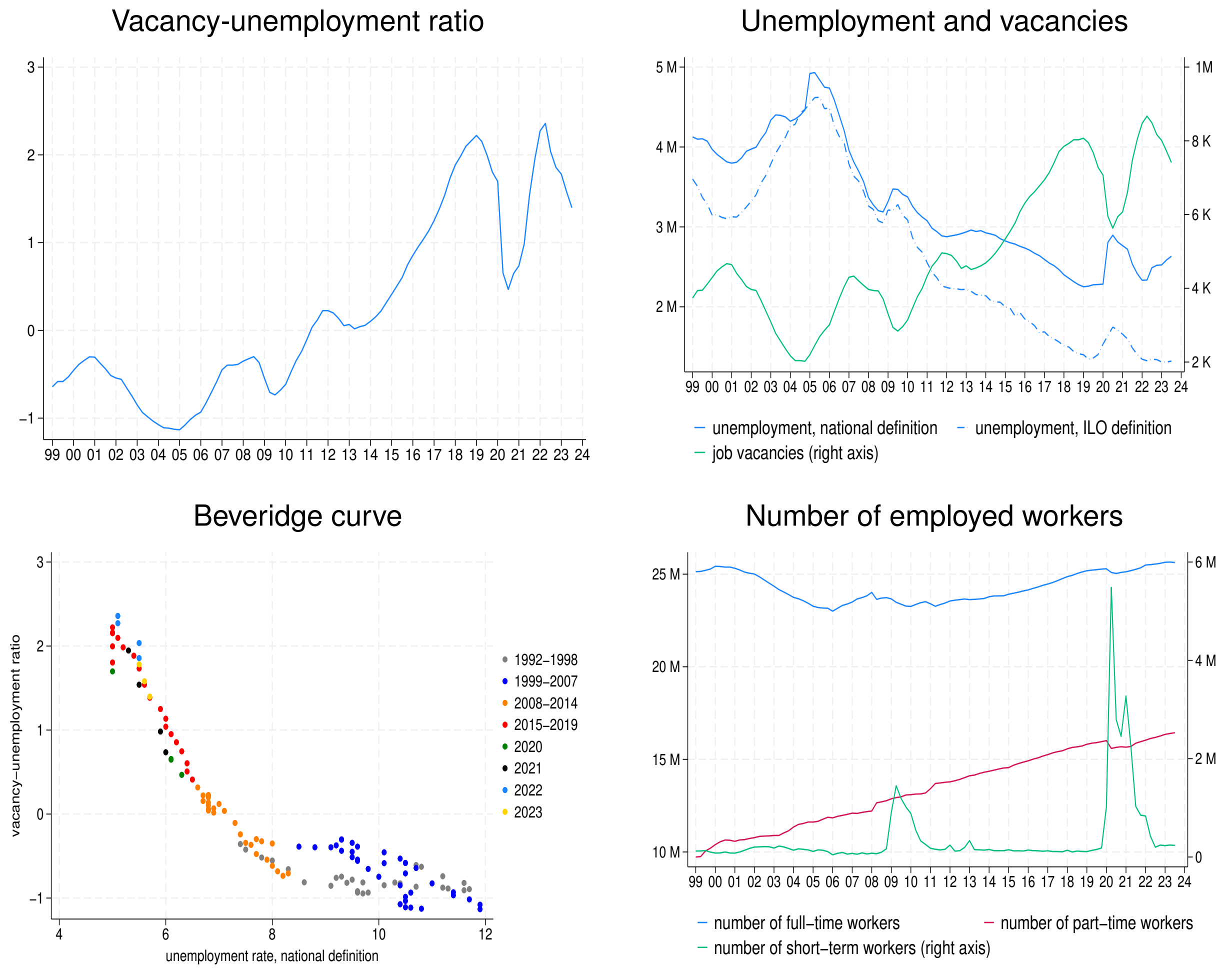
Note: The figure shows inflation rates of the CPI with base year 2020, of the CPI with base year 2015 plus base year 2020 in 2023, and the HICP. Inflation rates in the left figure are expressed as annual growth rates of unadjusted data, and on the right figure as annualised quarterly growth rates of seasonally adjusted data.

Figure B2: Wage growth



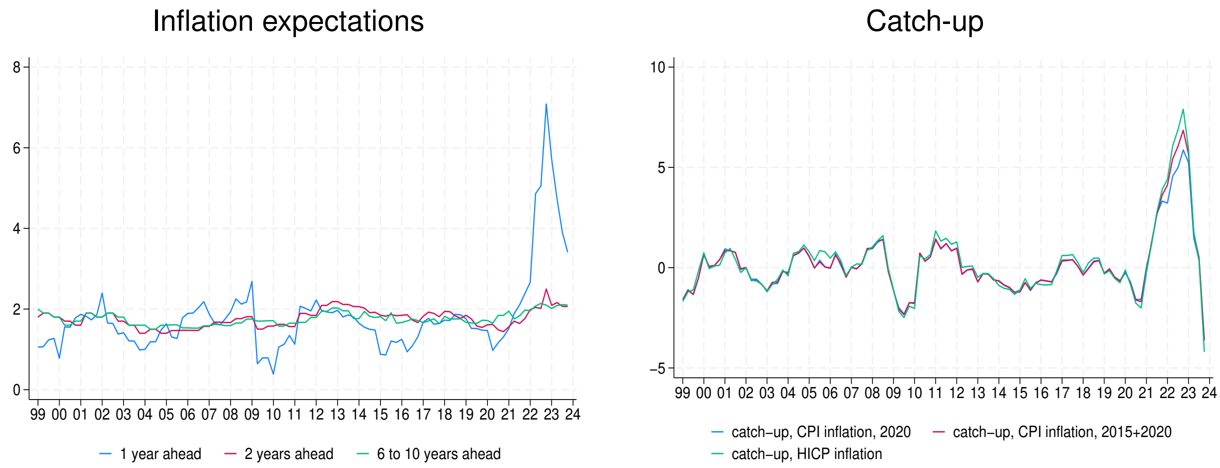
Note: qoq-rates of seasonally adjusted series

Figure B3: Labour market tightness



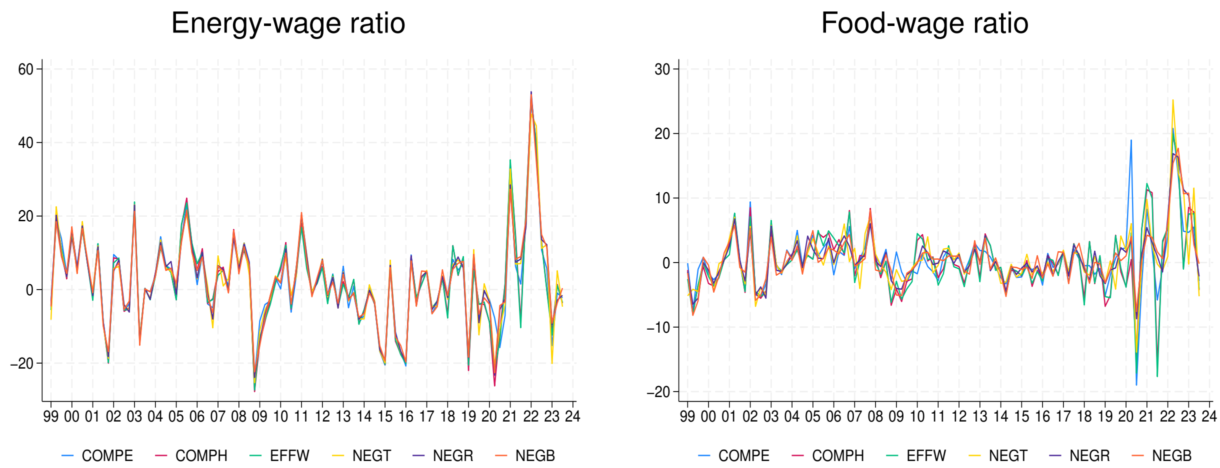
Note: The upper left figure shows the vacancy-unemployment ratio using the national definition of unemployment as the denominator and being standardised from 1992 until 2023. The upper right figure plots the vacancies and unemployment measures, both the national and the ILO definition, expressed in absolute numbers of persons. The lower left figure shows the Beveridge curve. The lower right figure plots the absolute number of full-time workers, part-time workers and short-term workers.

Figure B4: Inflation expectations and catch-up



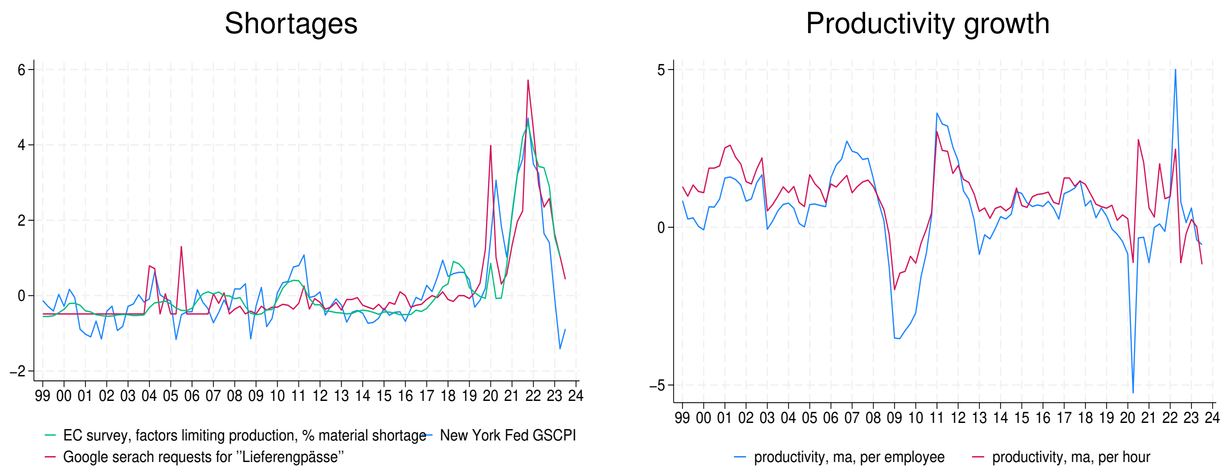
Note: The left figure shows one-year-ahead and 6-to-10 years ahead inflation expectations collected by Consensus Economics, and the right figure shows the catch-up term defined as the average headline inflation over the current and the three previous quarter minus the one-year-ahead expected inflation rate of the previous year.

Figure B5: Energy prices and food prices



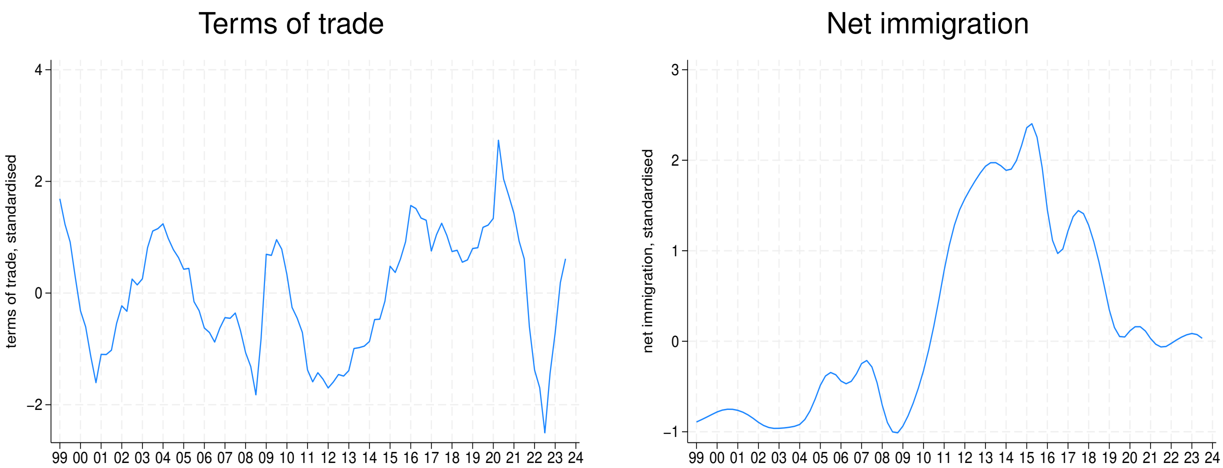
Note: The left figure shows the annualised growth rate of the energy price to wage ratio, and the right figure the annualised growth rate of the food price to wage ratio. Measures are computed using different wage series: COMPE - compensation per employees, COMP - compensation per hour, EFFW - effective wages, NEGT - total negotiated wages, NEGR - negotiated wages excluding arrangements, NEGB - negotiated wages excluding arrangements and lump-sum payments.

Figure B6: Shortages and productivity growth



Note: The left figure shows three different measures of supply shortages, the number of Google search requests for the term "Lieferengpässe", the New York Fed global supply chain pressure index (GSCPI) and the fraction of firms mentioning "material shortage" to the European commission survey on factors limiting production. All series are standardised from 1992 to 2023. The right figures shows the eight quarter of the annualised quarterly growth rate of real labour productivity, both expressed relative to the number of employees and to the number of hours worked.

Figure B7: Terms of trade and net immigration

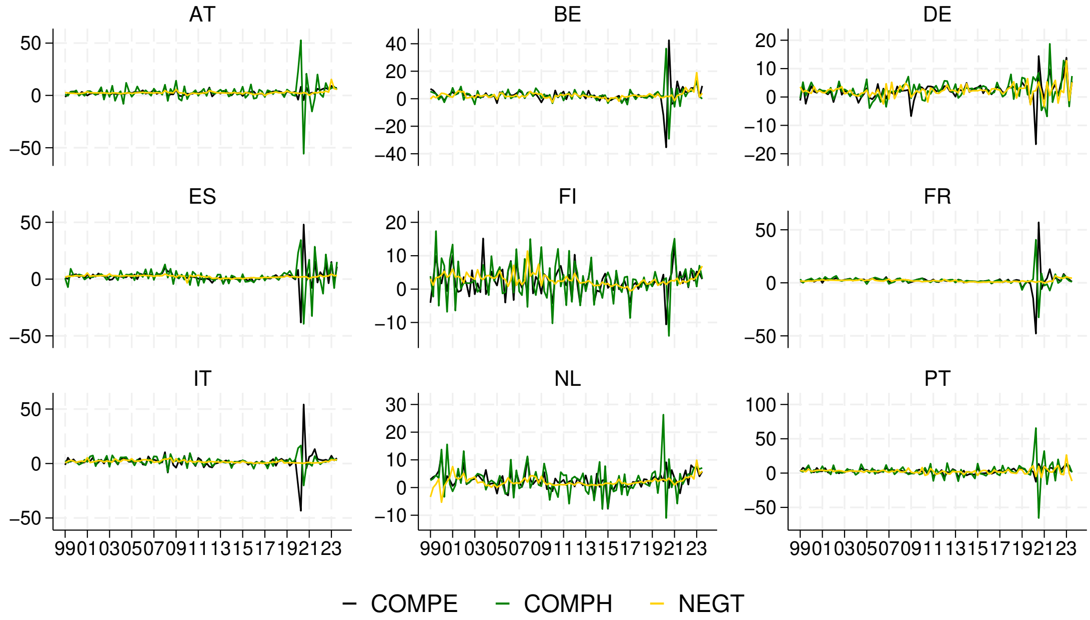


Note: The left figure shows the terms of trade defined as the ratio between the export deflator and the import deflator. The right figure shows the net immigration from member states of the European Union. Both series are standardised from 1992 to 2023.

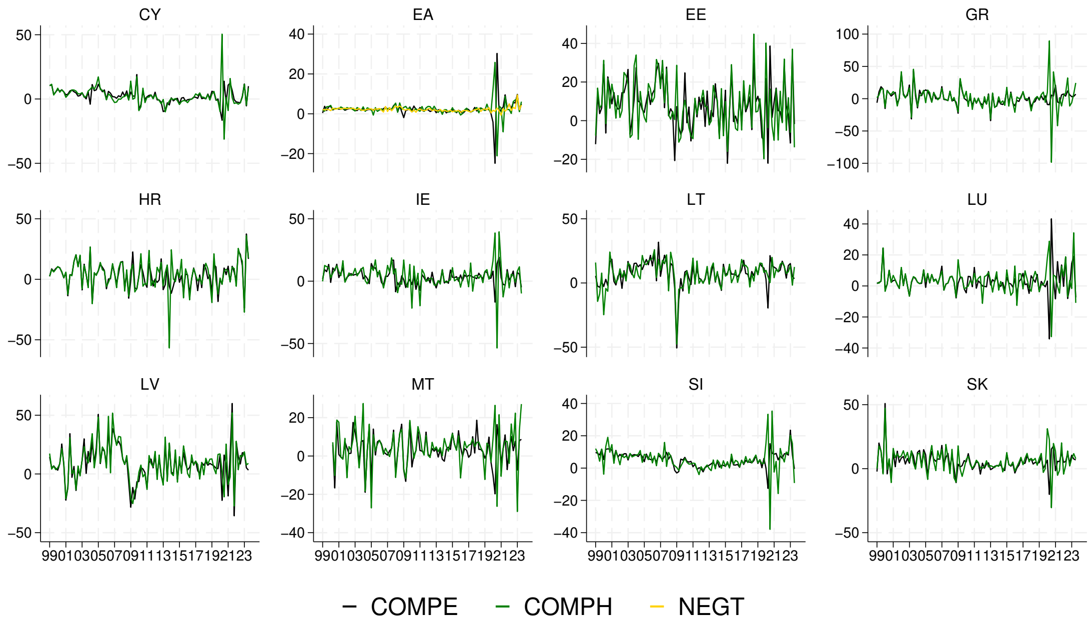
C Data plots for the euro area

Figure C1: Wage growth in euro area countries

Countries with negotiated wage measures



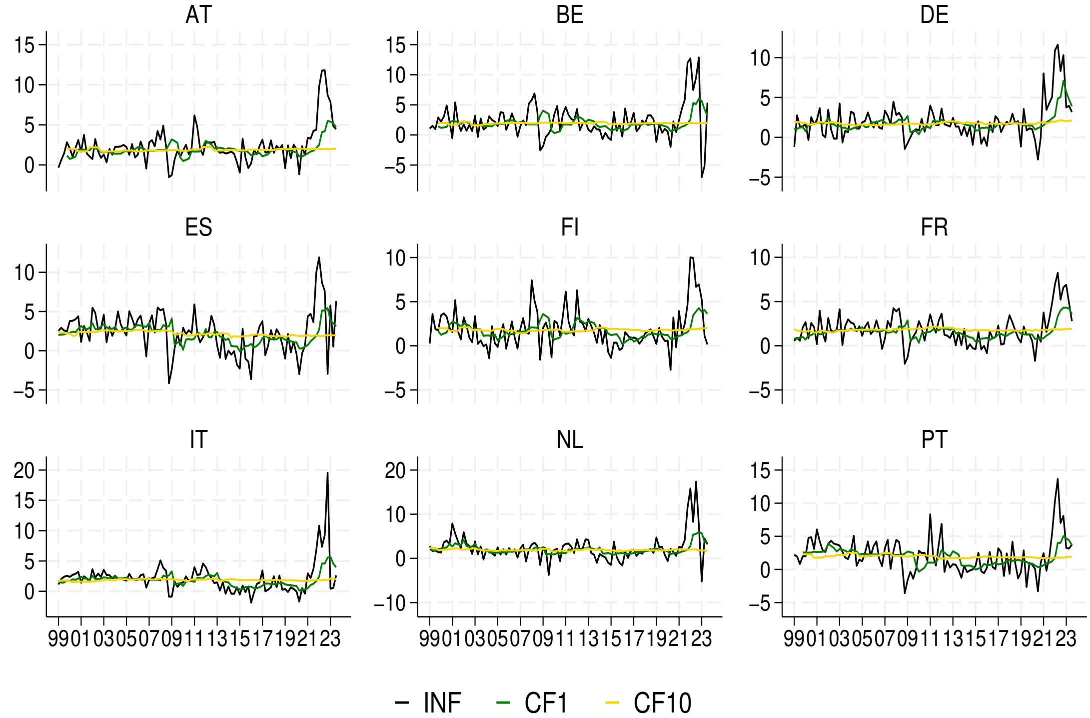
Countries without negotiated wage measures and euro area aggregate



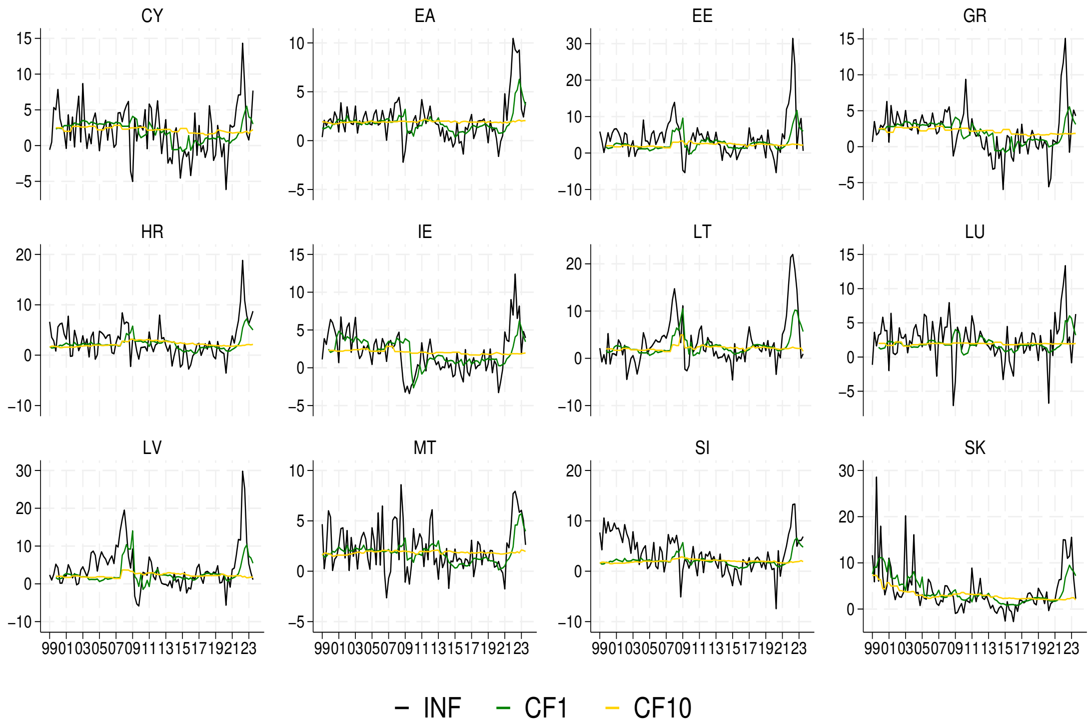
Note: The figures show annualised quarterly growth rates of three different wage measures for euro area countries and the euro area aggregate. COMPE - compensation per employees, COMPH - compensation per hour, NEGT - total negotiated wages.

Figure C2: Inflation and inflation expectations in euro area countries

Countries with negotiated wage measures



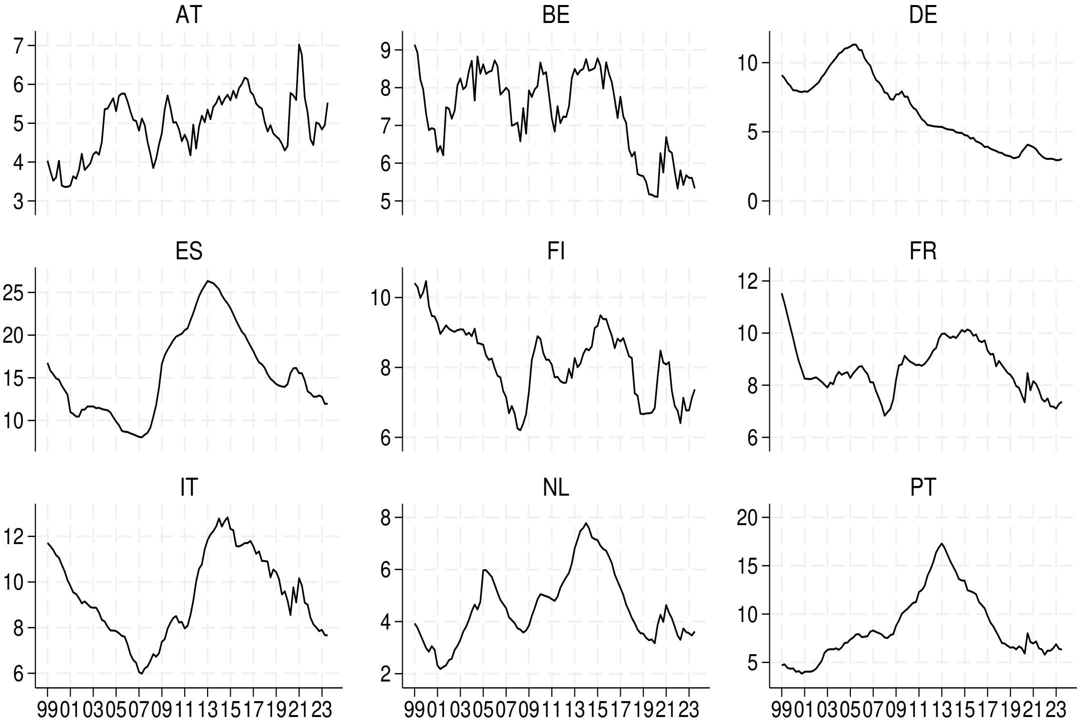
Countries without negotiated wage measures and euro area aggregate



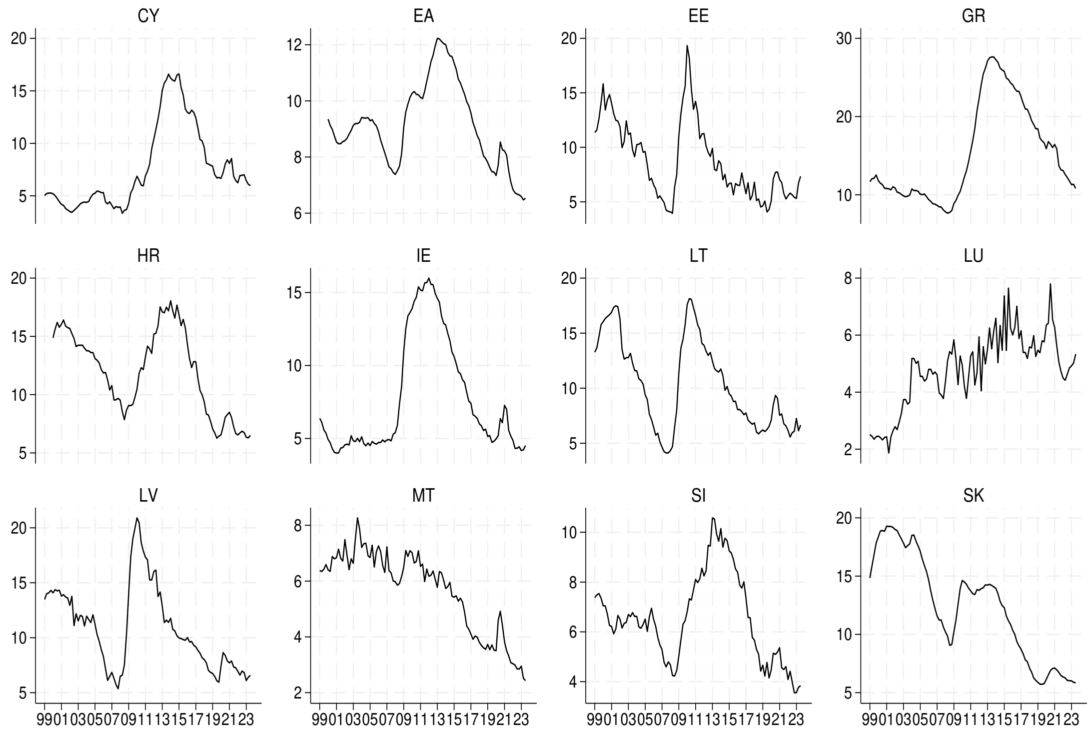
Note: The figures show inflation expressed in annualised quarterly growth rates, short-term inflation expectations $CF1$ and long-term inflation expectations $CF10$ for euro area countries and the euro area aggregate.

Figure C3: Unemployment rates in euro area countries

Countries with negotiated wage measures



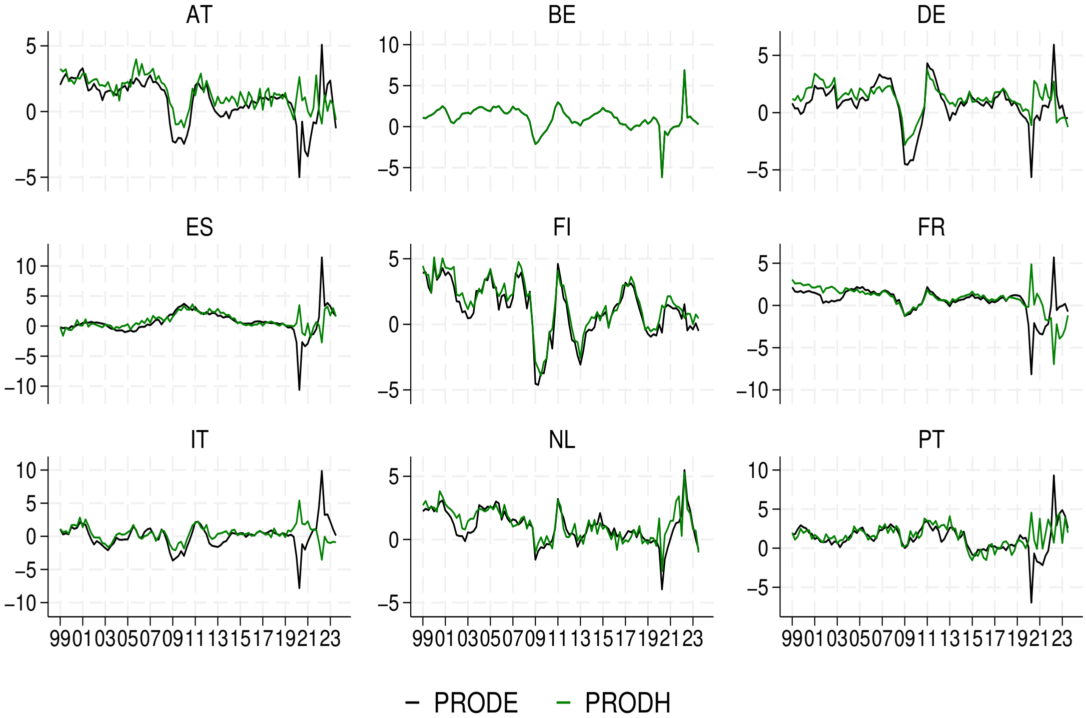
Countries without negotiated wage measures and euro area aggregate



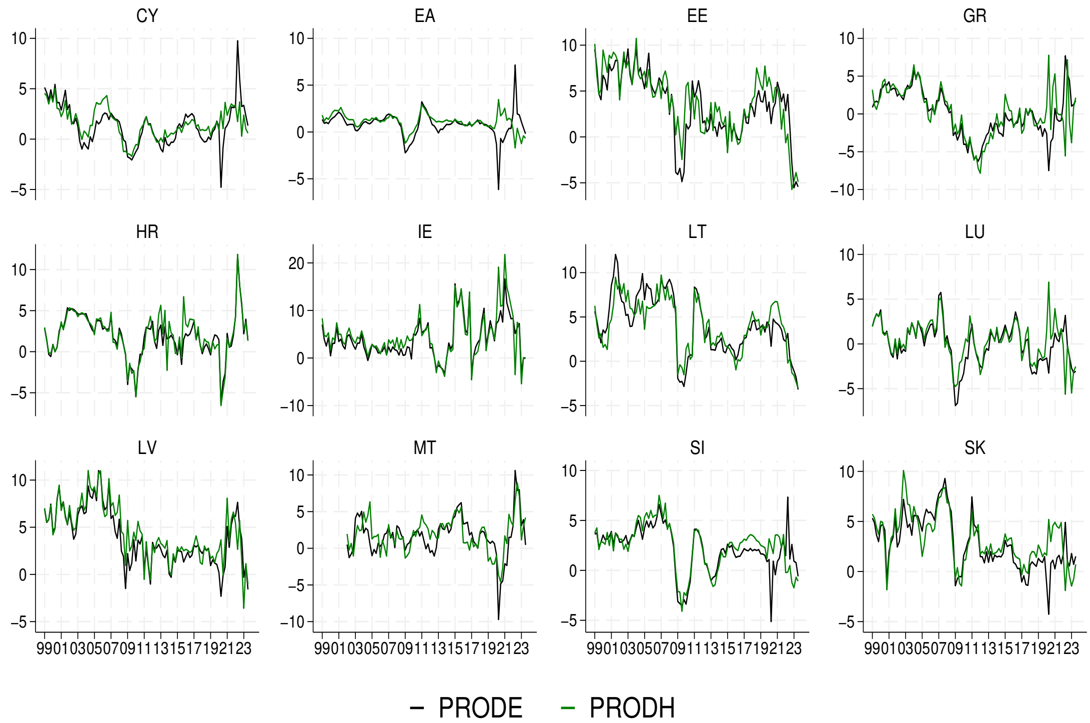
Note: The figures show unemployment rates for euro area countries and the euro area aggregate.

Figure C4: Labour productivity in euro area countries

Countries with negotiated wage measures



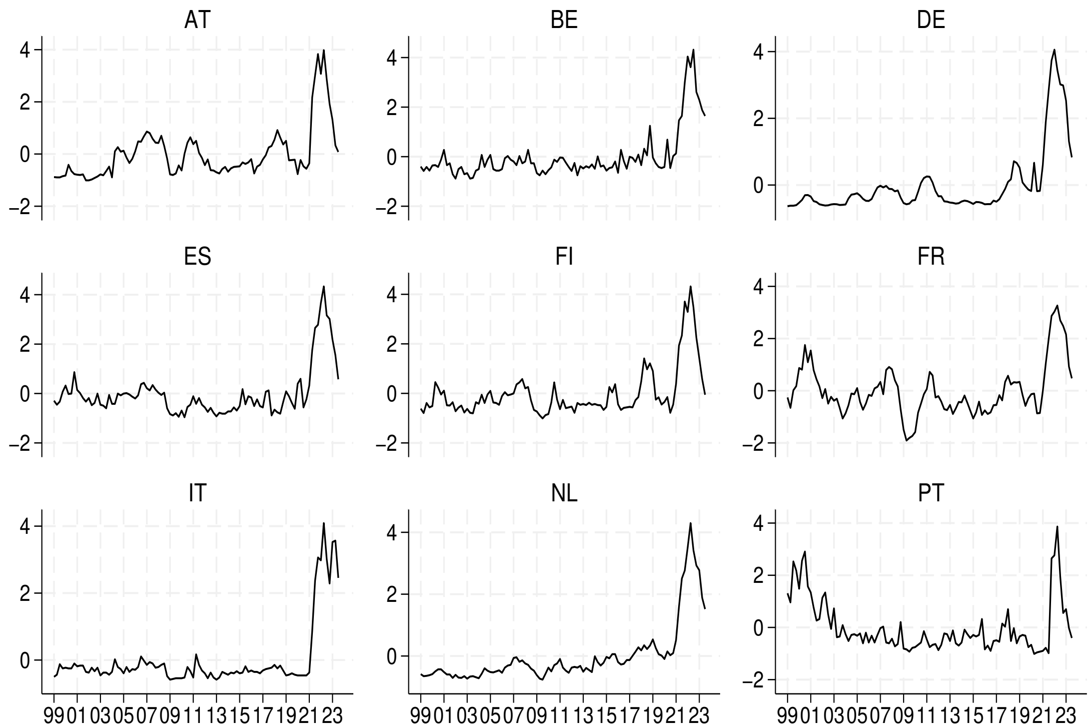
Countries without negotiated wage measures and euro area aggregate



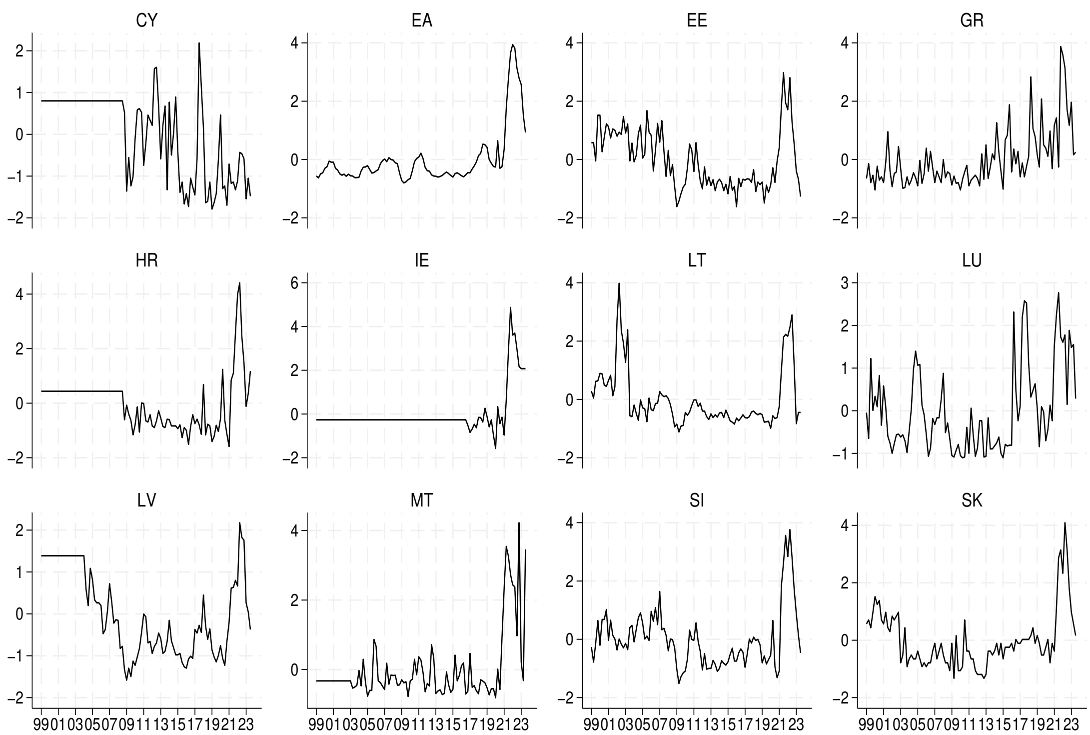
Note: The figures show labour productivity measures per employees, $COMPE$, and per hour, $COMPH$, for euro area countries and the euro area aggregate.

Figure C5: Supply shortages in euro area countries

Countries with negotiated wage measures



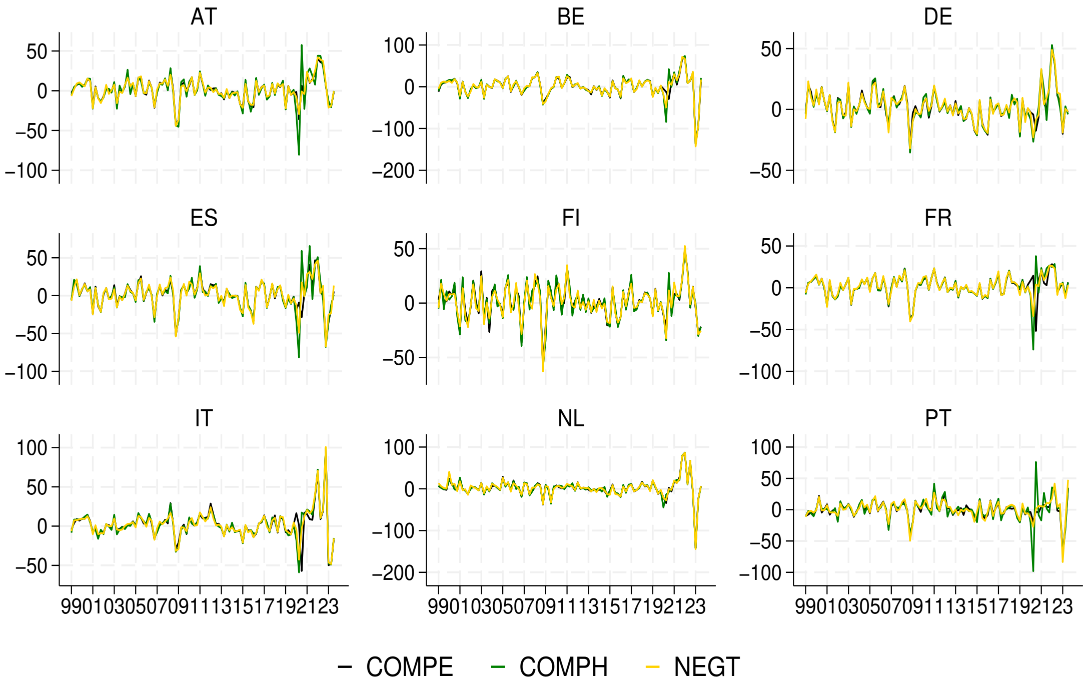
Countries without negotiated wage measures and euro area aggregate



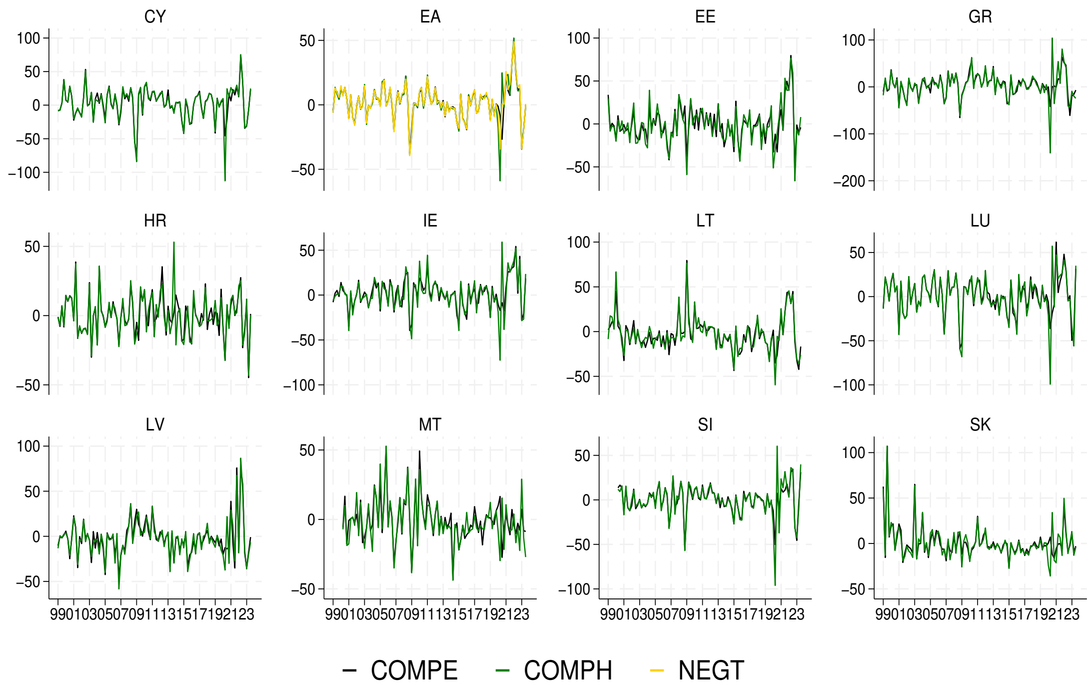
Note: The figures show supply shortages measured as standardised response shares of the EC commission survey on factors limiting production for euro area countries and the euro area aggregate.

Figure C6: Energy price inflation in euro area countries

Countries with negotiated wage measures



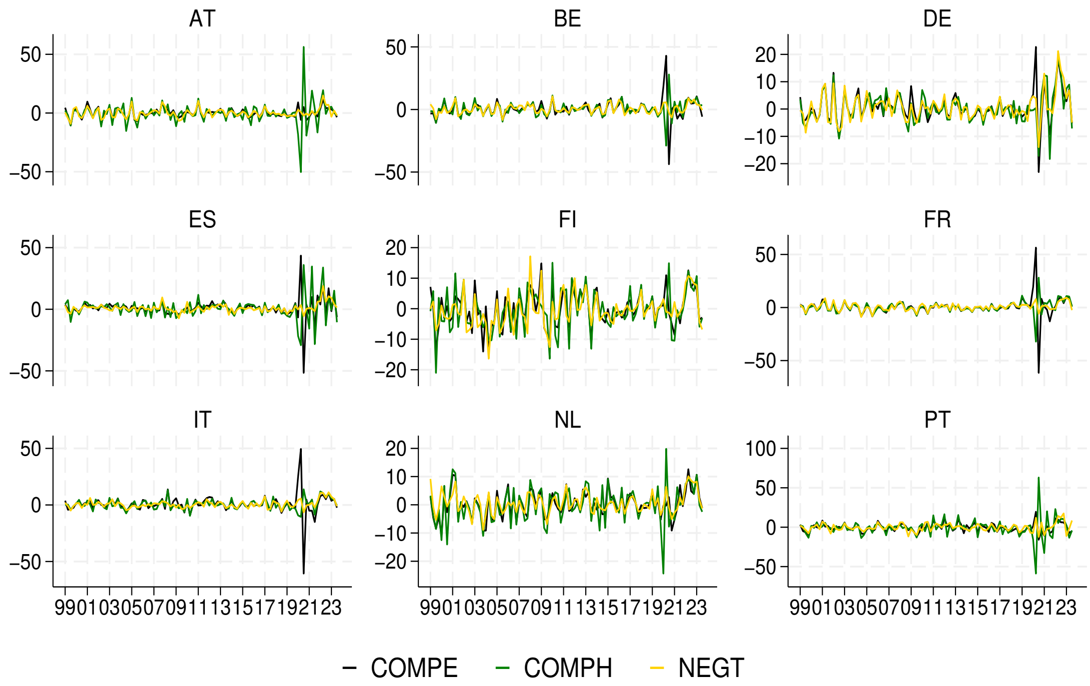
Countries without negotiated wage measures and euro area aggregate



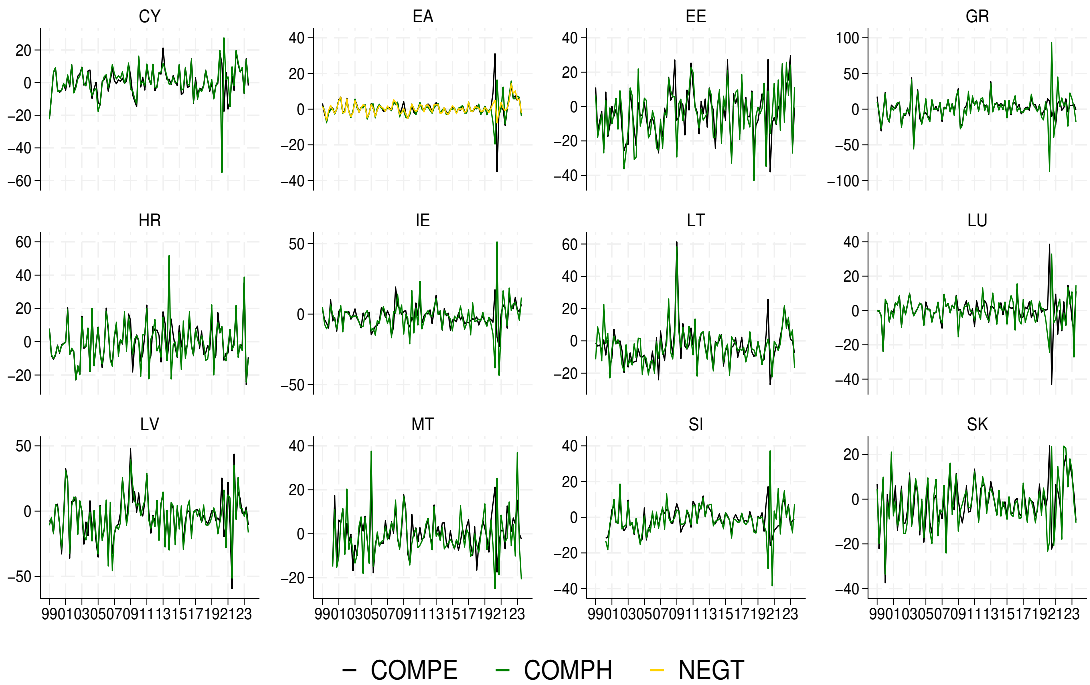
Note: The figures show the annualised quarterly growth rates of the HICP subcomponent energy relative to three different wage measures for euro area countries and the euro area aggregate. COMPE - compensation per employees, COMPH - compensation per hour, NEGT - total negotiated wages.

Figure C7: Food price inflation in euro area countries

Countries with negotiated wage measures



Countries without negotiated wage measures and euro area aggregate



Note: The figures show the annualised quarterly growth rates of the HICP subcomponent food relative to three different wage measures for euro area countries and the euro area aggregate. COMPE - compensation per employees, COMPH - compensation per hour, NEGT - total negotiated wages.

D Alternative results for Germany

Table D1: Alternative estimation results for the wage equation in Germany

	COMPE		COMPH		EFFW		NEGT		NEGR		NEGB	
WAGES												
Σ	-0.685	-0.631	0.101	-0.666	0.088	-0.622	-0.466	-1.334	-0.172	-0.206	0.203	0.211
p(sum)	0.015	0.021	0.694	0.011	0.713	0.015	0.096	0.000	0.475	0.344	0.385	0.302
p(joint)	0.061	0.037	0.309	0.001	0.260	0.000	0.001	0.000	0.792	0.716	0.000	0.000
CF1												
Σ	1.685	1.631	0.899	1.666	0.912	1.622	1.466	2.334	1.172	1.206	0.797	0.789
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
p(joint)	0.000	0.000	0.013	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.015	0.005
VU												
Σ	1.642	1.366	0.970	1.682	1.080	1.694	1.135	0.909	0.814	0.600	0.403	0.380
p(sum)	0.001	0.002	0.127	0.009	0.076	0.007	0.003	0.041	0.026	0.040	0.233	0.138
p(joint)	0.001	0.024	0.023	0.000	0.019	0.000	0.000	0.095	0.009	0.039	0.175	0.219
CATCH-UP												
Σ	-0.466	-0.711	0.175	-1.042	0.049	-1.102	-0.087	-1.424	-0.065	-0.561	0.053	-0.220
p(sum)	0.198	0.016	0.728	0.025	0.920	0.014	0.805	0.000	0.833	0.025	0.855	0.340
p(joint)	0.036	0.011	0.092	0.080	0.040	0.035	0.454	0.001	0.346	0.124	0.912	0.502
TERMS OF TRADE												
Σ	-0.667	-0.315	-0.828	-1.031	-0.882	-1.078	-0.488	-0.555	-0.416	-0.387	-0.281	-0.308
p(sum)	0.026	0.316	0.050	0.040	0.033	0.032	0.072	0.119	0.092	0.102	0.228	0.150
p(joint)	0.086	0.414	0.171	0.084	0.038	0.041	0.016	0.223	0.279	0.528	0.399	0.256
IMMIGRATION												
Σ	-0.066	0.202	-0.446	-0.351	-0.514	-0.383	-0.219	0.106	-0.147	0.004	-0.057	-0.001
p(sum)	0.806	0.469	0.253	0.432	0.178	0.391	0.383	0.740	0.515	0.985	0.788	0.997
p(joint)	0.231	0.020	0.722	0.890	0.685	0.776	0.699	0.804	0.909	0.837	0.996	0.996
PRODUCTIVITY												
Σ	-0.265	-0.207	-0.208	-0.406	-0.144	-0.381	-0.008	-0.126	0.030	0.101	0.107	0.179
pval	0.114	0.188	0.520	0.249	0.653	0.281	0.970	0.620	0.870	0.541	0.535	0.229
DUMMIES												
Σ	0.000	-9.439	0.000	6.670	0.000	5.076	0.000	1.492	0.000	1.612	0.000	-0.022
p(sum)	.	0.024	.	0.322	.	0.444	.	0.754	.	0.599	.	0.994
p(joint)	.	0.000	.	0.611	.	0.273	.	0.804	.	0.834	.	0.704
R2	0.396	0.697	0.310	0.461	0.364	0.509	0.482	0.512	0.309	0.274	0.354	0.327
Start	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3

Note: Measures are computed using different wage series: COMPE - compensation per employees, COMP - compensation per hour, EFFW - effective wages, NEGT - total negotiated wages, NEGR - negotiated wages excluding arrangements, NEGB - negotiated wages excluding arrangements and lump-sum payments. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

Table D2: Alternative estimation results for the price equation in Germany

	COMPE		COMPH		EFFW		NEGT		NEGR		NEGB	
INFLATION												
Σ	0.548	0.654	0.685	0.813	0.684	0.810	0.602	0.632	0.694	0.724	0.689	0.744
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WAGES												
Σ	0.452	0.346	0.315	0.187	0.316	0.190	0.398	0.368	0.306	0.276	0.311	0.256
p(sum)	0.001	0.008	0.031	0.162	0.023	0.143	0.015	0.015	0.046	0.058	0.057	0.101
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENERGY PRICES / WAGES												
Σ	0.059	0.036	0.030	0.011	0.031	0.011	0.035	0.030	0.030	0.023	0.031	0.025
p(sum)	0.022	0.154	0.232	0.662	0.220	0.665	0.177	0.235	0.242	0.361	0.247	0.350
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FOOD PRICES / WAGES												
Σ	0.232	0.164	0.267	0.137	0.270	0.139	0.266	0.179	0.203	0.114	0.217	0.116
p(sum)	0.015	0.070	0.009	0.137	0.006	0.121	0.011	0.046	0.039	0.191	0.031	0.200
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SHORTAGES												
Σ	-0.604	0.030	-0.685	0.036	-0.710	0.020	-0.415	0.148	-0.438	0.171	-0.405	0.161
p(sum)	0.103	0.807	0.101	0.776	0.080	0.872	0.325	0.237	0.290	0.183	0.351	0.235
p(joint)	0.317	0.430	0.292	0.469	0.271	0.477	0.437	0.168	0.231	0.226	0.255	0.274
TERMS OF TRADE												
Σ	0.074	0.061	0.100	0.034	0.112	0.050	0.046	-0.023	0.079	0.012	0.073	-0.003
p(sum)	0.439	0.512	0.326	0.726	0.264	0.600	0.648	0.805	0.432	0.894	0.482	0.979
p(joint)	0.216	0.744	0.327	0.511	0.281	0.469	0.569	0.821	0.378	0.670	0.311	0.566
PRODUCTIVITY												
Σ	0.081	0.049	0.014	0.095	-0.004	0.079	0.063	0.106	0.034	0.097	0.061	0.126
p(pval)	0.128	0.364	0.880	0.261	0.966	0.349	0.469	0.191	0.695	0.223	0.485	0.125
VAT												
Σ	0.000	2.813	0.000	3.146	0.000	3.541	0.000	3.120	0.000	3.353	0.000	2.945
p(pval)	.	0.002	.	0.001	.	0.000	.	0.000	.	0.000	.	0.000
9-EURO-TICKET												
Σ	0.000	-1.444	0.000	-0.821	0.000	-0.592	0.000	-0.709	0.000	-0.961	0.000	-0.847
p(pval)	.	0.067	.	0.375	.	0.532	.	0.355	.	0.181	.	0.250
HEAT PRICE BREAK												
Σ	0.000	-3.062	0.000	-2.729	0.000	-2.765	0.000	-3.193	0.000	-2.684	0.000	-2.796
p(pval)	.	0.000	.	0.000	.	0.000	.	0.000	.	0.000	.	0.000
R2	0.867	0.948	0.852	0.945	0.857	0.946	0.851	0.948	0.858	0.949	0.851	0.945
Start	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1	1996q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3

Note: Measures are computed using different wage series: COMPE - compensation per employees, COMP - compensation per hour, EFFW - effective wages, NEGT - total negotiated wages, NEGR - negotiated wages excluding arrangements, NEGB - negotiated wages excluding arrangements and lump-sum payments. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

E Estimation results for the euro area aggregate

Table E1: Estimation results for the wage equation on the euro area aggregate

	COMPE		COMPH		NEGT	
WAGES						
Σ	-0.671	0.552	-0.236	-0.518	-0.276	-0.789
p(sum)	0.064	0.010	0.387	0.029	0.256	0.003
p(joint)	0.066	0.000	0.047	0.005	0.002	0.000
CF1						
Σ	1.671	0.448	1.236	1.518	1.276	1.789
p(sum)	0.000	0.036	0.000	0.000	0.000	0.000
p(joint)	0.000	0.006	0.000	0.000	0.000	0.000
U						
Σ	-0.409	-0.090	-0.185	-0.259	-0.191	-0.223
p(sum)	0.000	0.501	0.119	0.082	0.004	0.002
p(joint)	0.002	0.219	0.011	0.017	0.002	0.002
CATCH-UP						
Σ	-1.014	-0.222	0.173	-0.263	-0.127	-0.287
p(sum)	0.000	0.216	0.522	0.235	0.405	0.032
p(joint)	0.000	0.086	0.051	0.091	0.000	0.000
PRODUCTIVITY						
Σ	0.606	0.021	0.039	-0.177	0.128	0.182
pval	0.004	0.908	0.870	0.447	0.329	0.068
DUMMIES						
Σ	0.000	8.338	0.000	8.583	0.000	-0.934
p(sum)	.	0.039	.	0.070	.	0.405
p(joint)	.	0.000	.	0.000	.	0.624
R2	0.360	0.925	0.434	0.857	0.553	0.646
Start	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3
N	76	91	76	91	76	91

Note: The table shows the results from fitting the wage equation to the euro area aggregate using three different wage series: COMPE - compensation per employees, COMP - compensation per hour and NEGT - total negotiated wages. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

Table E2: Estimation results for the price equation on the euro area aggregate

	COMPE		COMPH		NEGT	
INFLATION						
Σ	0.509	0.797	0.894	1.065	0.573	0.727
p(sum)	0.000	0.000	0.000	0.000	0.000	0.000
p(joint)	0.000	0.000	0.000	0.000	0.001	0.000
WAGES						
Σ	0.491	0.203	0.106	-0.065	0.427	0.273
p(sum)	0.000	0.022	0.242	0.408	0.002	0.016
p(joint)	0.000	0.000	0.000	0.000	0.000	0.005
ENERGY PRICES / WAGES						
Σ	0.033	0.008	-0.002	-0.012	0.027	0.023
p(sum)	0.009	0.449	0.816	0.272	0.053	0.067
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000
FOOD PRICES / WAGES						
Σ	0.076	0.037	-0.014	-0.037	0.047	0.025
p(sum)	0.125	0.510	0.752	0.536	0.366	0.666
p(joint)	0.000	0.000	0.000	0.000	0.000	0.000
SHORTAGES						
Σ	-0.114	-0.041	-0.011	0.026	0.150	0.199
p(sum)	0.464	0.517	0.946	0.730	0.348	0.021
p(joint)	0.025	0.000	0.650	0.000	0.521	0.000
PRODUCTIVITY						
Σ	0.130	-0.057	0.136	0.041	0.248	0.076
p(pval)	0.008	0.180	0.015	0.441	0.000	0.098
R2	0.963	0.980	0.967	0.979	0.965	0.982
Start	1999q1	1999q1	1999q1	1999q1	1999q1	1999q1
End	2019q4	2023q3	2019q4	2023q3	2019q4	2023q3
N	76	91	76	91	76	91

Note: The table shows the results from fitting the price equation to the euro area aggregate using three different wage series: COMPE - compensation per employees, COMP - compensation per hour and NEGT - total negotiated wages. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

Table E3: Estimation results for the short-term expectations on the euro area aggregate

SHORT-TERM EXPECTATIONS		
Σ	0.324	0.385
p(sum)	0.000	0.000
p(joint)	0.000	0.002
LONG-TERM EXPECTATIONS		
Σ	0.220	0.282
p(sum)	0.000	0.000
p(joint)	0.002	0.000
INFLATION		
Σ	0.456	0.333
p(sum)	0.000	0.000
p(joint)	0.000	0.000
R2	0.832	0.923
Start	1999q1	1999q1
End	2019q4	2023q3
N	76	91

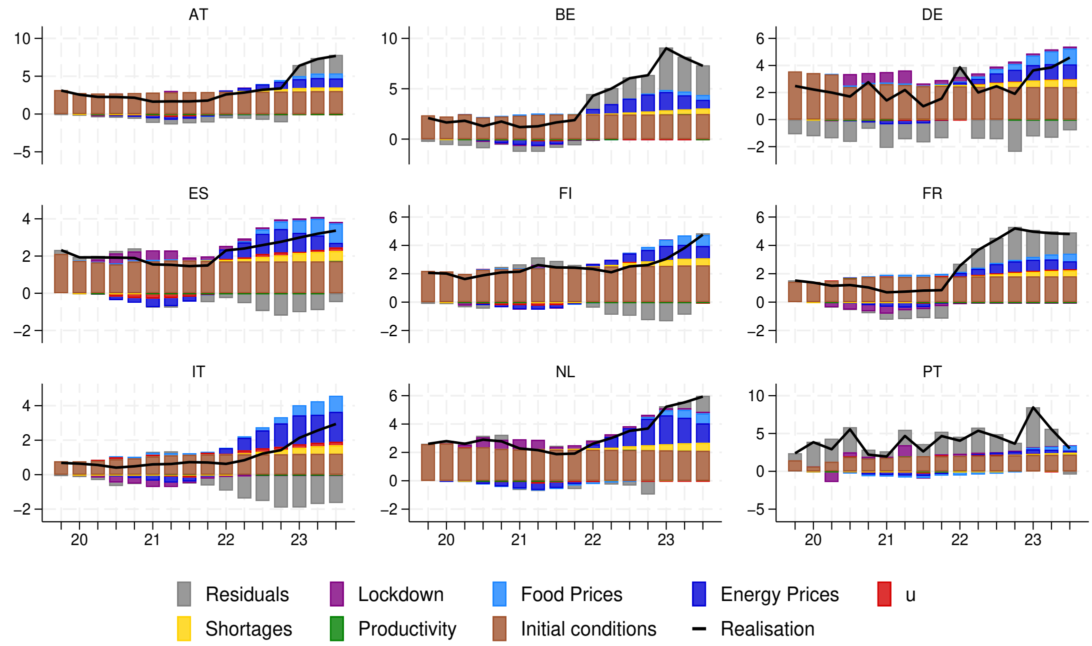
LONG-TERM EXPECTATIONS		
Σ	0.991	0.992
p(sum)	0.000	0.000
p(joint)	0.000	0.000
INFLATION		
Σ	0.009	0.008
p(sum)	0.232	0.030
p(joint)	0.397	0.001
R2	0.576	0.583
Start	1999q1	1999q1
End	2019q4	2023q3
N	76	91

Note: The table shows the results from fitting the short-term and long-term expectations equation to the euro area aggregate. $\sum$ reports the sum of the individual coefficients, e.g., $\alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4}$, p(sum) gives the p-value of testing whether the coefficients sum to zero ($H_0 : \alpha_{1,1} + \alpha_{1,2} + \alpha_{1,3} + \alpha_{1,4} = 0$) and p(joint) gives the p-value of testing whether the coefficients are jointly equal to zero ($H_0 : \alpha_{1,1} = \alpha_{1,2} = \alpha_{1,3} = \alpha_{1,4} = 0$).

F Additional euro area results

Figure F1: Decompositions using negotiated wages as wage variable

Wage growth



Inflation

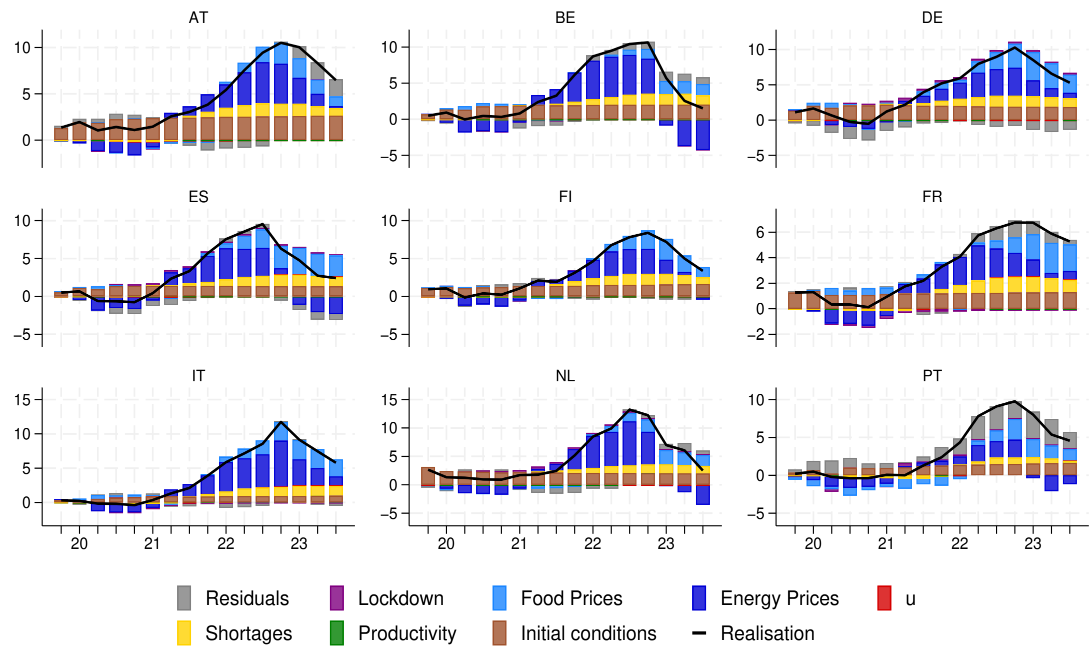
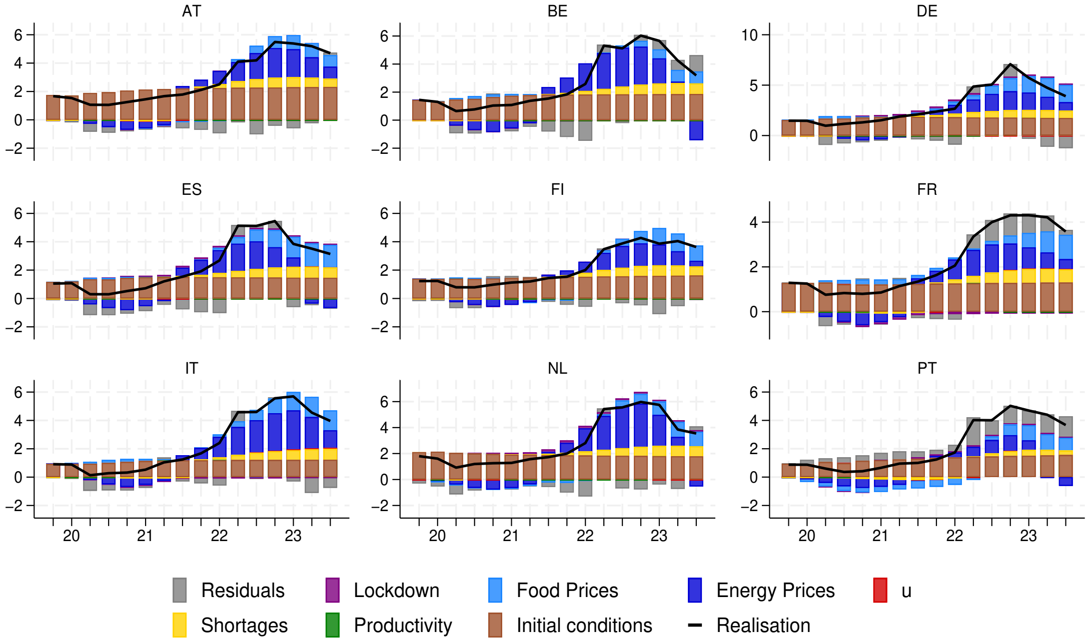


Figure F2: Decompositions using negotiated wages as wage variable

Short-term expectations



Long-term expectations