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ACCOUNTING FOR THE RECENT INFLATION BURST IN THE EURO AREA

by Domenico Depalo and Salvatore Lo Bello*

Abstract

We estimate a semi-structural model of wage and price inflation for the euro area following the framework set down by Bernanke and Blanchard (2023). Adding multiple labour market slack variables improves the fit of the wage equation, consistent with the findings of the recent literature. In contrast to the US, temporary wage shocks do not have permanent effects on price inflation. Temporary price shocks may trigger a self-feeding mechanism that eventually results into persistently higher inflation. Hence, the effect of shocks to labour market slack is smaller than those to the price of intermediate inputs of production. Historical decompositions reveal that the tightening of the labour market can explain only a minor share of wage inflation dynamics between 2020 and 2023, and the surge in price inflation can be entirely accounted for by the combined effect of energy inflation, food inflation and shortages. The subdued effect of labour market shocks on price inflation can be traced back mainly to the weak wage-to-price pass-through, notwithstanding the significant response of wage inflation.

JEL Classification: E31, J31, J63, J64.

Keywords: wage inflation, price inflation, unemployment, labour market tightness, economic slack, energy shock, shortages.

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1. Introduction[2]

Since the second half of 2021, inflation has risen to unprecedented levels in many advanced economies. The surge was arguably the result of a variety of factors, with both supply and demand shocks playing an important role. Assessing precisely the determinants of the inflation burst is of first-order importance for policy makers to formulate the most appropriate policy response. Recently, Bernanke and Blanchard (2023) have proposed a new model to understand the impact of a variety of economic variables on inflation and to unpack the inflation dynamics observed in the US. The model leverages a hybrid approach that resembles a structural vector autoregression (SVAR) with added exogenous variables. Arce et al. (2024) have applied the same model to euro area data.[3]

In this paper, we build on the approach proposed by Blanchard and Bernanke (2023) and Arce et al. (2024), applying a modified version of their model to euro area data. The differences of our analysis are twofold. First, motivated by recent evidence on the wage Phillips in the case of the Euro area (Lo Bello and Viviano, 2024), we enrich the wage equation with multiple variables of labour market slack and with their first differences. Consistent with the hypothesis that hysteresis in the labour market is important to explain wage growth, this addition significantly improves the regression predictive ability. Second, we perform a larger number of experiments and counterfactuals, reporting the effect of these shocks on the entire system of endogenous variables (as opposed to Blanchard and Bernanke (2023) and Arce et al. (2024), who mainly focus on the response of price inflation). We believe that the broader scope of our quantitative experiments is helpful in clarifying the relationships underlying the dynamic response of the various variables.

For the US, Bernanke and Blanchard (2023) find that the inflation burst in 2021 and 2022 was entirely driven by shocks to prices given wages, i.e. to the surge in the price of intermediate inputs (such as energy) amid global supply chains interruptions. In a second phase, the uptick in short-run inflation expectations triggered by the price shock eventually transmitted to wage growth, which were also independently supported by an unprecedentedly generous fiscal stimulus. Wage increases then started feeding back into price inflation. Bernanke and Blanchard conclude that, in order to tame inflation in the US, it is necessary to cool down the labour market, implying a hard landing for the economy. Replicating their analysis for the euro area, Arce et al. (2024) find that wage growth plays a much weaker role, because of a comparatively modest effect of labour market tightness on wages and a small wage-to-price pass-through. Moreover, they also find that the tightening of the labour market explains a relatively small share of the observed wage acceleration.

The results of Arce et al. (2024) may in principle be due to the specification of the wage equation, which yields a relatively poor fit to the data. We improve the wage equation by adding additional variables, showing that this addition yields important gains. However, the results of our paper are still very much in line with those of Arce et al. (2024). We find that temporary price shocks have the potential of triggering self-feeding mechanisms insofar as they affect inflation expectations, eventually feeding back into price inflation. On the contrary, temporary shocks to wage inflation do not bring about similar dynamics, mostly due to the low wage-to-price pass-through. The low sensibility of price inflation to wages is likely due to the relatively small share of total costs accounted for by the labour input, as well as its substitutability with other production inputs.[4] Turning to the effect of exogenous variables, we uncover that shocks to the price of intermediate inputs – such as energy – or to the functioning of global

[2] We would like to thank Emanuele Ciani, Federico Cingano, Eliana Viviano for their comments and suggestions.
[3] The results of Arce et al. (2024) are also reported in Bernanke and Blanchard (2024), a cross-country paper that applies the original model to eleven economies. See Pisani and Tagliabracci (2024) for the application of the same model to the Italian economy.
[4] The wage acceleration in the euro area 2023 coincided with the deflation of other production inputs (energy and other intermediate inputs), which triggered substitution away from the labour input, thereby curbing the final effect on inflation. See Panetta (2024).

value chains – proxied by an index of shortages – have larger and more persistent effects on price inflation than shocks originating in the labour market. Differently from what was argued for the US by Bernanke and Blanchard (2023), our results suggest that bringing inflation down will most likely *not* require a surge in the unemployment rate.

We use our model to decompose the sources of the inflation dynamics observed in the latest period (2020-2023). First and foremost, we find that a significant share of both wage and price inflation was due to the effect of initial conditions, i.e. it is the outcome of the lagged effects of the endogenous variables and of the starting level of the exogenous ones. As such, it is not attributable to any of the shocks that hit the economy through the pandemic or during the recovery. Turning to the remaining part of the dynamics, we find that labour market developments – as captured by both an increase in the labour market tightness and a decrease in the unemployment rate – played some role for wage growth in 2022-2023, but still a minor one compared to the combined effect of energy inflation, food inflation and shortages. Even more compellingly, we find that the very same shocks accounted for virtually the entire variation in price inflation and inflation expectations, consistent with the findings of Neri et al. (2023) and Corsello and Tagliabracci (2023). These findings are well in line with those of the impulse response functions, suggesting that the latest period was not particularly different from the past in terms of the relative impact of the different exogenous shocks. The decompositions also reveal that short-run inflation expectations rose less than what our model predicts, implying that factors missing from our analysis kept them down. We interpret this residual as the effect of the credibility of the monetary policy conduct, which kept expectations well anchored. Relatedly, we also study the effect of a temporary drift in inflation expectations, finding that the effects on inflation are small and short-lived. An implication of this result is that the ECB should not immediately react to deviations in expectations, as long as these are temporary.

The debate around the Phillips curve has gained renewed interest in recent years. In particular, starting from the Great Financial Crisis its validity has been questioned by several commentators. For example, Krugman (2015) argued that "if inflation had responded to the Great Recession and aftermath the way it did in previous slumps, we would be deep in deflation by now". In contrast, other economists conclude that the relationship is well and alive, possibly with minor modifications. For example, for the US, Blanchard (2016) and Coibion et al (2019) argue that the Phillips curve is alive and well, although the original relation might have changed. For the euro area, Hindrayanto et al (2019) reach a similar conclusion. Nevertheless, the slope of the Phillips curve has substantially declined (Coibion and Gorodnichenko (2015), Ciccarelli and Osbat (2017) and Deroose and Stevens (2017)). The results in Blanchard and Bernanke (2023), Arce et al. (2024), and ours suggest that the relationship is still valid.

Beside its validity, Aguiar-Conraria et al (2023) summarize the debate in three questions: 1) Has the short-run slope been stable? If not, was it because it is nonlinear (featuring different coefficients at distinct phases of the business cycle) or because the relationship has been subject to gradual changes or structural breaks? 2) What is the role of inflation expectations in the short run? Do they capture the changing patterns of inflation dynamics – persistence, forward-looking behavior, changing trends, and anchoring to the policy target? 3) Is the long-run Phillips Curve vertical? So far, there is no unanimous consensus on the most appropriate answers to these questions.

Motivated by this debate, several papers evaluate whether and how the slope of the Phillips curve changed, using split sample techniques (e.g. Guirguis and Suen, 2022), non-linear specifications (Busetti et al. 2021; Byrne and Zekaite, 2020), or different estimators (Fu, 2020; Furuoka et al, 2021). As for the role of expectations and more generally to the definition of specific components, some papers employed several definitions of the same indicator, not only for inflation but also for slack (Berger et al, 2016), e.g. because the unemployment rate become a poorer measure of slack (Benigno and Eggertsson (2023)). Related to this, Lo Bello and Viviano (2024) discuss the case of omitted variables, showing that the addition of multiple labour market slack variables improves the performance of the model especially in the latest period. Other papers point to structural changes that might have affected the relationship between inflation and slack. The most prominent examples include population ageing (Carvalho et al., 2016), workers' bargaining power (Lombardi, Riggi and Viviano, 2023), and market power (Baqaee, Farhi and Sangani, 2021). Finally, a different interesting perspective is in Kirpson and Staehr (2024), who focus on individual expectations, using a survey from the European Consumer Expectations Survey. They find a positive relationship between expected inflation and economic slack, even controlling for supply shocks, consistent with the Phillips curve. Our paper provides a contribution with respect to the most appropriate model specification, in an attempt to reduce the omitted variable bias and to maximize the predictive capability of the model.

The rest of the paper is structured as follows. In Section 2 we outline the estimating model and the empirical strategy, directly leveraged from Bernanke and Blanchard (2023), and the main results of the estimation. In Section 3 we compute the impulse response functions of a battery of shocks to both endogenous and exogenous variables. In Section 4 we perform historical decompositions of the inflation dynamics over the period 2020-2023. Finally, we conclude in Section 5.

2. Estimating the model's parameters

2.1 Estimation strategy

We estimate the model using an empirical strategy very similar to Bernanke and Blanchard (2023) and Arce et al. (2024). More precisely, we use a hybrid approach that approximates a structural vector autoregression (SVAR) with added exogenous variables, estimated equation by equation.

Our empirical specification relies on a flexible lag structure which includes information up until a year, for both the autoregressive components and the other exogenous variables, as in Bernanke and Blanchard (2023). Also, we impose that wages are sticky and respond to other endogenous variables with a lag. Wage inflation enters price inflation contemporaneously and with lags. Because inflation expectations depend on current inflation in addition to the autoregressive component, wage inflation has an indirect effect on them. A distinctive feature of our approach is a richer specification of the wage equation, which includes multiple variables capturing labour market slack (unemployment rate, labour market tightness and hours per worker) and first differences of unemployment and labour market tightness, to take into account the possible hysteresis in the labour market (as shown by Lo Bello, Viviano, 2024; on the importance of the intensive margin of labour utilization see Bulligan and Viviano, 2017).

Following the existing literature, we impose restrictions on the sum of the coefficients to ensure well-behaved long-run properties, namely that the Phillips curve is vertical in the long-run. For additional details of the model see Bernanke and Blanchard (2024).

Wage growth equation

A distinctive feature of our paper is related to the wage growth equation. In Bernanke and Blanchard (2023) and Arce et al. (2024), the nominal wage growth rate depends on lagged short-term inflation expectations, productivity growth (A^{LT}), labour market tightness (vu) and lagged unexpected inflation ($u\pi$):[5]

$$w_t=\Sigma_{i=1}^{4}\beta_{w,i}w_{t-i}+\Sigma_{i=1}^{4}\beta_{\pi^e,i}\pi^e_{t-i}+\Sigma_{i=1}^{4}\beta_{A^{LT},i}A^{LT}_{t-i}+\Sigma_{i=1}^{4}\beta_{vu,i}vu_{t-i}+\Sigma_{i=1}^{4}\beta_{u\pi,i}\, u\pi_{t-i}$$

[5] All the equations are conditional means, so error terms are omitted unless necessary.

They impose the constraint of vertical long-run wage Phillips curve, i.e. the estimation is subject to $\Sigma_{i=1}^{4}\beta_{w,i}+\Sigma_{i=1}^{4}\beta_{\pi^e,i}=1$. Throughout the note, this represents the "benchmark" model.

An improvement of our approach is that we also estimate:

$$w_t=\Sigma_{i=1}^{4}\beta_{w,i}w_{t-i}+\Sigma_{i=1}^{4}\beta_{\pi^e,i}\pi^e_{t-i}+\Sigma_{i=1}^{4}\beta_{A^{LT},i}A^{LT}_{t-i}+\Sigma_{i=1}^{4}\beta_{vu,i}vu_{t-i}+\Sigma_{i=1}^{4}\beta_{u\pi,i}u\pi_{t-i}+\Sigma_{i=1}^{4}\beta_{u,i}u_{t-i}+\Delta u_{t-4}+\Delta vu_{t-4}+\Sigma_{i=1}^{4}\beta_{hw,i}hw_{t-i}$$

where the first differences capture the possible hysteresis, whereby the natural level of slack changes over time in response to shocks (Lo Bello, Viviano, 2024), and the hours per worker hw_{t-i} capture the intensive margin of labour utilization. Note that we also include the unemployment rate (u) in the specification. These additional controls will also reduce the possible omitted variable bias that may affect the estimates of the existing literature. Indeed, Lo Bello and Viviano (2024) document that the correlation between labour market tightness and the unemployment rate in the euro area is large but far from perfect (-0.6).

Price inflation equation

The price inflation depends on its lags, nominal wage growth, productivity growth, relative energy (E) and food (F) price inflation, global supply chain pressures (S):

$$\pi_t=\Sigma_{i=1}^{4}\alpha_{\pi,i}\pi_{t-i}+\Sigma_{i=0}^{4}\alpha_{w,i}w_{t-i}+\Sigma_{i=0}^{4}\alpha_{A^{LT},i}A^{LT}_{t-i}+\Sigma_{i=0}^{4}\alpha_{E,i}E_{t-i}+\Sigma_{i=0}^{4}\alpha_{F,i}F_{t-i}+\Sigma_{i=0}^{4}\alpha_{S,i}S_{t-i}$$

subject to $\Sigma_{i=1}^{4}\alpha_{\pi,i}+\Sigma_{i=0}^{4}\alpha_{w,i}=1$ (homogeneity assumption).

Long-term inflation expectations

Long-term inflation expectations are modeled as:

$$\pi^{e10}_t=\Sigma_{i=1}^{4}\rho_{\pi,i}\pi_{t-i}+\Sigma_{i=0}^{4}\rho_{\pi^{e10},i}\pi^{e10}_{t-i}$$

subject to $\Sigma_{i=1}^{4}\rho_{\pi,i}+\Sigma_{i=0}^{4}\rho_{\pi^{e10},i}=1$ (in the long run, a sustained increase in inflation will raise inflation expectations by the same amount) .

Short-term inflation expectations

Short-term inflation expectations are modeled as:

$$\pi^{e1}_t=\Sigma_{i=1}^{4}\gamma_{\pi,i}\pi_{t-i}+\Sigma_{i=0}^{4}\gamma_{\pi^{e1},i}\pi^{e1}_{t-i}+\Sigma_{i=0}^{4}\gamma_{\pi^{e10},i}\pi^{e10}_{t-i}$$

subject to $\Sigma_{i=1}^{4}\gamma_{\pi,i}+\Sigma_{i=0}^{4}\gamma_{\pi^{e1},i}+\Sigma_{i=0}^{4}\gamma_{\pi^{e10},i}=1$(in the long run, a sustained increase in inflation will raise inflation expectations by the same amount).

2.2 Euro area data

We use publicly available data, as explained below. Unless specified, the sample period is between the first quarter of 1999 to the third quarter of 2023.

Endogenous variables

- HICP overall index, working day and seasonally adjusted.

- Hourly wages in the non-farm private sector; seasonally adjusted, as released in the National Accounts data.[6]
- Consensus forecast for expected inflation one year ahead (short term) and 10 years ahead (long term).

Exogenous variables

- HICP energy, neither calendar not seasonally adjusted.
- HICP food incl. alcohol and tobacco, working day and seasonally adjusted.
- Job vacancies-to-unemployed (v/u) ratio.
    - We can build this ratio only from 2006, as in Arce et al. (2024). Since our ratio is consistent with theirs between 2006 and 2023, we use their time series to impute the period between 1999 and 2006 through a simple linear projection.[7]
- NY Fed Global Supply Chain Pressure Index, lagged by one quarter.
- Labour productivity, measured as gross domestic value-added per worker, calendar and seasonally adjusted.
- Unemployment rate, which refers to the population 15-74 and is seasonally adjusted.
- Hours per worker is from National Accounts data and is computed as the ratio between total numbers of hours and employed individuals, both seasonally adjusted. We use a Hodrick-Prescott filter to disentangle the cycle, which we use in the empirical application, from the trend.

All inflation variables are annualized quarterly growth rates.

2.3 Estimation results

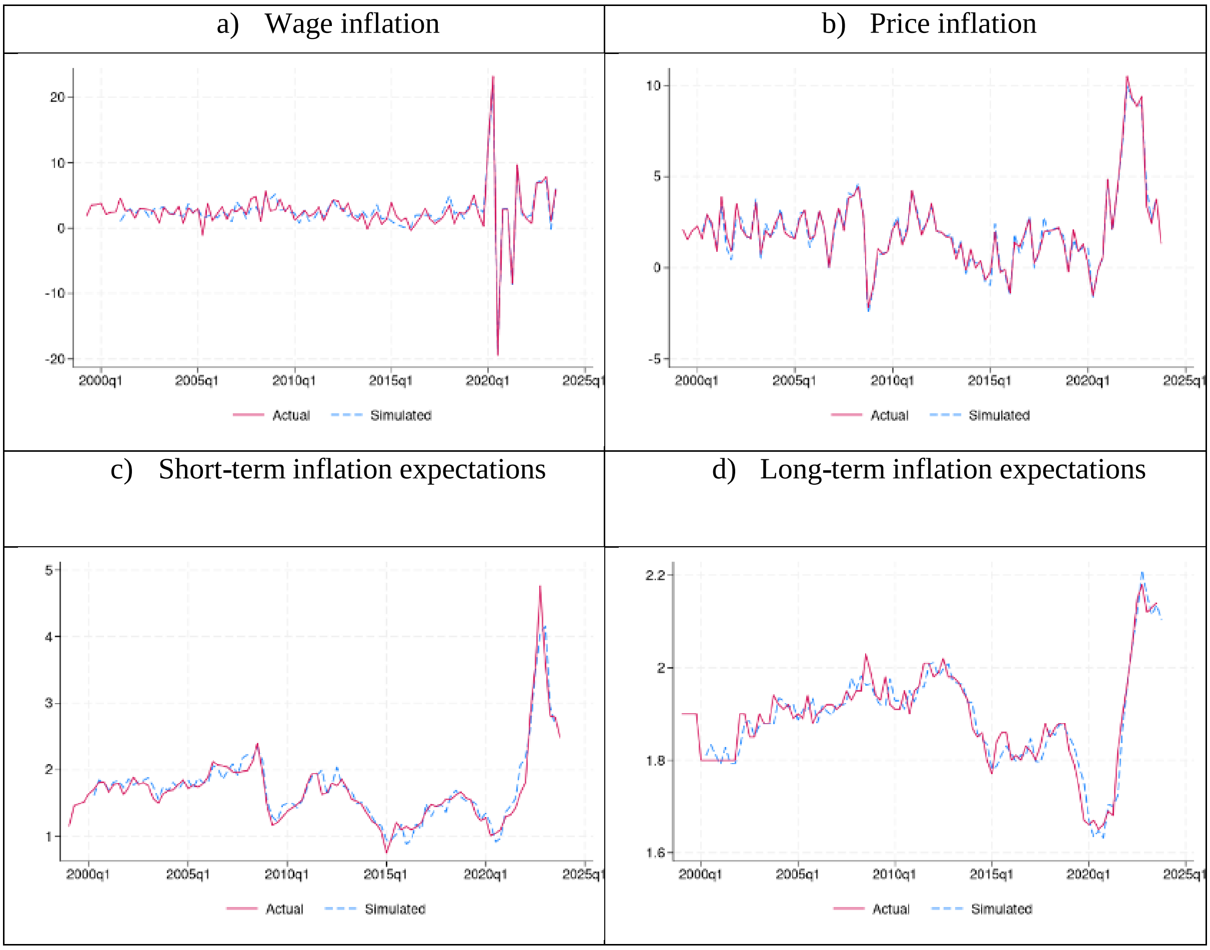
We present summary regression tables for each estimated equation, which summarize the coefficients of each explanatory variable with their (joint) statistical significance, the R-squared of the regressions and the number of observations.

From Figure 1, where we plot the actual and fitted values, it is clear that the model fits the data very well, especially with the inflation variables. The R-squared statistic confirms that the model explains most of the variation observed in the series.

[6] Arce et al. (2024) employ negotiated wages, which are agreed in advance, by definition, and therefore do not respond to the business cycle. For this reason, we prefer *actual* hourly wages, which take into account also the cyclical component of wages, i.e. the so called *wage drift* (for instance due the effects of competition across firms for workers).

[7] The imputation in Arce at al. (2024) exploits the EU Commission survey on labour shortage as a factor limiting production in industry.

Figure 1 – Actual and fitted values



The estimated coefficients conform to our prior expectations based on economic theory. Apart from results specific to each endogenous variable –that we discuss below–, two regularities are common to all the equations, namely the autoregressive component is important to explain the dynamic of our variables and, among our covariates, price inflation is the most important. As will be clear in the following, an important implication of this result is that direct shocks to price inflation have the largest potential to create self-feeding dynamics with permanent effects on inflation.

Table 1 shows the results of the estimation of the wage growth equation. According to our estimates, nominal wages are mean reverting (net of other coefficients): the negative and significant autoregressive coefficients imply that whenever wages increase, their q-o-q growth rate decrease.[8] The sum of the coefficients on labour market tightness is positive, suggesting that the euro area wage Phillips curve is indeed steep and that the pass-through of labour market shocks to wage growth is substantial. Unexpected inflation has a negligible effect on wages. However, the effect of short-term inflation expectations is positive and significant. These results imply that wages catch up with expected inflation, rather than with unexpected inflationary shock. Finally, productivity growth is positively associated with nominal wage growth, whereas unemployment is negatively associated, as predicted by the economic theory.

[8] In the Appendix, we repeat the analysis using the y-o-y change instead of the q-o-q, finding positive, small, coefficients for the lag structure. For the scope of our paper, this difference turns out to be immaterial.

Like in Lo Bello and Viviano (2024), the dynamic of unemployment rate and labour market tightness helps predicting wage inflation, even after controlling for their levels. This result implies that hysteresis in the labour market is important to explain wage growth, supporting of our model specification vis-a-vis the benchmark model (see Section 2.2 for further discussion).

Table 1 - Wage inflation equation

Sample period: first quarter 1999 to third quarter 2023

Dependent variable	**Wage growth**	**Labour market tightness**	**Unexpected inflation**	**Short-term inflation exp.**	**Productivity**	**Unempl.**	**Hours per worker**
Lags	1-4	1-4	1-4	1-4	1-4	1-4	1-4
Sum of coeff.	-1.553	1.184	-0.246	2.553	0.0607	-0.322	0.128
Joint sig. (P-value)	0.005	0.009	0.356	0.000	0.000	0.010	0.006
Adjusted R-squared	0.873						
Obs.	91						

Notes: Sample period is from the first quarter of 1999 to the third quarter of 2023. p-stat (joint) is the p-value for the joint hypothesis that each of the lag coefficients separately equals zero.

The price inflation equation reflects the imposed homogeneity assumption that the sum of the coefficients on past price and wage inflation sum to one. In general, the estimated coefficients are jointly statistically significant (Table 2). Beyond the already mentioned persistency of the price inflation dynamics (see the distributed lags structure), there is weak but significant pass-through from wage growth to price inflation, the bulk of which is contemporaneous. Arce et al. (2024) reach the same conclusion. The coefficients associated with relative energy price inflation and relative food inflation are also small but significant. The coefficients associated with supply chain pressures are positive, significant and economically relevant.

Table 2 - Price inflation equation

Sample period: first quarter 1999 to third quarter 2023

Dependent variable	**Price inflation**	**Wage growth**	**Relative energy price inflation**	**Relative food price inflation**	**Supply chain pressure**	**Producti-vity**
Lags	1-4	0-4	0-4	0-4	0-4	0-4
Sum of coeff.	0.962	0.038	0.005	0.013	0.110	0.063
Joint sig. (P-value)	0.000	0.000	0.000	0.000	0.085	0.282
Adjusted R-squared	0.997					
Obs.	94					

Notes: Sample period is from the first quarter of 1999 to the third quarter of 2023. p-stat (joint) is the p-value for the joint hypothesis that each of the lag coefficients separately equals zero.

The sum of coefficients of the long-run inflation expectations (Table 3) equals one to ensure homogeneity. Long-term inflation expectations are estimated to be very well anchored around the nominal anchor, more so than short-run inflation expectations, indicating that the credibility of the ECB inflation target is high.

Table 3 - Long-term inflation expectations

Sample period: first quarter 1999 to third quarter 2023

Dependent variable	**Long-term exp.**	**Price inflation**
Lags	1-4	0-4
Sum of coeff.	0.989	0.011
Joint sig. (P-value)	0.000	0.000
Adjusted R-squared	0.994	
Obs.	94	

Notes: Sample period is from the first quarter of 1999 to the third quarter of 2023. p-stat (joint) is the p-value for the joint hypothesis that each of the lag coefficients separately equals zero.

Also the coefficients of the variables included in the short-run inflation expectations equation (Table 4) sum to one to ensure homogeneity. The degree of anchoring of euro area short-term inflation expectations is still relatively strong, even though they do respond somewhat to realized inflation. The estimation also points to some pass-through of long-term inflation expectations to short-term inflation expectations.

Table 4 - Short-term inflation expectations

Sample period: first quarter 1999 to third quarter 2023

Dependent variable	**Short-term exp.**	**Long-term exp.**	**Price inflation**
Lags	1-4	0-4	0-4
Sum of coeff.	0.837	0.054	0.108
Joint sig. (P-value)	0. 000	0. 537	0. 000
Adjusted R-squared		0.943	
Obs.		94	

Notes: Sample period is from the first quarter of 1999 to the third quarter of 2023. p-stat (joint) is the p-value for the joint hypothesis that each of the lag coefficients separately equals zero.

Comparison of the two models

Given our refinement to the model specification, it is worth considering the performance of our approach and the one of Arce et al. (2024). We proceed in two steps. First we consider the coefficients, to appreciate their potential impact on the conditional mean of the outcome variables. Second, we investigate the properties of the residual components.

Figure 2 – Model estimates comparison

Sample period: first quarter 1999 to third quarter 2023

Note: The sample period is from the first quarter of 1999 to the fourth quarter of 2019 for the pre-pandemic estimation, and from the first quarter of 1999 to the third quarter of 2023.

The only difference between our model specification and the benchmark specification is in the wage equation (Section 2.1). In Figure 2, we plot the estimated coefficients. From a qualitative viewpoint, the two models return identical predications, with one important difference. The coefficient attached to productivity is negative in the benchmark model, but positive in ours. The positive coefficient is consistent with economic theory, in that wages increase with productivity. From a quantitative viewpoint, the main difference is related to the lagged effects of wage inflation and, because of the constraint of vertical long-run wage Phillips curve, to the effects of expected inflation: their coefficients are much higher (in absolute value) in our model. Interestingly, much of the difference is driven by the inclusion of tightness, whose effect is overall stronger, and unemployment dynamics. This finding is due to the high correlation between tightness and unemployment rate, and therefore suggests that controlling for more than one index of slackness is important to reduce the omitted variable bias (see Section 2.1). Finally, hours per worker do not have a major impact, beyond their contemporaneous effect.

Apart from the qualitative similarities, two aspects make the new specification superior to the benchmark model. First, the R-squared is larger (from 0.855 to 0.915), therefore the variance explained from our model is well above the benchmark. Second, and most important, the density function of the absolute value of errors (and not of the actual errors, which would not be informative) is closer to zero with the new model than with the benchmark. Therefore, we conclude that the new model specification outperforms the benchmark.

3. Impulse Response Functions

In the previous section, we analyzed the effect of specific variables as stemming out of their estimated coefficients in the regressions. That is, we commented on the *direct* effect – which can be both contemporaneous or lagged – that covariates have on each endogenous variable. However, our model allows for cross-effects across the endogenous variables. For instance, wage inflation has an impact of price inflation, which has an impact on inflation expectations, which in turn feeds back into wage inflation. Therefore, the inspection of the estimated coefficients is not enough to gauge the total impact of a shock through the dynamic system. In this section, we use the estimated model to compute impulse response functions (IRFs), that show the full dynamic effect of a given shock (which includes not only the direct effects but also and all knock-on effects through the entire system of equations). An additional advantage of IRFs is that they can be used to show the full pattern of the dynamic response of endogenous variables.

3.1 Shocks to endogenous variables

With respect to Blanchard and Bernanke (2023) and Arce et al. (2024), we consider a wider range of shocks. This provides a more complete representation of the possible shocks affecting the euro area economy. We start by analyzing the effect of temporary shocks to the innovations of our main endogenous variables. That is, we ask whether and how unexpected surges in wage or price inflation propagate through the economy and over time. The size of the shock is always equal to one standard deviation of the shocked variable.

Figure 3 shows the dynamic response of the endogenous variables: it is immediately apparent that temporary price shocks entail permanent effects on both wage and price inflation (red lines), whereas a temporary uptick in wage inflation produces only short-run effects (blue lines). More precisely, the wage shock produces fluctuations in wage inflation – and to a lesser extent to price inflation – that fully reabsorb within four quarters.[9] On the contrary, price shocks transmit to inflation expectations – especially to short-run expectations – which cause an increase in wage inflation and consequently also in price inflation, creating a self-feeding mechanism keeping inflation high on a permanent basis. Instead, the lack of permanent effects for wage shocks is due to the combination of a relatively weak pass-through of wages to prices, the fact that they do *not* directly affect inflation expectations and the overall negative lagged effects of the autoregressive component, which tends to curb the initial shock. All in all, this implies a low risk of wage-price spirals in the euro area. According to our estimates, we conclude that price shocks have a much higher potential to generate persistent inflation spirals.

Our framework is well suited to evaluate the response of inflation to temporary shocks to expectations. Understanding the importance of correcting deviations of inflation expectations is of first-order importance for the conduct of monetary policy.[10] Figure 4 shows the evolution of the dynamic system following a temporary shock to either short-run or long-run inflation expectations. We find that a sudden increase in short-run inflation expectations quickly transmits to wage inflation, causing higher wage growth by about 0.2 p.p. for up to 15 quarters, and reabsorbing thereafter. Associated variations in price inflation are qualitatively similar, but have a smaller magnitude. This reflects the fact that in our model specification inflation expectations affect wage formation but not price inflation. A shock to long-run inflation expectations hardly produces any effect. Overall, no significant permanent effects arise for neither of the two shocks. Two conclusions can be drawn from these results. Firstly, the ECB should look through temporary shocks to inflation expectations, as these do not necessarily bring about permanent consequences for inflation. Secondly, so far the credibility that the ECB gained in the conduction of the monetary policy anchored the expectations in the long run.

3.2 Shocks to exogenous variables

We now turn to the effect of the exogenous variables of our system. By construction, exogenous variables do not feature any self-propagation mechanism. Their ability to produce sustained effects on the system is mediated by their effects on the endogenous variables. As will be clear, permanent effects can be generated only via a sustained shift in inflation expectations. To ease the exposition, we plot the IRFs of a number of shocks in the same charts, so that it is handy to compare the effects. Concretely, we study the effects of both temporary and permanent shocks to labour market variables (tightness and unemployment rate) and other input prices (energy inflation and shortages), respectively shown in Figure 5 and 6.

For what concerns temporary shocks (Figure 5), we find that energy inflation is the variable that has the largest impact on price inflation, both contemporaneously and over the longer term. However, long-run effects are estimated to be very modest, as also reflected by the permanent and small changes in inflation expectations. Shocks to shortages turn out to be the second most powerful source of fluctuations in price inflation, even though by a much smaller degree than energy inflation. Instead, temporary labour market shocks (i.e. shocks to tightness or to the unemployment rate) produce very small effects on price inflation.[11] Once again, this can be explained by the weak pass-through of wages to prices and by the erratic effects of the lags of wage inflation on itself, which tend to partially undo the initial positive shock to price inflation.

[9] The erratic behavior of the IRFs associated to the wage shock is due to the overall negative coefficients associated to its lag structure (see the discussion in Section 2.3).

[10] For empirical analyses of the degree of anchoring of inflation expectations at the euro area level, see Corsello et al. (2021) and Neri et al. (2022).

[11] We have also experimented with shocks to hours per worker, finding even smaller effects.

When we turn to permanent shocks (Figure 6), we find the same ordering of the potential of these shocks to affect price inflation, even though the order of magnitude of the response is much stronger. As before, shocks to the unemployment rate do not generate any significant dynamics in inflation. Instead, permanent shocks to labour market tightness do affect in a permanent way wage inflation (0.8 p.p. in the long-run), but this passes on to price inflation only imperfectly (0.5 p.p.). These effects are still much smaller than the ones of a permanent shock to energy inflation or to shortage, than generate a surge in price inflation of respectively 4.7 and 3.2 p.p. (after 28 quarters). Remarkably, these effects continue to build up as time goes on. A fair amount of this excess price inflation spills over to wage inflation, due to the change in inflation expectations. Indeed, in such a scenario of permanently higher inflation, the model predicts a complete deanchoring of the long-run expectations (by 0.9 p.p. in the long-run, following the shock to energy inflation). To the extent that a permanent shock to energy inflation may seem like an implausible scenario – because it would correspond to a continuous acceleration of the energy price level – we have also experimented with a persistent shock to energy inflation (approximated by an AR(1) process with autocorrelation 0.9).[12] The results show that even in this less extreme scenario, the effect of a rise in energy inflation would still be far more powerful than that of a permanent shock to labour market tightness. Overall, our estimates suggest that labour market shocks have a much smaller effect on price inflation than other shocks to input prices such as energy or intermediate inputs.

4. Historical Decompositions

In the previous section we studied the dynamic effect of shocks, uncovering both the qualitative and quantitative properties of the equilibrium aggregate response. However, the inspection of the IRFs is not sufficient to draw conclusions on the actual importance of specific variables in driving fluctuations. In fact, the quantitative role of a given variable over a particular time period depends not only on its general ability to cause variation in the endogenous variables, but also on the frequency, intensity and timing of the shocks that actually took place (e.g. a variable with a strong IRF but that received very small shocks cannot have importantly driven the dynamics of the endogenous variables). To shed light on the drivers of wage and price inflation over the period 2020-2023, we perform an historical decomposition, that splits the time variation of the dependent variable into components that are attributable to the dynamics of the different covariates. Thanks to the linearity of the regression models, the sum of the components corresponds to the model's prediction.

To compute the decomposition, we first need to formulate a baseline scenario, that corresponds to the counterfactual in which no shock would have happened. In the baseline scenario, we set both energy and food inflation to zero, whereas we fix all other exogenous variables to the levels observed in 2019q4, which we take as the last period of the data realization. Given that the model features a 4-period lag structure, we need to feed into the model the last realizations of both endogenous and exogenous variables. Figure 7 shows the results of the decomposition.[13] The baseline scenario corresponds to the dynamics explained by the "initial conditions" (blue bars in the chart). It turns out that initial conditions were responsible for a sizable chunk of the pandemic and post-pandemic growth of our endogenous variables. Concretely, more than half (a third) of the observed wage (price) inflation can be accounted for by the effect of *previous* initial conditions (i.e. cannot be attributed to any shock taking place in 2020-2023). The remaining dynamics reflect the ensuing shocks, through both their direct and indirect

[12] One way to interpret the area between the solid and the dashed line is in terms of partial identification Manski (1990). If the true value of the autoregressive component is between 0.9 and 1.0, then the area correctly identifies lower and upper bounds of the true effect.

[13] For a better readibility of the graphs, we report in the main text the decompositions starting from 2021Q1. The graphs for the whole period can be found in the Appendix.

effects. To gauge this, we construct counterfactuals in which we let only one exogenous variable vary at the time, replicating exactly their observed dynamics.

For what concerns wage inflation, we find that the effect of labour market shocks was overall moderate: the tightening of the labour market exerted some wage pressure in 2022-2023, but this was still more modest than the combined effect of energy inflation, food inflation and shortages, that had an important indirect effect on wages through inflation expectations. Turning to price inflation, we find that virtually all of the dynamics is explained by energy inflation, food inflation and shortages. Zooming in into the most recent periods, we see that the sudden drop in price inflation was due to the quick reabsorption of the components related to energy and food inflation, whereas shortages kept inflation high also in 2023. Perhaps not surprisingly, inflation expectations were affected by the same shocks that were responsible for the dynamics of price inflation (i.e. energy and food inflation, as well as shortages). We also notice that the degree of anchoring of long-run inflation expectations was much stronger than the one of short-run expectations, which fluctuated substantially over the post-pandemic period, reaching 4.8 per cent in the last quarter of 2022. Interestingly, according to our model, short-run inflation expectations should have risen *more* than observed (i.e. our estimates produce a relatively large negative residual). This possibly reflects the credibility of monetary policy conducted by the ECB, which was able to keep expectations relatively stable; we quantify such an effect in the ballpark of 0.6-0.7 p.p. (see the grey bars in the chart).

5. Concluding remarks

We have extended the recent model proposed by Bernanke and Blanchard (2023), with an application to euro area data. The analysis shows that the most important determinants of the inflation burst in the euro area were supply-side shocks, such as the cost of energy and shortages. Instead, the role played by labour market developments was comparatively much smaller. Therefore, according to our results the reabsorption of price inflation would not necessarily require a large cost in terms of unemployment. Relative to the results for the US, we find a smaller effect of labour market tightness on wages and a weaker wage-to-price pass-through. These two differences explain the minor role played by the labour market in determining inflation dynamics.

The framework is well suited to assess the effect of both demand and supply-side shocks on inflation dynamics. As such, it could provide a useful tool to study future developments of input markets, for instance with respect to the current tensions in the Red Sea or related to other geopolitical risks. In future work, the model could be extended further by adding various elements, such as fiscal and monetary policies, as well as an explicit formation of labour demand.

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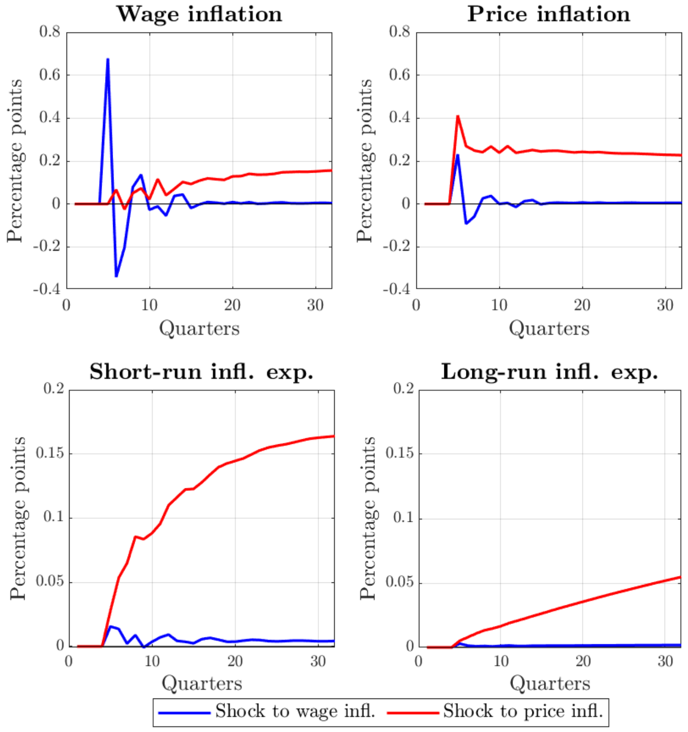
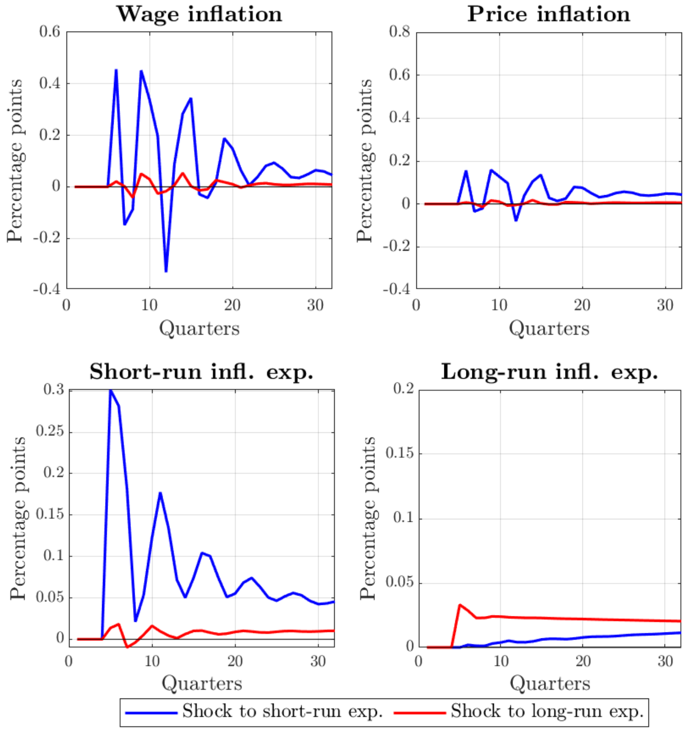
Figure 3 – Impulse response functions: temporary shock to wage and price inflation



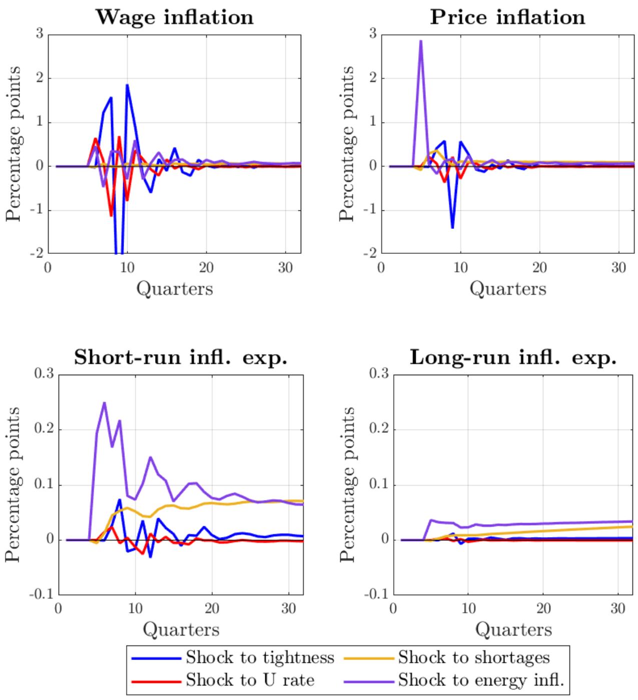
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a one-period shock to wage or price inflation (happening at period 5).

Figure 4 – Impulse response functions: temporary shock to inflation expectations



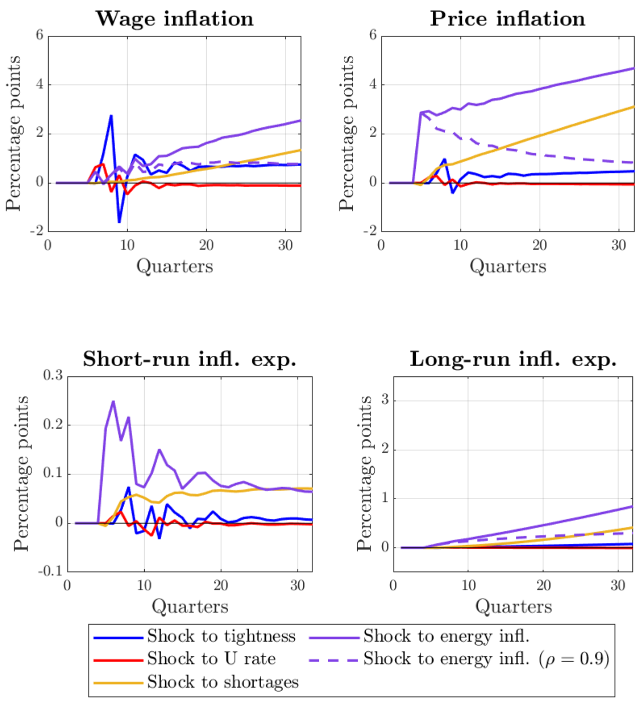
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a one-period shock to short-run or long-run inflation expectations (happening at period 5).

Figure 5 – Impulse response functions: temporary shock to labour and other input markets



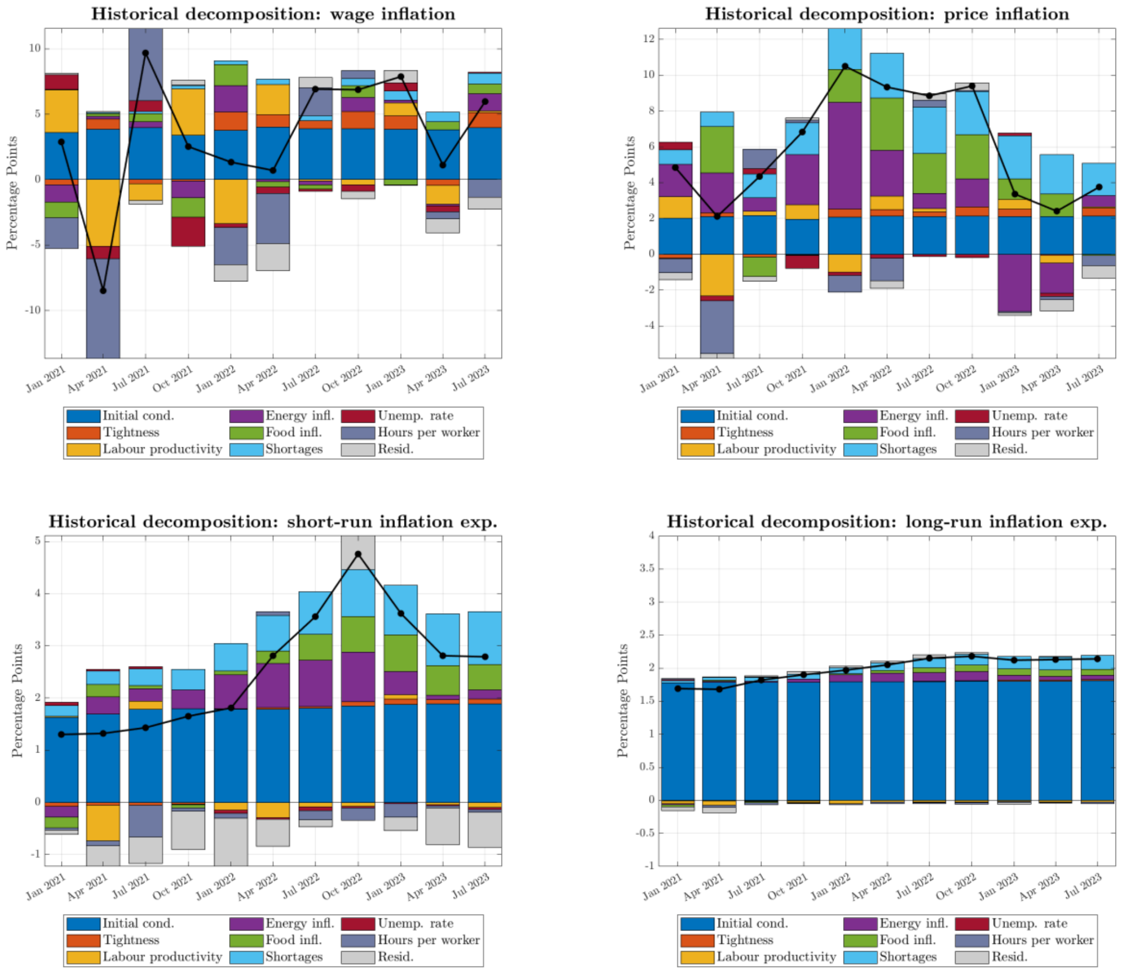
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a one-period shock to labour or other input markets (happening at period 5).

Figure 6 – Impulse response functions: permanent shock to labour and other input markets



Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a sustained (permanent) shock to labour or other input markets (happening at period 5).

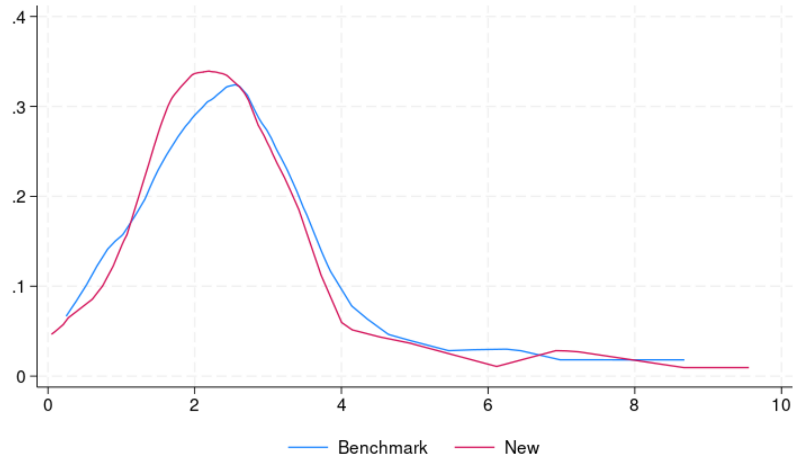
Figure 7 – Historical decompositions (2021-2023)



Source: see Section 2.2 for details; our calculations. *Note*: the plots show the historical decomposition of the dynamics of the endogenous variables: the "initial conditions" scenario feeds into the model the last four realizations of both endogenous and exogenous variables up to 2019Q4, as well as the levels of tightness, unemployment rate, labour productivity, hours per worker and shortages as observed in 2019Q4.

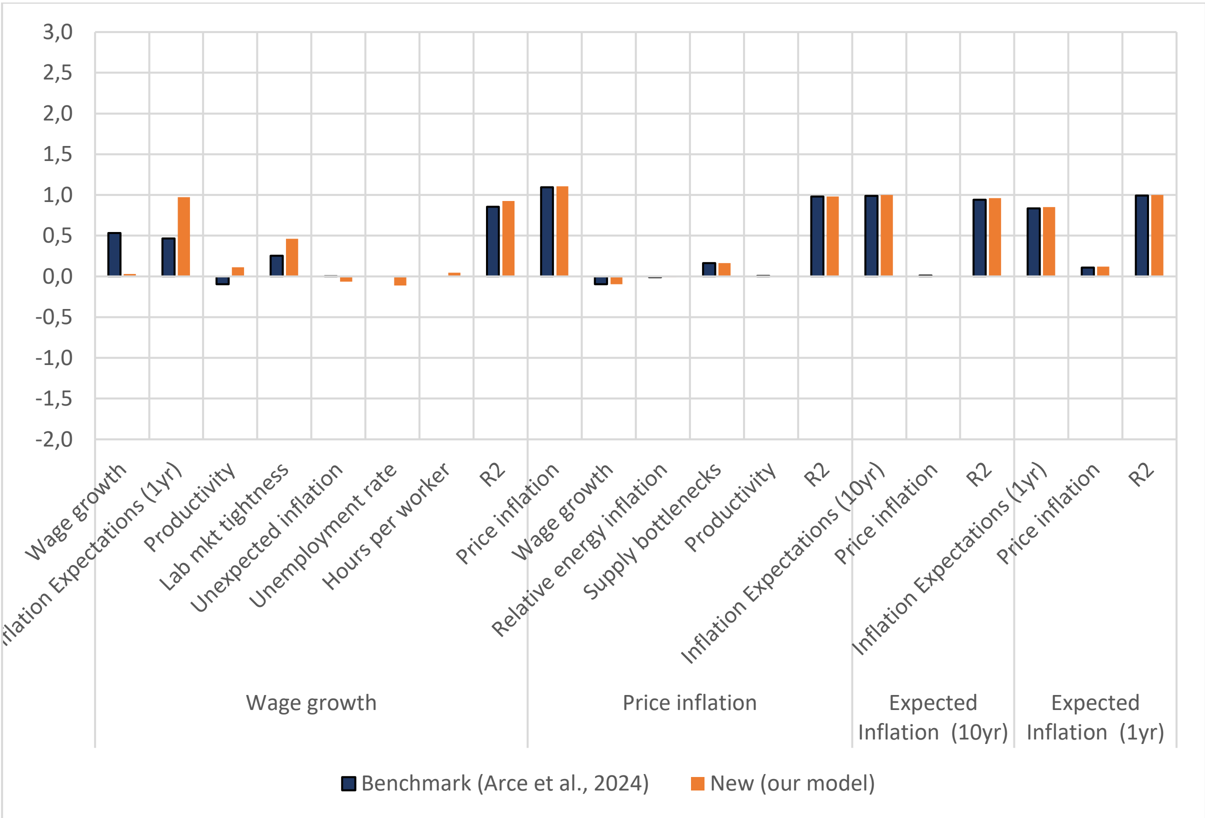
Appendix – Additional figures

Figure A1 – Error distribution



Note: The sample period is from the first quarter of 1999 to the fourth quarter of 2019 for the pre-pandemic estimation, and from the first quarter of 1999 to the third quarter of 2023.

Figure A2 – Model comparison based on alternative wage inflation measure (y-on-y variation)

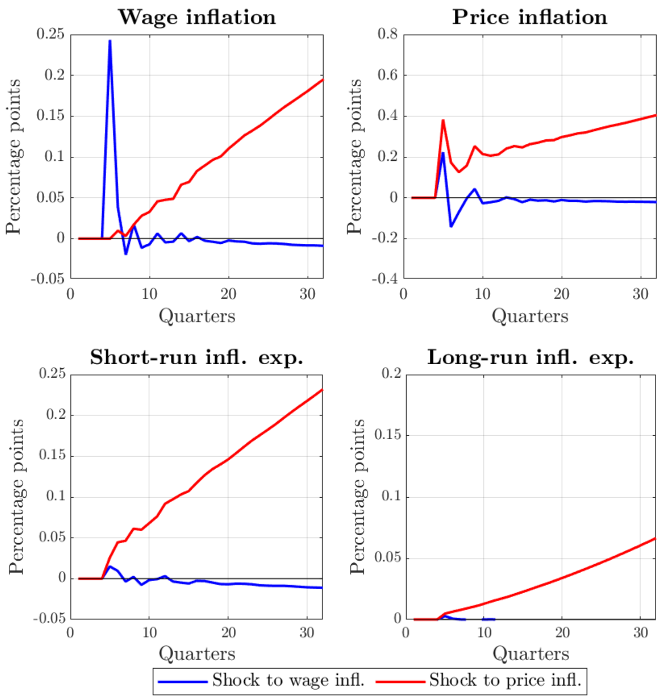


Note: The sample period is from the first quarter of 1999 to the fourth quarter of 2019 for the pre-pandemic estimation, and from the first quarter of 1999 to the third quarter of 2023.

Figure A3 – Historical decompositions (2020-2023)

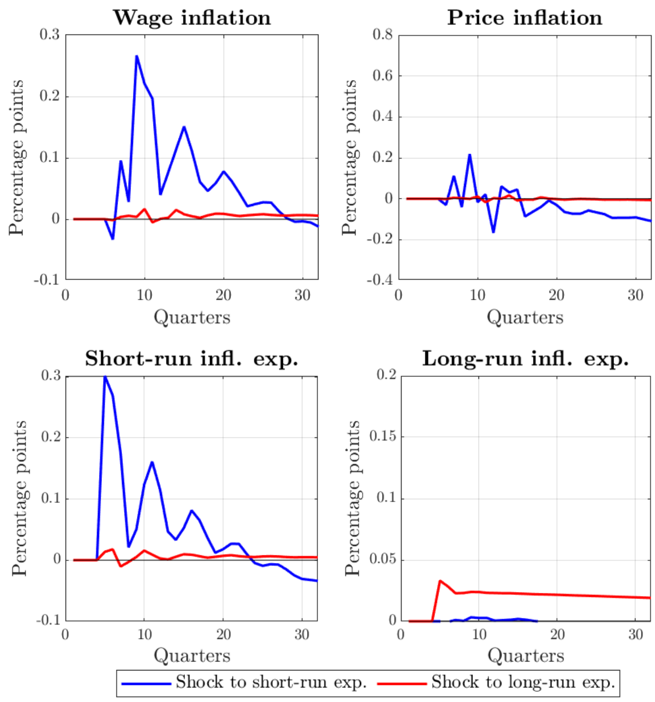
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the historical decomposition of the dynamics of the endogenous variables: the "initial conditions" scenario feeds into the model the last four realizations of both endogenous and exogenous variables up to 2019Q4, as well as the levels of tightness, unemployment rate, labour productivity, hours per worker and shortages as observed in 2019Q4.

Figure A4 – Impulse response functions: temporary shock to wage and price inflation (y-o-y wage growth)



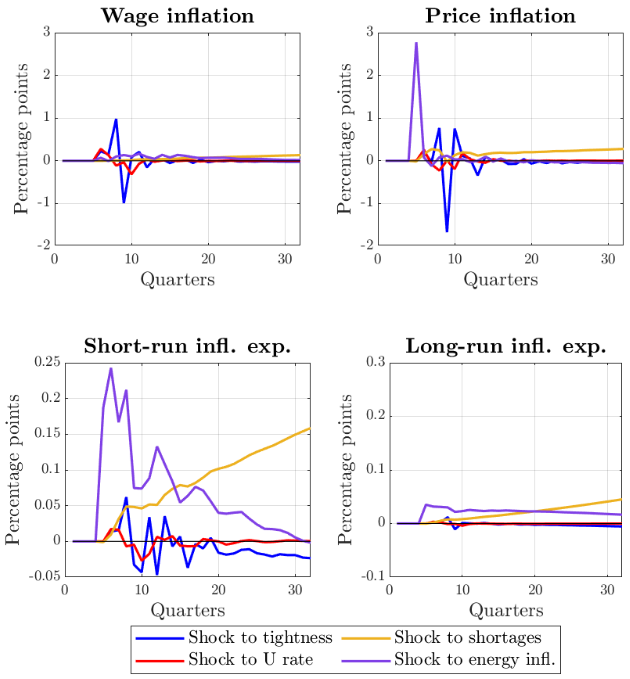
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a one-period shock to wage or price inflation (happening at period 5). Wage inflation is measured as the y-o-y growth rate.

Figure A5 – Impulse response functions: temporary shock to inflation expectations (y-o-y wage growth)



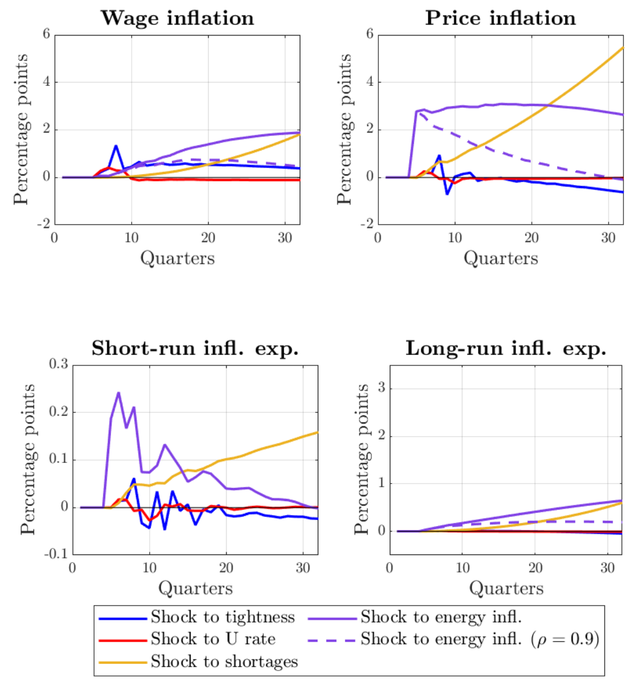
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a one-period shock to short-run or long-run inflation expectations (happening at period 5). Wage inflation is measured as the y-o-y growth rate.

Figure A6 – Impulse response functions: temporary shock to input markets (y-o-y wage growth)



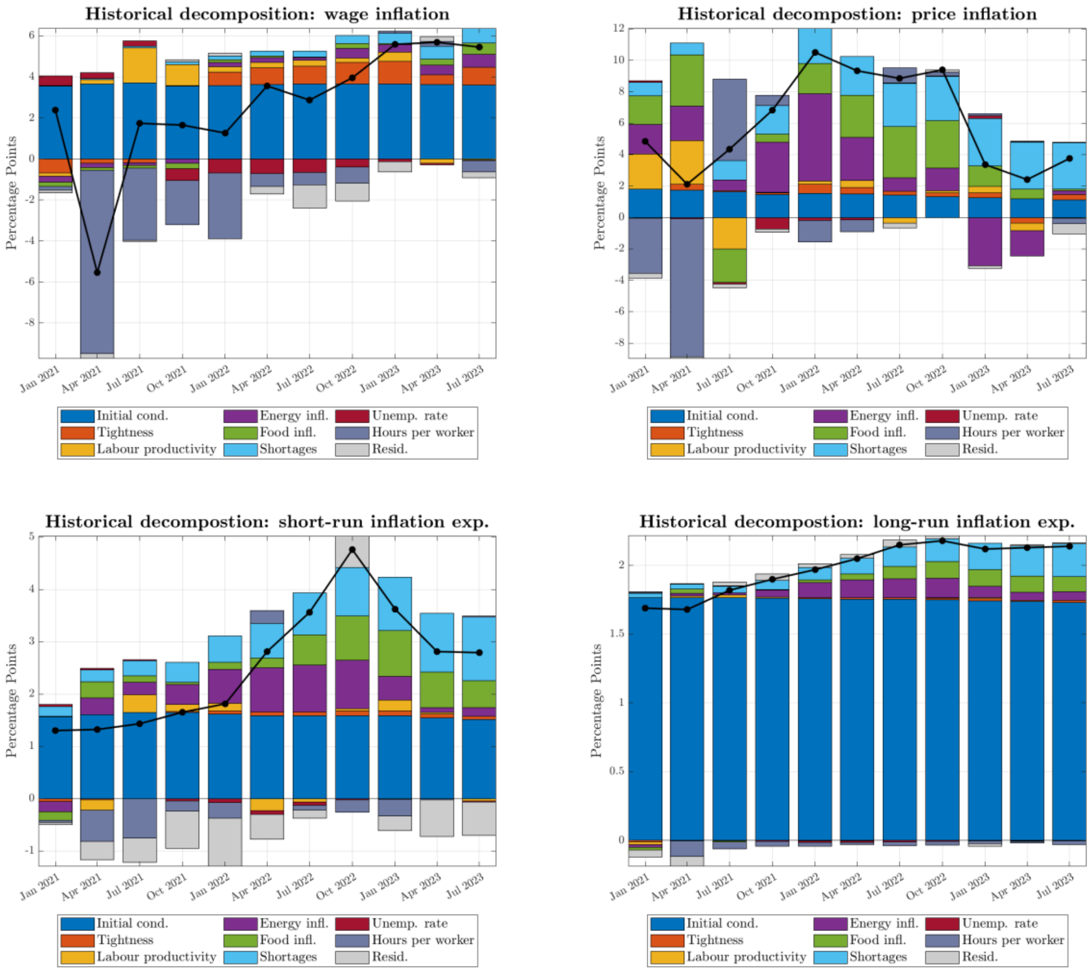
Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a one-period shock to labour or other input markets (happening at period 5). Wage inflation is measured as the y-o-y growth rate.

Figure A7 – Impulse response functions: permanent shock to input markets (y-o-y wage growth)



Source: see Section 2.2 for details; our calculations. *Note*: the plots show the dynamic response of the endogenous variable to a sustained (permanent) shock to labour or other input markets (happening at period 5). Wage inflation is measured as the y-o-y growth rate.

Figure A8 – Historical decompositions (2021-2023), y-o-y wage growth



Source: see Section 2.2 for details; our calculations. *Note*: the plots show the historical decomposition of the dynamics of the endogenous variables: the "initial conditions" scenario feeds into the model the last four realizations of both endogenous and exogenous variables up to 2019Q4, as well as the levels of tightness, unemployment rate, labour productivity, hours per worker and shortages as observed in 2019Q4. Wage inflation is measured as the y-o-y growth rate.