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What caused the post-pandemic era inflation in Belgium?

Replication of the Bernanke-Blanchard model for Belgium.

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Abstract

This paper reports the estimation and simulation of the Bernanke and Blanchard (2023) model on Belgian data. The model offers a consistent framework that ties together wage growth, inflation expectations and price inflation. It is used to study the surge and persistence of inflation in the post-pandemic period in Belgium. According to the model, a sequence of shocks to product shortage, energy and food components is found to be the main reason behind the duration of high Belgian inflation in this period. Though the Belgian replication of the model predicts sensitive short-term inflation expectations to realised inflation, a large wage catch-up - reflecting automatic wage indexation - and some role for labour market tightness in wage growth, their contribution to a persistent inflation is strongly attenuated by a weak estimated wage-price pass-through.

Keywords: inflation, wage indexation, inflation expectations, shortages, energy prices, food prices.

JEL Codes: E31, E24, E37.

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Non-technical summary

The global pandemic aftermath has triggered a significant shift in inflation dynamics worldwide, challenging monetary strategies: Persistent low inflation gave way to sudden waves of intense inflationary pressures. In this context, Bernanke and Blanchard (2023) have developed a semi-structural wage-price-expectation model to assess the relative role of the main drivers of US post-pandemic inflation. In a joint project involving the two authors and ten central banks - including the National Bank of Belgium - the exercise has been reproduced for different economies (Bernanke and Blanchard, 2024). This paper reports the details of the replication for the Belgian economy.

According to the estimated model, the post-pandemic inflation in Belgian consumption prices was mainly driven by a sequence of energy, food and supply-chain disturbances. While long-term inflation expectations remain stable, short-term expectations show some sensitivity to the large realised inflation figures.

In the recent years, fears of a wage-price spiral come (back) into view as short-run inflation expectations influence wage bargaining, and workers may try to "catch-up" their loss in purchasing power by pushing for higher nominal wages in an environment of tight labour markets. Belgium, in particular, faces concerns due to its automatic wage indexation system potentially exacerbating inflation. In the model, these factors explain the substantial wage inflation observed recently for the Belgian economy. The size of the Belgian consumption price inflation data points, however, is not out of line with those observed in other countries. The model reconciles this fact with a rather weak estimated pass-through of wage factors (including indexation) to final prices.

The weak estimated wage-price pass-through is consistent with evidence of markup adjustments in recent years (Bijnens et al., 2023). Caution is nevertheless recommended when interpreting this pass-through, as the estimation sample period is dominated by a stable inflation period, and the model may fail to recognise non-linearities in the relationship between wage, prices and inflation expectations.

Consistent with the recent forecasts of the National Bank of Belgium (December 2023), model-based projections suggest a swift return of Belgian consumption price inflation below 2 % in the future, indicating a temporary nature of the inflationary pressures.

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1 Introduction

The aftermath of the global pandemic has brought about a remarkable shift in inflation dynamics in many countries. While persistent winds of low inflation have challenged the targeted course set by monetary masters prior to the onset of the pandemic, the recent years witnessed sudden waves of fierce inflationary pressures. As central bankers navigate this altered landscape, their attention is now directed towards managing and mitigating the inflationary storm. Though the tempest was initially perceived as vigorous but short-lived, it turned out to be more persistent, with the first signs of relief only appearing as we write these lines.

To appropriately adjust the monetary compass and apprehend the long-lasting inflationary pressures witnessed in the post-pandemic era, it is imperative to investigate its contributing factors. Do they find their sources in a sequence of transitory shocks, which suggest more favourable times once those vanish away? Or has a wage-price spiral emerged which may prolong the inflation episode? Over the period 2021Q1-2022Q3, energy price growth exceeded its pre-covid 95% percentile on several occasions: three times for oil prices, and four and six times for euro area wholesale electricity and gas prices, respectively.[1] Disruptions in global food markets led to unprecedented inflation rates in 2022-2023 in the food components of consumption price indices. The international supply shortages and supply-chain bottlenecks that emerged in the wake of the pandemic added extraordinary pressures on inflation. This sequence of energy, food and supply-chain disturbances gave substance to a narrative of a “bad luck" regarding the persistence in the post-pandemic inflation burst. Alternative explanations to a long-lasting inflation above target underscore the drift in inflation expectations and the increased cost pressures coming from wage indexation in a context of tight labour markets.

The latter force is a source of particular attention in Belgium due to its mechanism of automatic wage indexation, which is often feared to trigger an escalating wage-price spiral after large inflationary shocks. In this paper, Belgian inflation in the post-pandemic era is analysed through the lens of the Bernanke and Blanchard (2023) semi-structural model of aggregate wage-price determination. The partial-equilibrium model brings together key

[1] Source: ECB Macroeconomic Projection Exercise. Price growth is computed as quarter-on-quarter growth rates. Data for the oil price are the UK Brent, US dollar per barrel, and are collected over the period 1995Q1-2019Q4. Euro area wholesale electricity and gas prices (EUR per MWh) are collected over 2006Q1-2019Q4.

ingredients that makes it of particular interest to study the relative forces behind inflation and its persistence. It consists in four equations explaining nominal wage growth, headline inflation, and short- and long-run inflation expectations. Key measures of shocks in labour and goods markets are integrated in the empirical version of the equations. Moreover, three important channels of endogenous inflation persistence are present in the model. First, inflation expectations that de-anchor against a backdrop of high realised inflation can amplify the impact of shocks on the magnitude and the duration of inflation episodes. Second, when realised inflation exceeds workers' expectations, they may ask for a "catch-up", that is a compensation for the past loss in purchasing power. In Belgium, part of this catch-up is automatic due to the legal framework that governs wage formation. Finally, endogenous persistence can also emanate from diffused and long-lasting input-output price-price effects. This can be reflected in the model by the presence of significant lags in the inflation process. The Bernanke and Blanchard (2023) setup thus helps to provide insights on the role of second-round effects in explaining past and future persistence in inflation.

Our replication study is part of a common exercise on the drivers of post-pandemic inflation with Ben Bernanke and Olivier Blanchard and colleagues from several central banks (the Bank of Japan, the Bank of England, the Bank of Canada, the European Central Bank, De Nederlandsche Bank, the Bundesbank, Banque de France, Banca d'Italia and Banco de España).[2] A summary of cross-country outcomes is available in Bernanke and Blanchard (2024). We provide in the present paper the details on the Belgian replication of the model. Similar to the other studies, estimation indicates that the main drivers of Belgian inflation in the post-pandemic era are transitory price-given-wage shocks. The model interprets the length of high inflation episodes as being mostly exogenous, produced by a sequence of shocks to energy, food and shortage factors. Though a non-negligible role for labour market tightness is obtained at the level of Belgian wage growth, it has no discernible effect on headline inflation. Long-term inflation expectations for Belgium are found to be strongly anchored, another common finding with other analysed countries.

The Belgian data however suggest a certain degree of de-anchoring of short-term inflation expectations,[3] captured by the model through an estimated sensitivity of expectations

[2] See Nakamura et al. (2024); Haskel et al. (2023); Bounajm et al. (2023); Arce et al. (2024); Bonam (forthcoming); Menz (forthcoming); Aldama et al. (forthcoming); Pisani and Tagliabracci (2024); Ghomi et al. (2024) for details about the replication of the Bernanke-Blanchard model with the data of each country.

[3] When short-term inflation expectations are measured by one-year ahead consumption price inflation expectations from Consensus Economics. An alternative measure, computed as the average of one-year

to realised inflation. In the model, the short-term expectations have a direct impact in wage setting and their de-anchoring may thus contribute to a wage-price spiral. Moreover, and in contrast with the replication of the model for other countries, we estimate a large catch-up effect, which can be related to the Belgian automatic wage indexation. These two wage-price channels - via inflation expectations and catch-up - are however strongly attenuated by a small estimated wage-price pass-through for Belgium compared to other country analyses. Consequently, the scale of the Belgian inflation episodes is not out of line with those observed in other countries, despite the substantial wage growth experienced on the same period.[4] This result is to some extent consistent with empirical evidence on markup adjustments by Belgian firms in the post-covid era (Bijnens et al., 2023). The model thus suggests little role for wage factors in the inflation figures observed up to 2023Q2 and in model-based projections for 2024-2027. A preliminary extension of the model to non-linear terms, which account for a larger wage pass-through in periods of high wage and/or price inflation, gives more explanatory power to wage factors - including indexation - and predicts a more persistent path for Belgian headline inflation for 2024. This finding suggests the importance of non-linearities in the Belgian wage-price pass-through.

In the baseline Bernanke and Blanchard (2023) model, a homogeneity restriction is imposed in the estimation to ensure that a permanent rise in wage growth is reflected one-to-one in price inflation in the long run. When this assumption is imposed, considerable second-round effects are estimated to be a sustained driver of inflation in the coming years. This source of inflation persistence is however not robust to a relaxation of the restriction, which seems preferred by the data. In this case, the model projections approach the ones of the National Bank of Belgium (hereafter, NBB) published in December 2023 as part of the Broad Macroeconomic Projection Exercise conducted by the Eurosystem.

The paper is organised as follows. Sections 2 and 3 sketch the theoretical and empirical versions of the Bernanke and Blanchard (2023) model. The Belgian dataset is described in Section 4. A discussion on Belgian labour market specificities, relevant to put the model

ahead forecasts from the National Bank of Belgium and the Federal Planning Bureau, displays a softer and smoother deviation from a level above but close to 2%. Both measures are analysed in the present paper.

[4] As noted in De Sloover et al. (2022) and de Beauffort et al. (2023), a stronger reaction of the energy component of Belgian headline inflation to wholesale energy prices has led to a somewhat stronger rise in measures of consumption prices in Belgium compared to the euro area as a whole. Reasons behind this phenomenon are related to the methodology used in the measure of energy components, based on new contracts instead of existing ones, to the taxation of heating oil and the functioning of gas and electricity markets and the share of variable contracts in those markets.

results into perspective, is presented in Section 5. The estimation of the equations of the model is reported and interpreted in Section 6. Model outcomes are illustrated by an impulse-response analysis (Section 7), a historical shock decomposition (Section 8), and by model-based projections in Section 9. The estimated wage-price pass-through is discussed in Section 10 and a robustness analysis to non-linearities is also proposed in this section.

2 Theoretical model

The aggregate wage-price model of Bernanke and Blanchard (2023) consists in a system of four equations, which jointly pins down nominal wage growth π^w, consumer price inflation π, short- and long-term inflation expectations π^e and π^*:

$$\pi_t^w = \pi_t^e + \alpha\left(\pi_{t-1} - \pi_{t-1}^e\right) + \beta\left(x_t - \alpha x_{t-1}\right) + z_t^w \quad (1)$$

$$\pi_t = \pi_t^w + \left(z_t^p - z_{t-1}^p\right) \quad (2)$$

$$\pi_t^e = \delta\pi_t^* + (1-\delta)\pi_{t-1} \quad (3)$$

$$\pi_t^* = \gamma\pi_{t-1}^* + (1-\gamma)\pi_{t-1} \quad (4)$$

Equation 1 specifies wage inflation in terms of short-term inflation expectations, deviations of realised inflation from past expectation (or "catch-up"), labour market tightness x, and exogenous factors affecting wage determination z^w.[5]

According to (2), there is a one-to-one pass-through of wage inflation into price inflation. Changes in the relative costs of non-labour inputs, in firms' markup, and in other factors affecting the price setting are captured in the shock term, z^p.

Short- and long-term inflation expectations are weighted averages of long-term expectations and realised inflation.

[5] As detailed in Bernanke and Blanchard (2023), this equation is obtained by assuming that nominal wage depends on expected current price p^e, a real aspiration wage ω^A, and an indicator of labour market slack:

$$w_t = p_t^e + \omega_t^A + \beta x_t \quad (5)$$

$$\omega_t^A = \alpha\omega_{t-1}^A + (1-\alpha)\left(w_{t-1} - p_{t-1}\right) + z_t^w \quad (6)$$

Combining these two equations delivers Equation 1.

The importance of persistence channels

Alongside the exogenous persistence in inflation rates that emanates from the persistence of shocks, there are two main channels of endogenous persistence in the theoretical model of Bernanke and Blanchard (2023): a "catch-up" channel and a channel that goes through the de-anchoring of inflation expectations.[6]

In the wage equation (1), parameter α measures the degree of the "catch-up" channel. When α equals 0, there is no catch-up and wages depend on expected price inflation and labour market slack. If α is large, workers try to catch-up for deviations between realised inflation and previous period inflation expectations. When realised inflation turns out to be higher than expected, workers ask for a compensation for the past loss in purchasing power. The resulting wage inflation adds pressure on price inflation via the price equation (2) of the system, and hence contributes to price inflation persistence. Note that, by symmetry, in the case where realised inflation is smaller than expected, workers agree to concede some of the past gains in purchasing power.

In the two inflation expectation equations, parameters δ and γ measure the degree of reaction of agents' expectations to changes in observed inflation. The smaller these coefficients, the larger is a de-anchoring of inflation expectations after a shock that generates fluctuations in realised inflation. In this case, a non-negligible price-expectations spiral is triggered, as high inflation expectations feed wage inflation, which in turn pushes price inflation upwards. Consequently, shocks that ex-ante produce a one-period change in price inflation can generate significant permanent effect on inflation ex-post. Though there is no explicit anchor nor inflation target in the model,[7] the larger the values of δ and γ, the closer we are to a specification with strong anchoring of inflation expectations.

Note that there is an interaction between the catch-up coefficient α, de-anchoring and labour market tightness in Equation (1). The labour market slack term can be re-expressed as follows: $\beta(1-\alpha)x_t + \beta\alpha(x_t - x_{t-1})$. When $\alpha = 1$, only the first difference in labour market tightness affects wage inflation. In this case, a transitory change in slack has a transitory effect on wage (and hence price) inflation in the model.[8] If $\alpha \neq 1$, both the level and the

[6] On the top of these two endogenous persistence channels, another one arises in the empirical model described later in this paper. Once the model is brought to the data, lags on price inflation are added to Equation (2), and can be a source of persistence in the inflation process.

[7] Note that this can easily be remedied by adding a constant term to Equation (4).

[8] This holds true even when there is a strong de-anchoring of inflation expectations. In this case, however,

first difference of labour market slack affect wage inflation. Now transitory change in slack have permanent effects on wage (and price) inflation. A significant de-anchoring of inflation expectations adds oil to the engine and amplifies the permanent effects.

3 Empirical model

The model is estimated based on quarterly data from 1996Q2 to 2023Q2,[9] following an approach in the spirit of the SVAR analysis. The four equations are estimated separately using least-square techniques. Identification is obtained by assuming that wage inflation reacts with one quarter delay to other variables. To help the model fit the data, the empirical version has a more flexible lag structure - it includes four lags for each variable - and several additional variables are incorporated compared to the theoretical setup presented in Equations (1) to (4). The empirical model takes the following form:

$$\begin{aligned} \pi_t^w &= \theta^w + \sum_{i=1}^{4} \rho_i^w \pi_{t-i}^w + \sum_{i=1}^{4} \psi_i^w \pi_{t-i}^e + \sum_{i=1}^{4} \alpha_i^w \left(\frac{\sum_{j=0}^{3} \pi_{t-j-i}}{4} - \pi_{t-4-i}^e \right) \\ &\quad + \sum_{i=1}^{4} \beta_i^w x_{t-i} + \lambda^w \Lambda_{t-1} + \varepsilon_t^w \qquad (7) \\ \pi_t &= \theta^p + \sum_{i=1}^{4} \rho_i^p \pi_{t-i} + \sum_{i=0}^{4} \kappa_i^p \pi_{t-i}^w + \sum_{i=0}^{4} \zeta_i^p \pi_{t-i}^{enrg} + \sum_{i=0}^{4} \eta_i^p \pi_{t-i}^{food} \\ &\quad + \sum_{i=0}^{4} \tau_i^p s_{t-i} + \lambda^p \Lambda_t + \varepsilon_t^p \qquad (8) \\ \pi_t^e &= \sum_{i=1}^{4} \rho_i^e \pi_{t-i}^e + \sum_{i=0}^{4} \delta_i^e \pi_{t-i}^* + \sum_{i=0}^{4} \xi_i^e \pi_{t-i} \qquad (9) \\ \pi_t^* &= \sum_{i=1}^{4} \gamma_i^* \pi_{t-i}^* + \sum_{i=0}^{4} \xi_i^* \pi_{t-i} \qquad (10) \end{aligned}$$

The first four lags of each dependent variable are included in each equation. A measure of productivity Λ is included to allow for wages to depend on an exogenous trend in productivity growth and for prices to relate to unit labour cost rather than wages. As discussed below, the productivity measure is constructed as a moving average over eight quarters, so that only

the transitory effects can be very persistent.

[9] The parameter estimates are however broadly robust and the key takeaways of the model intact when the model is estimated on a pre-covid sample. We thus only present the estimation results based on the full sample in this paper.

one lag (or the contemporaneous value) of the variable is used in the wage equation (in the price equation, respectively). Moreover, the catch-up term is measured as the year-on-year inflation rate minus the previous year short-term inflation expectations. Contemporaneous and lags of energy and food inflation rates are added in the price equation to account for their importance in the fluctuations of headline inflation. Finally, a measure of shortage s is also incorporated in (8). Its aim is to serve as proxy to capture the effects of supply chain disruptions and the shortages of certain goods on inflation. During the pandemic period, these shortages reflected a combination of both demand- (contraction in consumer expenditures due to lockdowns and fear of infection, and sharply increasing demand post-covid) and supply-side factors (global supply chain and transportation disruptions).

The following homogeneity restrictions are tested on the coefficients based on the theoretical model:

$$\begin{aligned}
\sum_{i=1}^{4}\rho_i^w + \sum_{i=1}^{4}\psi_i^w &= 1 \\
\sum_{i=1}^{4}\rho_i^p + \sum_{i=0}^{4}\kappa_i^p &= 1 \\
\sum_{i=1}^{4}\rho_i^e + \sum_{i=0}^{4}\delta_i^e + \sum_{i=0}^{4}\xi_i^e &= 1 \\
\sum_{i=1}^{4}\gamma_i^* + \sum_{i=0}^{4}\xi_i^* &= 1
\end{aligned}$$

The last two restrictions imply that a given change in inflation is, in the long run, passed on in full to inflation expectations. These changes in inflation expectations are then in the long run completely transmitted to wage inflation via the first coefficient restriction. This restriction can also be interpreted as to ensure that wage Phillips curve is vertical in the long run. Consistent with the theoretical model, a given change in wage inflation also fully percolates to price inflation via the second imposed restriction.

4 Data

We describe here the data used in the estimation of the empirical model presented in the previous section. Plots of the endogenous and main exogenous variables can be found in

Figures 9 and 10 in the appendix.

4.1 Endogenous variables

Wage inflation

Nominal wage inflation π^w is measured as the quarter-on-quarter growth rate of the nominal hourly wage cost of the private sector, computed as total compensation of employees divided by the total volume of hours worked.[10] The data come from Belgian national account available on NBB.Stat, and are calendar and seasonally adjusted, but not adjusted for job retention schemes. A robustness analysis to collectively agreed wages, that is the direct outcome of wage negotiation between social partners, is implemented in Appendix E. Though the later wage concept is a timely indicator, we believe that compensation per hour gives a more accurate idea of the actual labour costs for firms. Total compensation includes the wage drift (i.e. the difference between negotiated wages and actual wages) as well as employers' social-security contributions. These elements represent an important part of the labour costs borne by the employer and are hence relevant for the price equation. We control for employer's social contribution in the wage regression using an additional exogenous variable u_t described below.

During the Covid episode, job retention schemes in Belgium were linked to the unemployment insurance scheme. That is, if needed due to the Covid crisis, workers would register for temporary unemployment (in case of force majeure) and receive 70% of their original wage directly from the government (plus potentially some supplement).[11] Social contributions are paid by employers only for the hours worked. An important issue for our econometric analysis is that workers who use the job retention scheme tended to be low-wage workers. This led to a severe upward effect in measured compensation in 2020Q2 and downward corrections once these workers terminated their temporary unemployment.

Started in March 2020 and initially foreseen to expire in August 2020, the Belgian job

[10] An alternative could be the compensation per employee of the private sector. A drawback of this variable is to be more sensitive to changes in job regimes (temporary contracts, part-time vs full-time) or the treatment of extra hours compared to the compensation per hour. We nevertheless tested this alternative (along with a measure of productivity per employee instead of per hour) and obtained a poorer fit (mainly for the pre-covid period) of the wage equation though the main takeaways of the Belgian replication exercise appear to remain robust. See also Jonckheere and Saks (2019) who fit a wage Phillips curve on Belgian data using compensation per employee.

[11] See more details in Serroyen (2021).

retention scheme was extended several times up to 2021. This explains the erratic pattern in the compensation per hour (and per employee) observed not only in 2020 but also, to a lower extent, in 2021. We thus use a time series for compensation per hour corrected for the 2020-2021 period.[12] Starting in 2019Q4 a counterfactual wage evolution is computed until 2021Q4. This counterfactual is computed according to a model where the wage level is regressed on its own lag, a time trend, an index of past prices and the implicit rate of social contributions. We use this corrected measure in our baseline configuration, which avoids the use of dummies for 2020Q2 and 2020Q3 (or until 2021Q4) in the estimation.[13]

Price inflation

Our measure of price inflation π is the quarter-on-quarter inflation rate of the National Index for Consumer Prices (NICP), seasonally adjusted obtained from NBB.Stat. Its composition slightly differs from the Harmonised Index for Consumer Prices (compiled using a methodology harmonised across euro area countries), but correlation between the two inflation rates is very high (0.95). The NICP is the reference index for Belgian automatic wage indexation, which makes it more relevant for the wage-price model.

Inflation expectations

Regarding short-term inflation expectations π^e, we use 1-year ahead consumption price inflation expectations from Consensus Economics (CE), measured as the quarterly average from the monthly Consensus survey.[14] As a possible alternative, we explore the use of an average of the 1-year ahead forecasts from the NBB and the Federal Planning Bureau (FPB) as these forecast series are made available in the reports that serve as basis for wage negotiations.[15] An advantage of the CE series is its availability (since 1989, compared to 2004 and 2012 for the NBB and BFP series respectively). An important difference in the post-covid period is the much stronger de-anchoring of CE predictions compared to the NBB and FPB ones, as can be seen in Figure 9.

Long-term inflation expectations π^* are measured by the 6-10 year ahead consumption price inflation expectations from Consensus Economics (CE). This series is available only

[12] We warmly thank Koen Burggraeve for the computation and sharing of this corrected measure.

[13] Results are however robust when we use the original time series and add quarter dummies for the period 2020Q2-2021Q4 as we did in previous estimations of the model.

[14] We are indebted to Joris Wauters for helping us in the collection of the CE inflation expectation data.

[15] We warmly thank Ludovic Dobbelaere for the sharing of FPB forecasts.

from 2018Q1 onwards. It is backcasted using long-term inflation expectations for the euro area as a whole, measured by the five-year ahead annual HICP inflation forecast of the ECB Survey of Professional Forecasters (SPF).

4.2 Exogenous variables

Energy price

Energy price inflation π^{enrg} is computed as the quarter-on-quarter growth rate of the relative price of energy, measured as the rate of change of the ratio of NICP energy component (not seasonally adjusted) to the compensation per hour.

Food prices

We use the quarter-on-quarter growth rate of the relative price of (processed and unprocessed) food for π^{food}, measured as the rate of change of the ratio of NICP (processed and unprocessed) food components (not seasonally adjusted) to the compensation per hour.

Labour market tightness

Our labour market tightness variable x consists in an average over two indicators. The first one is 1 minus the harmonized unemployment rate for Belgium, seasonally adjusted and available on NBB.Stat. The second one is the percentage of manufacturing firms pointing to "labour shortage as a factor limiting production" in the European Commission business survey (EC). The indicator is not seasonally adjusted. A job-vacancy-to-unemployment ratio is available on Eurostat for Belgium, but the time series only starts in 2013 and is highly correlated with the EC indicator (0.93). Hence, we decided not to include the ratio in our analysis and to continue with the EC indicator. Both the unemployment rate and the EC indicator are detrended before entering the average. For the former we use a simple time trend, for the latter we use a 3rd order polynomial.

Shortage

The first component of a principal component analysis on several indicators is used as our shortage variable s. These indicators are a) a Google trends indicator based on searches for the words "pénurie" (French) and "penurie" and "krapte" (Dutch), b) the Global Supply Chain Pressure index from the Federal Reserve of New York, and two seasonally-adjusted purchasing managers' indices for European markets compiled by S&P Global (with access via Refinitiv Eikon), c) one tracking manufacturing suppliers' delivery times, and the other being d) an index for input prices in both manufacturing and services.[16]

Productivity

Productivity Λ is computed as an eight-quarter moving average on the quarterly growth rate of productivity, itself measured as Belgian private value added per hours worked, seasonally adjusted. Note that the time series displays an erratic pattern at the end of the sample (2022Q2-2023Q2) as the long moving average includes quarterly rates from the pandemic episode. Results are however similar whether we use this time series or when we attempt to smooth the erratic behaviour by modifying the length of the moving average in an ad-hoc manner, or when we use the quarterly productivity growth rate instead of the average. In our baseline configuration, we thus use the eight-quarter moving average up to 2019Q4, and then modify the length of the moving average to smooth the erratic pattern of the series. In the 2020-2021 period, we either use a seven-quarter average, excluding the contemporaneous productivity rate the first time there is a "jump", or an eight-quarter average if the contemporaneous value and its lag form a "compensating zigzag". In 2022Q4, a four-quarter moving average is used and extended after each quarter up to 2023Q2 where six quarters are used.

Social contributions

We add an exogenous variable u as the quarterly (detrended) implicit rate of social contributions measured by the ratio of total employers' social contributions to (before tax) gross wages. The addition of this variable improves the fit of the wage equation but does not significantly change the coefficients of other variables, and hence the key takeaways of the Belgian exercise. It has the advantage to take onboard contributions of some government intervention in the analysis as for instance the decline in the employers' social contribution rate in 2016 and the recently announced temporary decline in 2023.

5 Belgian labour market specificities

In Belgium, an automatic indexation of wages and social contributions to the (modified) National Consumption Price Index is implemented. This indexation is complete but its

[16] We also conducted robustness checks with the shortage indicators of the NBB quarterly survey on production capacity available on NBBstat. They were however not found to add any extra explanatory power in the price inflation regression compared to the above indicators.

pass-through to wages is differed as indexation mechanisms and timing differ across sectors. As indicated in Conter and Faniel (2022), many private wage earners (about 42%) benefit from indexation the month after a smoothed average of the modified NICP crosses 2%. In some sectors this indexation takes place on an annual basis (about 41% of private sector workers, often in January), while in others it can be semi-annual or quarterly.

Wage formation in the Belgian private sector is based on a bi-annual and centralised bargaining between union representatives of employers and workers. The outcome of the negotiation between social partners is a collectively agreed wage, to be implemented at the sector and firm level. This bargaining process is however framed by the 1996 Law on the Promotion of Employment and the Preventive Safeguarding of Competitiveness. Every two years, and before wage negotiations take place, a maximum margin is established for the evolution of nominal wages based on the “wage gap” between the Belgian private sector labour costs and those in the three main trading partners: France, Germany and the Netherlands. This aims to ensure that Belgian labour costs do not increase too rapidly compared to the trading partners, and hence to avoid too important competitiveness losses for Belgian firms. This maximum margin then serves as a restrictive framework for the wage bargaining between unions. Note that this maximum margin comes “on top of” automatic indexation, which is thus guaranteed. In periods of high inflation automatic indexation may expand the wage gap in such a way that it severely contracts the maximum margin. This is what is observed in the recent period, with a maximum margin at 0% for 2023-2024. These Belgian specificities, automatic wage indexation and the existence of a wage negotiation margin, are important to keep in mind when analysing the estimation outcomes of the model. We will refer to them on several occasion in the next sections when commenting the results.

In addition to this wage formation framework, the Belgian government intervened on several occasions in the wage formation process when no agreement is found by social partners or to help Belgian firms to restore their competitiveness (e.g., strong wage moderation policies in the period 2014-2016 with among other measures a decline in employers’ social contributions).[17]

[17] A key measure taken by the Belgian government during this period is an ”index jump" in 2015Q2, where automatic wage indexation was temporarily blocked until 2016Q2. Our results are robust to the inclusion of a dummy variable for this period in the wage inflation equation.

6 Estimation results

The wage inflation equation

We present here the results of alternatives of the estimation of the wage equation (7). The first alternative (Wage 1) is the closest to the original equation of the empirical model of Bernanke and Blanchard (2023). It is also the one reported in the cross-country study of Bernanke and Blanchard (2024). In this configuration, four lags are used for the dependent variable and the main regressors (inflation expectations, labour market tightness and catch-up). For the productivity measure, only the first lag is added given that it is constructed as an average that already includes lags of the quarterly productivity rate. To the original configuration in (7), we add two variables: the implicit rate of social contributions and an interaction between the first quarter of the year and the first lag of the catch-up term. To the extent that the catch-up term partly reflects Belgian automatic indexation in an environment of high inflation as the one characterised by the post-covid era, this interaction variable proves useful in helping to capture the fact that an important part of workers in the private sector are indexed in January.[18]

Table 1 shows the results of the estimation of the wage equation. The fit of the wage equation, similar across alternatives, is not too bad when assessed by the reported R-squared measure for the full sample. It however appears to be limited for the pre-pandemic era as indicated by the smaller R-squared measure computed based on data and predictions before 2019Q4 and as shown in Figure 11 in the appendix. In all alternatives, the coefficients on the lagged wage inflation are negative, reflecting a significant and negative coefficient on the first lag.[19] The coefficient of lagged productivity has the expected sign, but is not statistically significant. The sum of parameters associated with social contributions are estimated to be quite stable and around 1, reflecting the important role of such government measures can have on Belgian wage growth as also noted in Jonckheere and Saks (2019).

In Wage 1, the sum of parameters of past inflation expectations are quite important,

[18] Note that when realised inflation is lower than past inflation expectations, the catch-up term turns negative even in a period with high inflation. Using a dummy that takes the value 1 in the first quarter of the year only if catch-up is positive may in this case make more sense. The estimation results are virtually the same when using this alternative dummy variable.

[19] This result remains puzzling to us. A regression of wage inflation on its own lags produces a positive sum of coefficients associated with a p-value a bit above 10%. The AR(1) coefficients of two components of hourly wage, total compensation and total hours worked are positive with the one of the former slightly larger than for the latter.

driven by a large coefficient on the fourth lag of the series. As discussed in Section 3, a homogeneity restriction is applied such that the sum of coefficients on lagged wage inflation is equal to the one on lagged expected price inflation. Estimation results are robust to a relaxation of the restriction - and hence not shown here for brevity - as it is not rejected by the data (the p-value of the test is 0.61) in an unconstrained regression with the same set of regressors as in Wage 1.

The estimation indicates a non-negligible, though delayed, role for labour market tightness on Belgian wage inflation. The sum of coefficients on this variable is important, due to a large and significant coefficient on the fourth lag (0.83). The catch-up term is associated with a large sum of coefficients (0.73 or 1.17 for the first quarter of the year as we add the effect of the interacting dummy). This finding contrasts with small values found for other countries and reported in Bernanke and Blanchard (2024). This result is driven by the presence of realised price inflation in the catch-up term and the effect of the Belgian automatic indexation scheme. When realised inflation turns out to exceed past inflation expectations, part of the catch-up is "automatic" for Belgian workers due to wage indexation. Note however that the symmetric case is harder to reconcile with automatic indexation: The estimates also imply that when inflation expectations measured one year ago are larger than realised inflation, the catch-up term is negative - and hence produces downward pressures on wage inflation - even when realised inflation is high and generates indexation. In an alternative configuration of the equation, Wage 2, we "extract" the (first lag of) realised year-on-year inflation of the catch-up term to control for it explicitly in the regression. In this case, the effect of the catch-up term fades away, indicating that realised inflation is driving the large catch-up parameters found in Wage 1.

Pursuing in this direction, we replace the catch-up term by realised inflation (quarter-on-quarter inflation rates) in the alternative equations Wage 3 and Wage 4. The model fit is similar to the previous configurations, as indicated by reported R-squared measures and plots of data and predicted values in Figure 11 in the appendix. Coefficients on lagged wage inflation, labour market slack, productivity and social contributions are robust to these specifications. Lagged price inflation is positive and significant, as expected in regard to Belgian automatic wage indexation.[20] These specifications with realised inflation are closer to

[20] Note that we leave the sum of the coefficients on lagged NICP price inflation unconstrained. It is not expected to sum to one (with or without adding the sum of lagged wage inflation), as the NICP index used for wage indexation is somewhat modified to exclude some unhealthy items from its composition, in particular tobacco, alcoholic beverages and motor fuels, and an average is used to smooth the transmission of heating

what is used in NBB macro models, and helps to avoid the symmetry issue in the catch-up explained above. A noticeable difference is the individual weight assigned to lagged price inflation, calibrated to be between 2/3rd and 3/4th on the first lag in NBB macro models, while it is more diffused in the present setup, as indicated by the detailed estimates in Table 5 in the appendix.

The distinction between Wage 3 and 4 is that the homogeneity constraint is imposed in the former configuration. It is relaxed in Wage 4 which makes us able to test its statistical relevance using a Wald test. The coefficients on short-run inflation expectations are affected by the relaxation of the constraint, and significantly decrease - while remaining statistically significant in a joint Wald test - in the last configuration of the wage equation. The sum of coefficients on lagged wage inflation and short-run inflation expectations is equal to -0.27, while the p-value associated with this test is small but nevertheless above 10% (i.e., it is equal to 0.13 as reported in parenthesis in the last-but-three row of Table 1).

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oil prices. Note also that lags of wage inflation are estimated with negative coefficients, which generate a dampening in the pass-through of realised price inflation in the wage equation.

Table 1: Estimation of the wage inflation equation.

	Wage 1	Wage 2	Wage 3	Wage 4
wage inflation	-0.43***	-0.45***	-0.53***	-0.51***
short-run infl. exp.	1.43***	1.45***	1.53***	0.24**
lab. market tightn.	0.94**	0.92**	0.88**	0.81**
catch-up	0.73	-0.03		
productivity	0.01	0.07	0.19	0.15
social contributions	1.11**	0.98*	1.09**	1.18**
dQ1 x catch-up	0.44	0.48		
price inflation (yoy)		0.67		
dQ1 x price infl. (yoy)		-0.03		
price inflation (qoq)			0.81*	1.45*
dQ1 x price infl. (qoq)			0.18	0.19
constant	0.76**	-0.43	-0.83	0.19
homog. constraint?	yes	yes	yes	no (0.13)
number of obs.	105	105	105	105
R^2 pre-covid	0.37	0.38	0.39	0.40
R^2 full sample	0.56	0.57	0.56	0.58

Note: Statistical significance of the joint test is indicated by asterisks: * p-value $<$ 0.10, ** p-value $<$ 0.05, *** p-value $<$ 0.01.

The price inflation equation

Table 2 reports the results of the estimation of the price inflation equation (8), under alternative configurations. For variables that enter the equation with four lags, the sum of coefficients is reported. We refer to the appendix and Table 6 for more detailed estimates.

Alternative Price 1 replicates the original setup of Bernanke and Blanchard (2023) using Belgian data, and is the one reported in Bernanke and Blanchard (2024). Persistence in inflation is estimated to be large in this configuration, as measured by the sum of coefficients on lagged inflation equal to 0.91. The sum of coefficients on wage growth is 0.09, consistent with the imposed homogeneity restriction. The long-run effect of energy, estimated to be equal to 0.01/(1-0.91) = 0.11, is in line with energy's average share in the total consumption index basket (0.12). The long-run effect of food components is, however, estimated to be equal to 0.44 is more than the double the average share of food in the CPI (0.21). In both cases negative estimates on most of the lags of these variables, partly offset the estimate of the contemporaneous variable. A similar outcome is obtained for the wage growth regressor. An effect of shortage on price inflation is found, and is somewhat differed as it is driven by a significant coefficient on the third lag. Labour productivity is associated with a positive coefficient, which is opposite to what can be expected, but it is not statistically significant.

A possible interpretation of the lags on price inflation and relative energy and food inflation can be found in input-output aspects of production. Accordingly, large estimated lags on price inflation could reflect diffused and persistent second-round price-price effects. We found, however, that the homogeneity restriction - which imposes that the coefficient on wage inflation and on the lags of price inflation sum to one - importantly influences the estimation of the price inflation equation. In Price 2, the constraint is relaxed and the estimated persistence of the inflation process drops to 0.25. A Wald test rejects the null hypothesis of the sum of these coefficients equal to one indicating that the data do not support the homogeneity restriction.[21] Except for productivity growth, the total of coefficients on other variables becomes larger in this alternative specification.[22] In particular, the total estimated parameters on energy and food inflation rates are now closer to their respective shares in the index. Labour productivity growth has the expected sign, but remains not statistically significant.

As a robustness check and to the extent that firms take unit labour cost into account, we test an alternative, Price 3, where labour productivity is included in the homogeneity constraint. The estimation results of this alternative are within the range formed by the other two. Inflation persistence drops and the parameters on other components increase compared to Price 1, but not as much as in Price 2.

The fit of the price inflation equation is very good and similar across the three alternatives,

[21] In contrast, the homogeneity constraint is not rejected for US data, as reported in Bernanke and Blanchard (2023).

[22] It is interesting to note that coefficients on contemporaneous variable - or on the third lag for shortage - remain quite robust across the configurations. An explanation on the findings of a smaller sum of coefficients in Price 1 could be that as estimated persistence is high, the model "needs" counteracting lags to avoid a too large effect of variables on price inflation for such a similar value on contemporaneous variables.

as indicated by high R squared measure and the plot of actual vs predicted values in Figure 12 in the appendix.

Table 2: Estimation of the price inflation equation.

	Price 1	Price 2	Price 3
price inflation	0.91***	0.25*	0.75***
wage inflation	0.09***	0.34***	0.16***
energy component	0.01***	0.08***	0.03***
food components	0.04***	0.21***	0.09***
shortage	0.11*	0.22***	0.16**
productivity	0.02	-0.06	0.10**
constant	-0.02	0.75***	0.07
homog. constraint?	yes	no (0.00)	yes†
number of obs.	105	105	105
R^2 pre-covid	0.92	0.94	0.93
R^2 full sample	0.97	0.97	0.97

Note: Statistical significance of the joint test is indicated by asterisks: * p-value $<$ 0.10, ** p-value $<$ 0.05, *** p-value $<$ 0.01.

The inflation expectation equations

The results of the estimated equations of short- and long-term inflation expectations are presented in Table 3. The two alternative specifications for the short-term inflation expectations differ in the measure used for the dependent variable. In the alternative SR1, also reported in Bernanke and Blanchard (2024), we use 1-year ahead consumption price inflation expectations from CE. Alternative SR2 makes use of the averaged 1-year ahead forecasts from NBB and FPB. The estimated persistence of the series are similar under the two alternatives. CE data are however more sensitive to realised inflation, which gives slightly more room to a de-anchoring of short-term inflation expectations in SR1. This sensitivity is more pronounced than in model replications for Anglo-Saxon countries and Japan, but in line or even smaller than in replications for European countries (EA, DE and FR). The model outcomes thus do not go along with the recent finding by Steffen et al. (2023) that the pass-through of realised inflation on short-term inflation expectations is more elevated in a country with high wage indexation such as Belgium. NBB/FBP forecasts are more driven by long-run inflation expectations relative to CE forecasts. The model displays a better fit with CE forecasts (see reported R-squared as well as Figure 13 in the appendix).

Two configurations are tested for the long-run inflation expectation equation. The first specification LR1, reported in Bernanke and Blanchard (2024), imposes no constant term and that the coefficients of lagged expectations and realised inflation sum to one, as in the original setup. The second specification, LR2, allows for a constant term, that we calibrate to 1.9 annual percentage points to reflect the ECB targeted inflation rate. Hence, this configuration allows for a return of inflation expectations to this target in the long run. Long-term expectations for Belgian headline inflation are strongly anchored under the two alternatives considered, as indicated by the insignificant sum of coefficients estimated for realised inflation. For LR1, it results in an extremely persistent inflation expectations process, close to unit root. In LR2, the target is statistically significant and the process is less persistent. The fit is comparable across the two alternatives as the near-unit root coefficient implied by LR1 mimics the role of the constant term in LR2.

Table 3: Estimation of the equations for short- and long-term inflation expectations.

	SR 1	SR 2	LR 1	LR 2
short-run infl. expectations	0.65***	0.65***		
long-run infl. expectations	0.12*	0.22*	0.99***	0.82***
price inflation	0.23***	0.12***	0.01	0.01
target				0.17***
homog. constraint?	yes	yes	yes	yes†
number of obs.	105	104	105	105
R^2 pre-covid	0.92	0.50	0.77	0.78
R^2 full sample	0.97	0.61	0.77	0.77

Note: Statistical significance of the joint test is indicated by asterisks: * p-value $<$ 0.10, ** p-value $<$ 0.05, *** p-value $<$ 0.01.

† The homogeneity restriction includes the inflation target coefficient.

Different specifications of the estimated model

In the lines above, alternative specifications of each equation have been described to illustrate the robustness of the model Bernanke and Blanchard (2023) applied to Belgian data. In the lines below, we present the outputs generated by the estimated model. We draw on the alternatives to construct different four-equation model specifications that we found relevant to discuss the results:

- A "**BB**" configuration which consists in **Wage 1 - Price 1 - SR 1 and LR 1** equations. This configuration is the one closest to - and hence most consistent with - the original model of Bernanke and Blanchard (2023) applied to US data. This is the configuration reported in Bernanke and Blanchard (2024).

- As the model dynamics turn out to be sensitive to the estimated persistence of the inflation process, we also consider a configuration with Wage 1 - **Price 2 (or alternatively Price 3)** - SR 1 and LR 1 equations. We call these alternatives "**BB-P2**" and "**BB-P3**", respectively.

The main results and messages are robust to other alternatives explored in the previous subsections so that we do not report their combinations in the next parts of the paper. A major reason for this robustness is that the different alternatives impact price inflation via their effects on wage growth, and that we estimate a small pass-through of wages to prices. Note also that due to the strong degree of estimated persistence in the long-run inflation expectation equation LR1, the model outcomes are robust to the presence of an inflation target/constant so that we do not present a configuration with Equation LR2.

7 Shock simulations

The dynamics of the estimated model are well illustrated using an impulse response analysis. An impulse or "shock" to each of the main exogenous variables is introduced, and the estimated model is used to track the responses of endogenous variables, with a focus on price inflation. The model captures the direct effects on inflation as well as second-round effects that are generated via the responses of the other endogenous variables, that is wage inflation and short- and long-run inflation expectations, and via the estimated persistence of the inflation process itself. We start by giving an impulse to energy inflation, and next analyse responses to exogenous changes in food inflation, shortage and labour market slack. Note that as the relative energy and food inflation rates are endogenous to wage growth, we let the relative price evolve endogenously in the model outputs reported in this paper.[23]

The top-left subplot of Figure 1 shows the response of Belgian inflation to a one-standard-deviation shock to energy inflation (+44.5% in annual terms) that lasts one quarter, across different configurations of the model. Price inflation is reported as quarter-on-quarter growth rates expressed on annual terms. In Appendix C we report the main model inputs, including impulse responses, in year-on-year growth rates. It increases by 5 percentage points on impact, which is consistent with the weight of the energy component in the consumption price index. The strength of the short-term response is significant but relatively short-lived. Some inflationary pressures nevertheless come back in the medium term with a rebound in inflation after one year.

The responses of price inflation to a one-standard-deviation shock in food inflation (5%

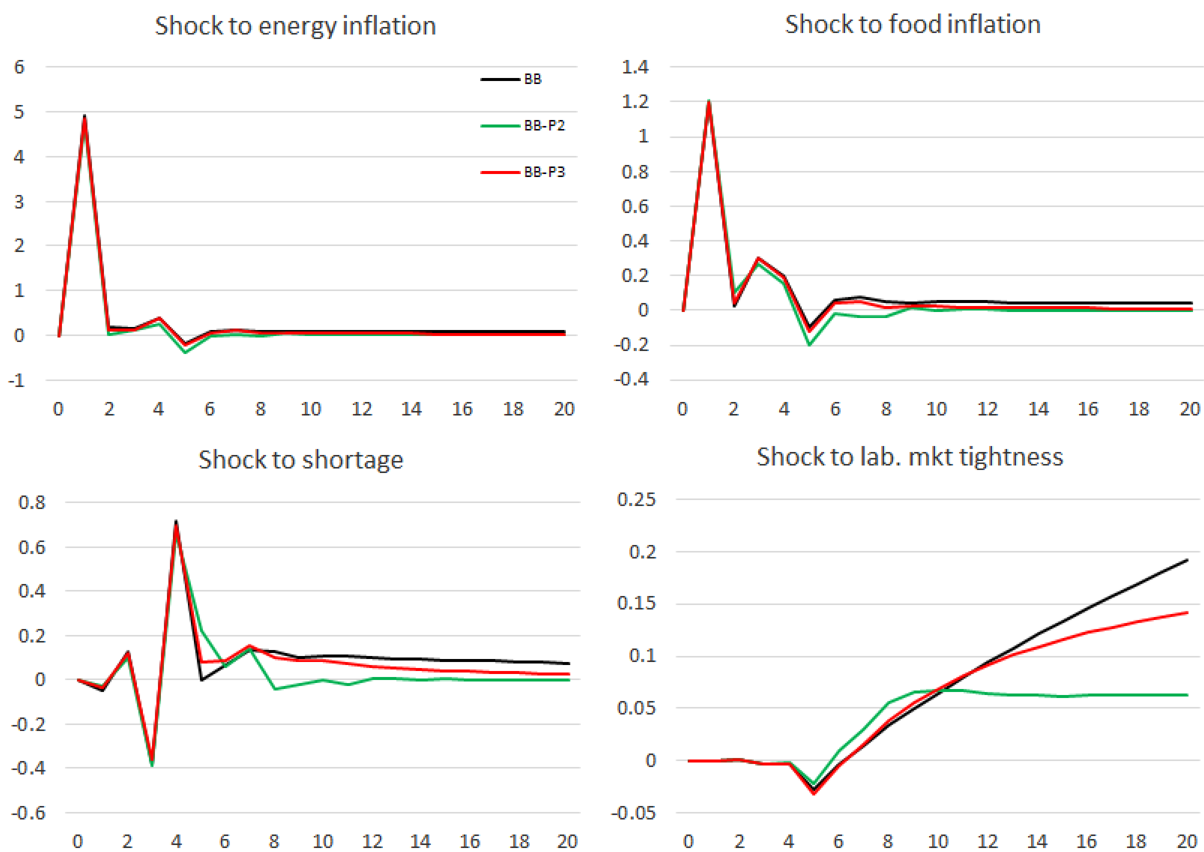
[23] In contrast, Bernanke and Blanchard (2023) and Bernanke and Blanchard (2024) assume exogenous relative prices in simulations. For the energy or food price shocks, this assumption implies a permanent increase in the relative prices. For other shocks, any response of wages is reflected in a movement in the price of energy or food so as to keep the relative price constant. This divergence in the assumption regarding relative prices explain that our outputs are slightly different from what is reported for Belgium in Bernanke and Blanchard (2024). The key messages of the analysis remain however robust to this change in the simulation assumption.

in annual terms) is reported in the top-right subplot of Figure 1. Outcomes similar to the energy inflation impulse emerge. The short-term effect is strong but short-lived, and on impact in line with the weight of the food component in the consumption price index. Permanent effects are obtained, though they appear negligible and around 3 basis points (in annual terms) in the BB specification of the model. The estimated coefficients on lags of food inflation alternate negative and positive signs, which produce a jigsaw pattern in price inflation. All configurations generate a rebound in the third quarter, as a consequence of the positive second lag estimated for the food component in the inflation equation.

The third price-given-wage shock analysed is a one-standard-deviation and one-period impulse introduced to the shortage variable present in the inflation equation. This sudden increase in shortage can stem from demand and/or supply factors. For instance, it could reflect a combination of the rapid increase in demand after a period of subdued spending and the increased global supply-chain disruptions that characterized the post-covid era. The model predicts a delayed inflationary pressure, with a significant increase in Belgian consumption price inflation after three quarters. Permanent inflationary pressures are limited and depend on the estimated persistence of the inflation process. They vanish in the configuration where the homogeneity constraint is relaxed, which is associated with a small estimated persistence.

Finally, the simulation outcomes of a permanent one-standard-deviation shock to labour market tightness are illustrated in the bottom-right subplot of Figure 1. The effects on wage growth, and hence on price inflation, kicks in after four quarters due to the significance of the fourth lag of the labour market tightness in the wage equation. The overall effect on price inflation is quite small in the first 5 years that follow the shock. Absent of any second-round effects, and due to the permanent character of the shock, wage inflation would be permanently raised to a new constant level. However due to the wage-price spiral effects of the model, wage and price inflation continue to increase in the long run. Two opposite forces affect this ever-increasing path in the Belgian replication of the model: A strong catch-up applies an accelerating pressure while the well-anchored inflation expectations help to mitigate the phenomenon. The persistence of the price inflation process importantly interacts with these two forces, with the result that the spiral effects are strongly calmed down in specifications where it is estimated to be smaller.

Figure 1: Impulse responses of Belgian consumer price inflation (NICP, QoQ, annualised).



8 Drivers of the post-pandemic inflation

The four-equation estimated model and its implied impulse response functions can be used to decompose wage and price inflation into their sources. Figures 2 and 3 report such a decomposition for the annualised quarter-on-quarter growth rates of Belgian consumption price and wages, respectively.[24] The historical decomposition of the two variables measured with year-on-year growth rates are available in Appendix C (Figures 17 and 18). Each bar represents the contribution of a shock, measured as the deviation of the data value of the corresponding exogenous variable from its pre-covid sample average. The contributions of initial conditions indicate how inflation would have evolved absent of shocks. The fit of the model of the post-covid era can be assessed by looking at the contributions of residuals. We only report the historical decomposition constructed based on the BB configuration of the model, as other configurations generate very similar outcomes. The findings around the main drivers of post-pandemic Belgian inflation highlighted here are thus robust to changes in the specification of the model. We focus here on the 2019Q4-2023Q2 period. A full sample decomposition of price inflation and wage growth is reported in Figures 14 and 15 in the appendix.

The model explains Belgian consumer price inflation in the post-covid period by price-given-wage factors, that is, energy, food and shortage shocks. The model fit of post-covid inflation is very good, as indicated by the small contributions of residuals. These results are in line with model replications conducted for other countries and summarised in Bernanke and Blanchard (2024). The contribution of the energy component starts in 2021 and peaks in 2022Q1, which corresponds to the start of Russo-Ukrainian war. The reversal in energy price drives headline inflation sharply down at the start of 2023. Shortage contributions gradually increase since 2021 and reflect both demand and supply factors. These contributions are consistent with inflationary pressures generated by a latent demand after a period of subdued spending due to lockdowns coupled with the observed global supply-chain disruptions. Though these tensions seem to have reversed recently (which is reflected by our shortage variable since end 2022), estimated lagged effects in the model explain why the shortage factor remains significant in the first half of 2023.

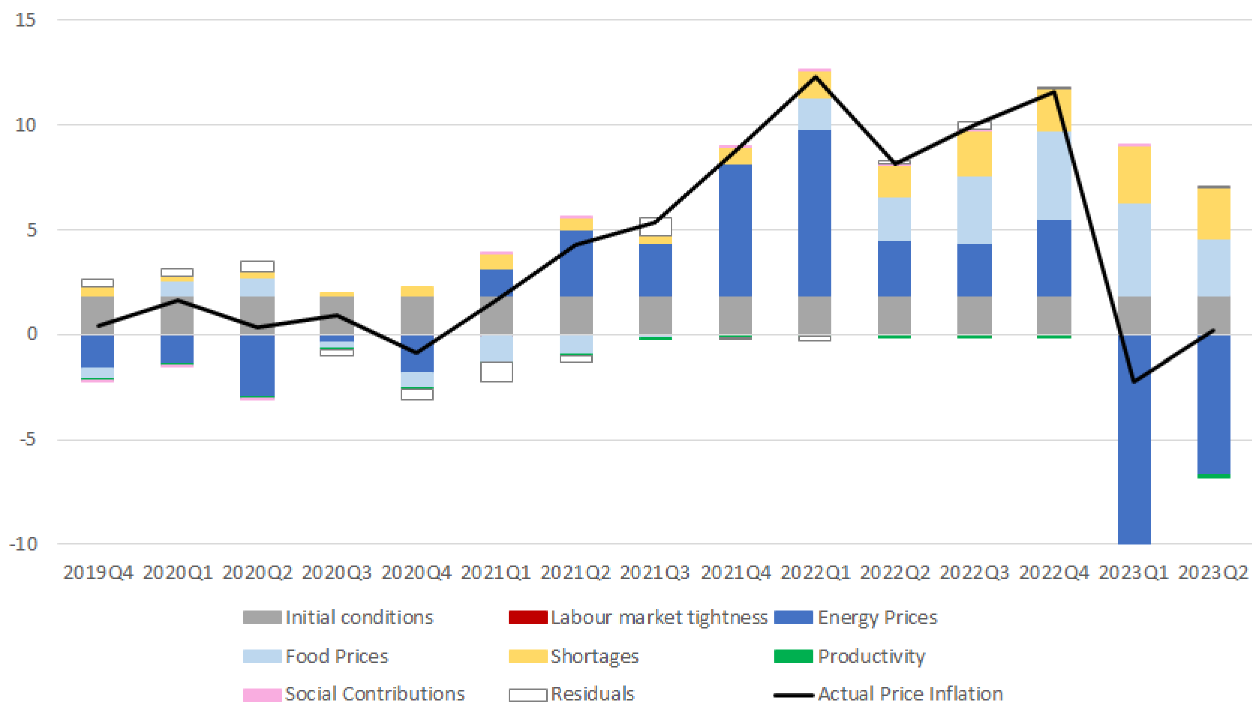
[24] As mentioned previously, we let the relative energy and food inflation rates to adjust endogenously to wage growth, and make (non-relative) energy and food inflation rates evolve exogenously. This explains small differences in the historical decomposition of price inflation reported here and the one for Belgium reported in Bernanke and Blanchard (2024) who make the assumption of exogenous relative prices.

The role for labour market tightness in Belgian headline inflation fluctuations is negligible. This emanates despite a non-negligible effect of labour market conditions on wage growth since end 2022, as indicated in Figure 3. The significant coefficient obtained on (the third lag of) the labour market variable combined with an increase in its post-covid value to achieve a historical peak in 2022Q3 explains this contribution. This finding is complicated to reconcile with the absence of significant negotiation margin (on the top of automatic indexation) in the post-covid era.[25] The presence of the wage drift - component of hourly wage cost that comes on top of the negotiated wages - which can be sensitive to labour market tightness could explain the contributions in this period. However, it seems to be only a part of the explanation as labour market tightness is also found to be relevant in the decomposition of collectively agreed wage growth, as shown in Appendix E.

The price-given-wage drivers of price inflation are also significant contributors of the Belgian wage growth in the post-covid era. Their contributions are also larger than what is obtained for replication of the model for other countries (see for instance Bernanke and Blanchard, 2023; Arce et al., 2024, for the US and euro area, respectively). The reason is the relatively larger coefficients obtained on the catch-up term and short-run inflation expectations in the Belgian version of the model, which trigger an important channel for realised inflation to affect wage growth. In the post-pandemic period, this channel is consistent with Belgian automatic wage indexation that transmitted a large part of changes in energy, food and shortage factors to wages. This channel also helps the model to fit the post-covid wage growth in Belgium relatively well compared to the pre-covid sample period, with the exception of 2022Q4 and 2023Q1. An explanation could be the difficulty for the model to account for the different indexation schemes and timing across sectors. The dummy variable used for the first quarter of each year helps - though imperfectly - to account for the fact that many private sector workers are indexed in January.

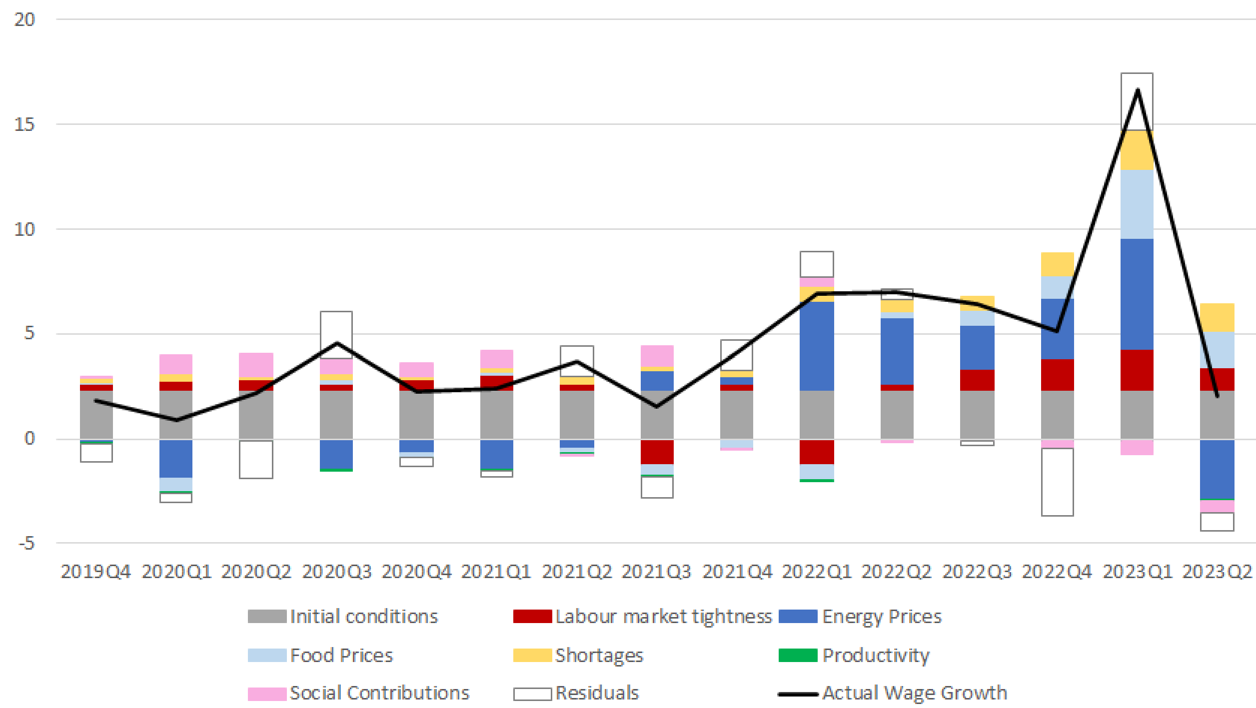
[25] In principle, an alternative specification of the wage equation extended to an interaction variable between labour market tightness and a proxy for this wage negotiation margin could help to discipline the model in case of an absence of significant margin. This interaction variable was however not found statistically nor economically significant in the estimation, so that we did not report this alternative here.

Figure 2: Historical shock decomposition of headline inflation (QoQ inflation rates, annualised).



The figure reports a shock decomposition of Belgian headline inflation, measured by annualised quarter-on-quarter growth rates of the National Index for Consumer Prices, from 2019Q4 to 2023Q2. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

Figure 3: Historical shock decomposition of wage growth (QoQ growth rates, annualised).



The figure reports a shock decomposition of wage inflation, measured by annualised quarter-on-quarter growth rates, from 2019Q4 to 2023Q2. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

9 Model-based projections

The estimated model can be used to provide some insight into the future evolution of Belgian wage growth and headline inflation. Two projection exercises are presented. The first one focuses on the sensitivity of future inflation to labour market tightness. The second exercise sets the model in the context of conditional forecasts close to the Eurosystem Broad Macroeconomic Projection Exercise (hereafter BMPE).

9.1 Alternative paths for labour market tightness

The first conditional projection exercise is along the lines of the model-based projections reported in Bernanke and Blanchard (2023) and Bernanke and Blanchard (2024). The sketch of this exercise is centered around different scenarios for the state of the labour market. The idea of this projection exercise is to evaluate the remaining effect of tight labour market once the price-given-wage inflationary effects have faded away. In a first scenario ("tight lab. mkt"), Belgian labour market remains tight, and the future path of our exogenous variable is imposed close to the maximum pre-covid sample value (that is, $x = 3$). In a mid scenario ("neutral lab. mkt"), the labour market tightness variable returns progressively to its pre-covid sample average ($x = -0.1$), that we interpret as a steady-state or neutral value. Finally the variable is set to its historical minimum ($x = -2$) a third scenario ("lab. mkt slack"). This third scenario could correspond to the outcome of a very restrictive macro policy that significantly brings labour demand downwards and unemployment upwards.

The projection framework also includes a conditional path for other exogenous variables. Productivity, shortage and social contributions are set equal to their (pre-covid) historical mean. Concerning energy and food relative price inflation, we deviate from Bernanke and Blanchard (2023) who assume that the growth rates of the price of energy and food relative to wage are both equal to zero for the projection period. As wage growth is endogenous in the four-equation system, this assumption is equivalent to consider energy and food inflation to evolve in parallel with wage inflation, which is questionable for a small open economy like Belgium. We instead impose the inflation rate of energy and food to their pre-covid sample average (that is 2.9% and 2.2% respectively, in annual terms) and let the growth rates of energy and food prices relative to wage to evolve endogenously, given the model-based projection for wage inflation.

Though we reproduce this simulation as it is part of the common cross-country exercise summarised in Bernanke and Blanchard (2024), an important caveat applies to the Belgian replication. As mentioned earlier, the absence of negotiation margin in the period 2023-2024 strictly limits the role of labour market tightness on the short-term future evolution of wage growth and hence price inflation in Belgium. This institutional factor is not reflected in the model projections presented here.

That being, said, and as reported by Figure 4, there is little difference in the model-based projection for headline inflation under the three scenarios for labour market tightness (see solid, dashed and dotted lines on the plots on the bottom subplot).[26] This outcome is obtained even though the different scenarios produce a marked dichotomy in the projected path for wage inflation (subplot on the top). The reason for this result is a combination of two factors. First, the price inflation equation is expressed in terms of the growth rates of energy and food prices relative to wages. When wage inflation is strong (or weak), it endogenously applies an opposite force to the relative inflation rates of energy and food. This creates a compensation at the level of the consumption price inflation equation. The second factor is the sum of estimated coefficients of wage growth in this equation. Would this sum be relatively larger relative to energy and food components (as for instance in US and EA studies), a significant dichotomy would also take place for the projection of headline inflation. For Belgium, however, the sum of these parameters is relatively small which makes the compensation effect dominant.[27]

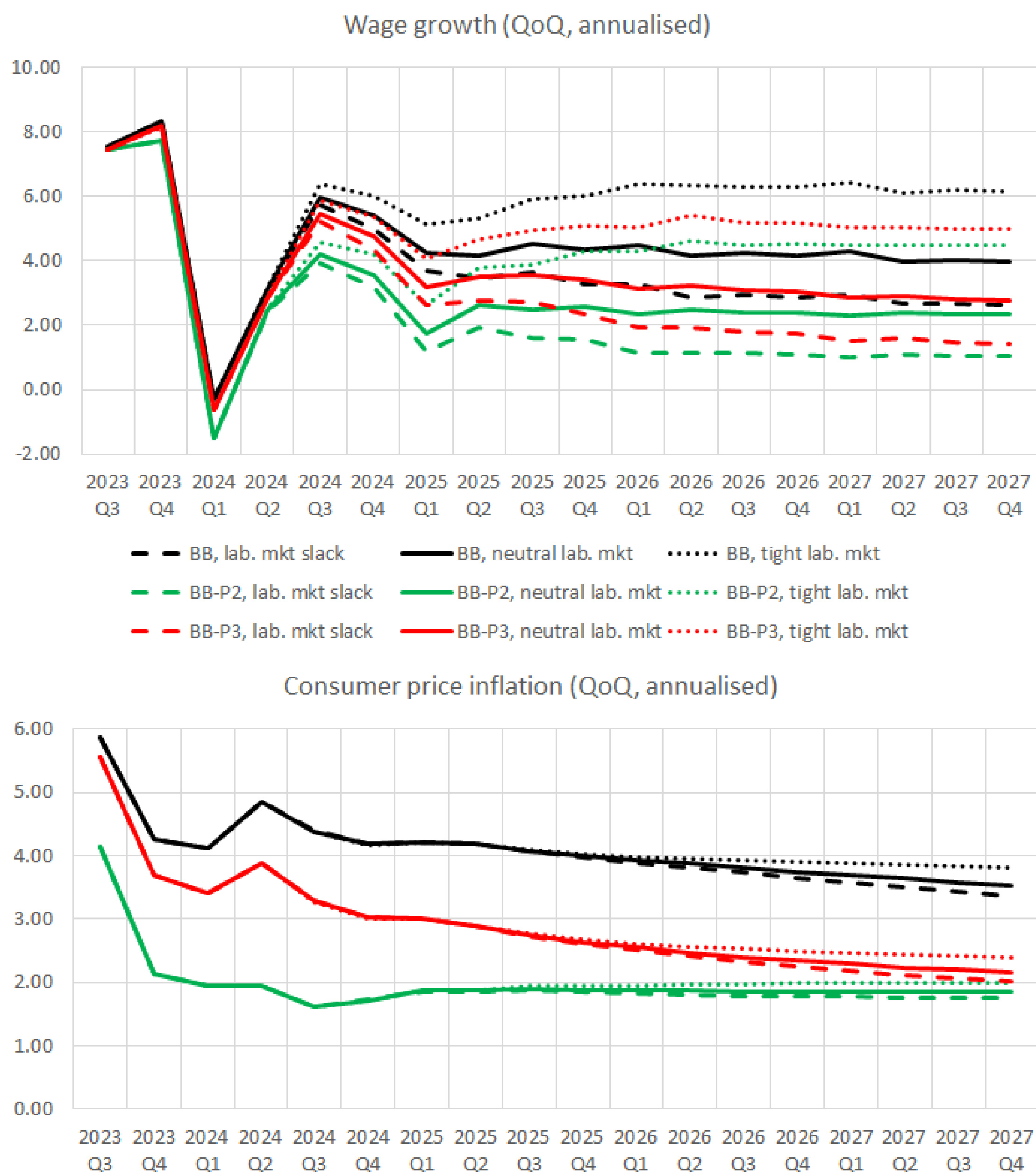
Figure 4 also shows a very long-lasting price inflation under the BB configuration of the model. The significant persistence (0.91) estimated when the homogeneity restriction applies to wages only drives this result. As discussed in Section 6, this persistence is estimated to be significantly lower in alternatives where the homogeneity constraint also includes productivity (0.75, BB-P3) or when it is relaxed (0.25, BB-P2). In these alternative specifications, headline inflation converges relatively faster. Note that even though the coefficients of wage growth are estimated to be larger in these two alternatives, so are the coefficients of relative energy and food inflation components. Consequently a similar compensation effect arises compared to the BB specification, and the dichotomy across labour market tightness sce-

[26] Projections for year-on-year figures deliver the same message and are reported in Figure 19 in Appendix C.

[27] Note that an estimation of the price inflation equation with energy and food inflation not taken relative to wage growth does not seem to help for Belgian data. The estimated sum of coefficients of wage growth is almost halved in such a case. As a result, the difference for projected headline inflation is again small across the considered scenarios.

nario is again small when it comes to headline inflation.

Figure 4: Model-based projections based on different paths for labour market tightness.



9.2 Conditional projections using Eurosystem's technical assumptions

The conditional projection exercise presented in this section makes use of conditional paths for our exogenous variables consistent with the Belgian framework of the BMPE of December 2023. That is, we impose the inflation rates of the energy and food components of the Belgian consumption price to be aligned with the recent data (2023Q3) as well as the BMPE projected path (for 2023Q4-2026Q4). The BMPE exercise stops in 2026Q4. After this date, we assume that these variables follow their pre-covid historical average. The path of the shortage variable consists in the 2023Q3 observed datapoints, and of a forecast made by a univariate AR(2) model estimated with pre-covid data. For the conditional evolution of employers' social contributions, we use the BMPE path for the implicit social contribution rate and map it into our variable. Productivity and labour market tightness are assumed to come back to their pre-covid historical mean. Figure 5 reports the conditional paths and model projections for Belgian wage growth and headline inflation based on these conditional paths.[28] For comparison purposes, the BMPE forecasts are also reported.

Similar to the projections of the previous subsection, there are significant differences in terms of persistence between configurations with alternative assumptions on the homogeneity in the price inflation equation (BB, BB-P2 and BB-P3). When estimated persistence in the inflation process is high, the model projects a sustained inflation around 3.5% at the end of 2027. In the configuration where the homogeneity restriction is relaxed, BB-P2, low estimated persistence drives projected inflation rates below 2% in 2025 and back around 2% in 2027. This configuration is the closest to the NBB projections of December 2023 for the (seasonally adjusted) Belgian consumption price index (NICP).

Figures 6 and 7 propose a shock decomposition of the conditional projections of price and wage inflation, respectively. This decomposition is obtained in a similar way than the one illustrated in Section 8, but by extending the sample data with the conditional projections for endogenous variables and the conditional paths for exogenous variables. The main factors behind the conditional projections of inflation are again price-given-wage shocks. Shortage continue to have inflationary contributions in the end of 2023, while its positive contribution to inflation disappears in 2024. Food and energy price rises in the beginning of 2024 temporarily generate large headline inflation figures. Energy shocks are also responsible

[28] Projections for year-on-year figures are reported in Figure 20 in Appendix C.

for the two important declines in the quarter-on-quarter growth rates of the consumer price index projected for 2025Q2-Q3 and 2026Q2-Q3.

Figure 5: Model-based projections based on December 2023 BMPE assumptions.

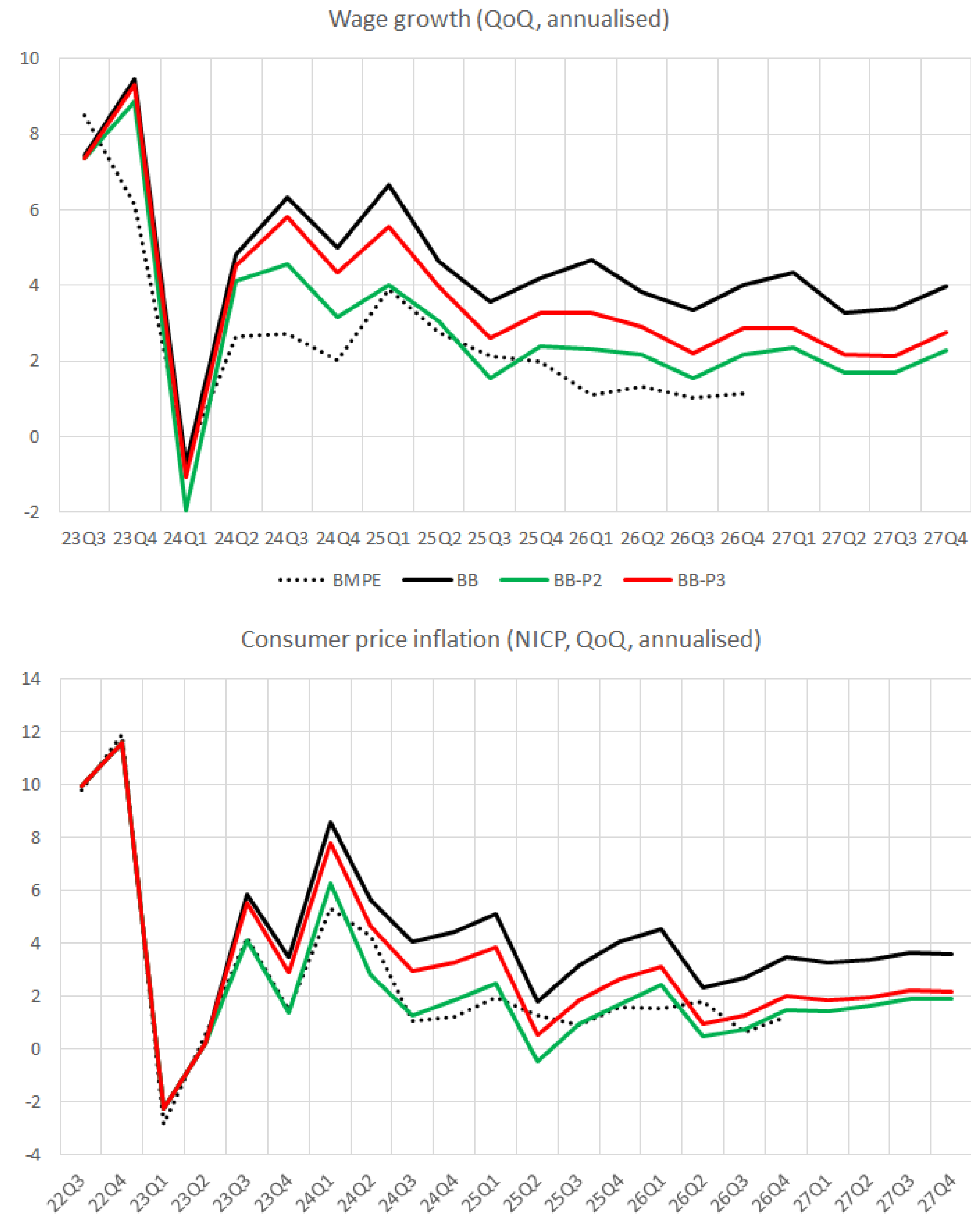
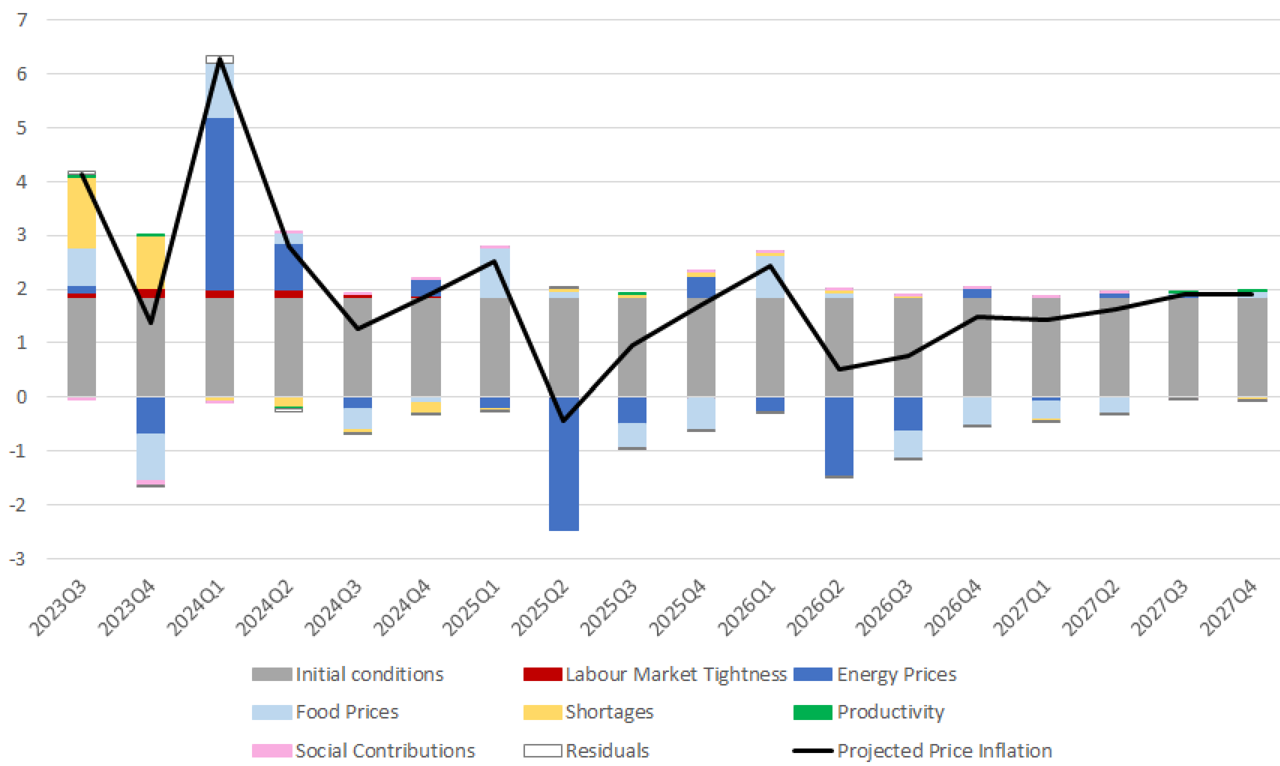
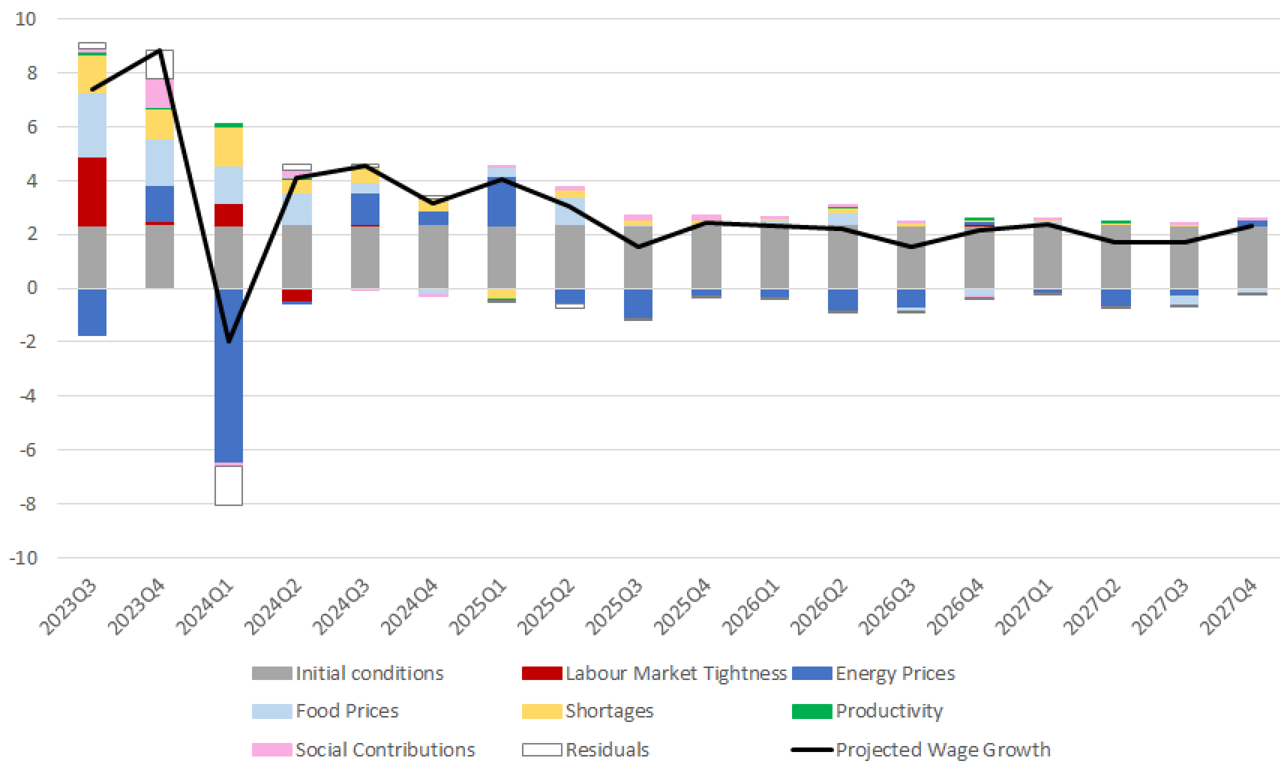


Figure 6: Shock decomposition of the conditional projection for headline inflation (QoQ inflation rates, annualised). Model projections of configuration BB-P2, based on December 2023 BMPE assumptions.



The figure reports a shock decomposition of projected Belgian headline inflation, measured by annualised quarter-on-quarter growth rates of the National Index for Consumer Prices, from 2023Q3 to 2027Q4. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

Figure 7: Shock decomposition of the projections of wage growth (QoQ growth rates, annualised). Model projections of configuration BB-P2, based on December 2023 BMPE assumptions.



The figure reports a shock decomposition of projected wage inflation, measured by annualised quarter-on-quarter growth rates, from 2023Q3 to 2027Q4. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

10 Discussion on the wage-price pass-through

The results shown so far of the Belgian replication of the Bernanke-Blanchard model indicate little role for wage factors for explaining post-pandemic price inflation. This finding also holds for the pre-pandemic period.[29] Despite a large (sum of) coefficients in the wage growth equation on short-term inflation expectations and catch-up (reflecting in part the automatic wage indexation), the pass-through to price inflation seems limited. The sum of estimated parameters associated with wage growth in the Belgian price inflation equation is relatively small compared to what is estimated in the replication of the model for other countries (Bernanke and Blanchard, 2024). In Appendix D, we obtain similar outcomes using an extension of the model to a core inflation equation, which helps to investigate the potentially more intimate relationship between wage growth and the core component of NICP inflation.

To some extent, this weak estimated pass-through finds echo in recent empirical studies on Belgian firms.[30] Bijnens et al. (2023) report evidence of adjustment in the markups of Belgian firms that offset rising wages in 2022. Bijnens and Duprez (2022) underline that Belgian sectors with a high "wage intensity" (that is, where the wage share is the largest, mainly services) are also found to display a lower level of cost pass-through, and are thus less able to reflect the increase in wage cost on their prices. The negative correlation between profit margins and wage costs in Belgium is also found in the pre-covid data (Baugnet and De Keyser, 2015; De Keyser et al., 2023). One possible reason behind this phenomenon is the important role of strategic complementarities for Belgian firms both on domestic and foreign markets. Amiti et al. (2019) show that Belgian firms are tending to act as price-takers and change prices in reaction to its competitors' price changes and to a lesser extent in reaction to variation in their own costs. This price setting behaviour - and the resulting

[29] When wages are treated as an exogenous variable, a shock decomposition of headline inflation - not reported here - indicates a very small contribution of wages to inflation for the full sample period in the model specifications presented above. As shown in the historical decomposition of the full sample reported in Figure 14 in the appendix, the labour market tightness in particular plays almost no role at the level of consumer price inflation.

[30] Note that our conclusion of limited wage-price pass through seems in contrast with Gagliardone et al. (2023) who find a steep marginal cost-based Phillips curve using Belgian micro data. The comparison with their study is however not easy for several reasons. First they underline the total marginal cost pass-through, while what is discussed in our paper is the wage-price pass-through. For Belgian firms, intermediate inputs (and foreign inputs in particular) is quite important and thus reduce the share of wages in total marginal costs. Second, we look at total consumer prices, at the end of the production chain. In Gagliardone et al. (2023), domestic production prices at different positions in the pricing chains are used (the bulk of their prices is business-to-business), which may imply a faster pass-through. We expect more rigid prices in end prices. Third they mainly focus on manufacturing (though their database also indirectly covers the costs and prices of some services).

markups adjustments - might be strong in a small open economy as Belgium as local firms face important competition from foreign firms that sell (or may potentially sell) in the Belgian market. Moreover, Belgian firms have a large share of foreign inputs in production, which thus reduces the share of Belgian wage in firms' total cost.

In this section, we test the robustness of the weak wage-price pass-through by extending the model with non-linear terms in the price inflation equation: a binary variable that takes the value of 1 in periods of high inflation is interacted with wage growth, and the square of wage growth is included to account for periods with high wage inflation. This way to treat non-linearities is admittedly basic but can help to have a first glance at their importance. More sophisticated techniques (e.g. regime-switching regressions involving all the terms and not only wage growth) are worth investigating in future research. This extension is also used to shed more light on the potential role of wage indexation in the explanation of the post-pandemic inflation and the persistence of inflation in projections.

An extension to a non-linear wage-price pass-through

Table 4 reports the estimates of the price inflation equation with and without two types of non-linear terms. The first column is the Bernanke-Blanchard equation without non-linear terms and without the homogeneity constraint (Price 2),[31] as already reported above. In the second column, a first form of non-linearity is added to the equation (Price $2^{\star}$). A binary variable is constructed to account for high inflation regimes. It takes the value 1 when the previous period quarter-on-quarter price inflation in annual terms exceeds 3% (that is the 75th percentile of the pre-covid sample). This includes the post-pandemic episodes, but also covers several episodes before 2019Q4 (21 datapoints). This dummy variable is interacted with wage growth and its four lags. The associated sum of coefficients is reported in the third row of the table. It appears to add some extra role for wage inflation with a sum of coefficients estimated to be about one third of the one on wage inflation alone. The joint test of the estimated parameters is however not statistically significant. The coefficients of other variables appear robust to this extension, and the fit of the model is similar.

In the third column (Price $2^{\star\star}$), we add the square of wage growth to the equation to assess the influence of high wage inflation episodes. The joint tests of both the interaction

[31] We choose to conduct the robustness analysis on the Price 2 specification for two reasons. First, it is not obvious how to set up the homogeneity constraint once non-linear terms are added to the equation. Second this specification has been shown to deliver a projection close to the one of the December 2023 BMPE.

dummy term and wage growth squared display statistical significance. The sum of coefficients of wage inflation (not interacted) is reduced by about 30%, from 0.34 to 0.24. The coefficients on energy and food components are somewhat inflated, as reflected by the larger sum of parameters under this configuration. The fit of the model is marginally improved.

Table 4: Estimation of the price inflation equation (NICP, QoQ annualised) without and with non-linear terms.

	Price 2	Price 2⋆	Price 2⋆⋆
price inflation	0.25*	0.14	-0.1**
wage inflation	0.34***	0.35***	0.24***
wage infl x high price infl.		0.11	0.12**
wage infl. squared			0.04***
energy component	0.08***	0.08***	0.11***
food components	0.21***	0.23***	0.26***
shortage	0.22***	0.22***	0.23***
productivity	-0.06	-0.08	-0.03
constant	0.75***	0.88***	1.05***
homog. constraint?	no (0.00)	no	no
number of obs.	105.00	105	105
R^2 pre-covid	0.94	0.94	0.96
R^2 full sample	0.97	0.97	0.98

Note: Statistical significance of the joint test is indicated by asterisks: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01.

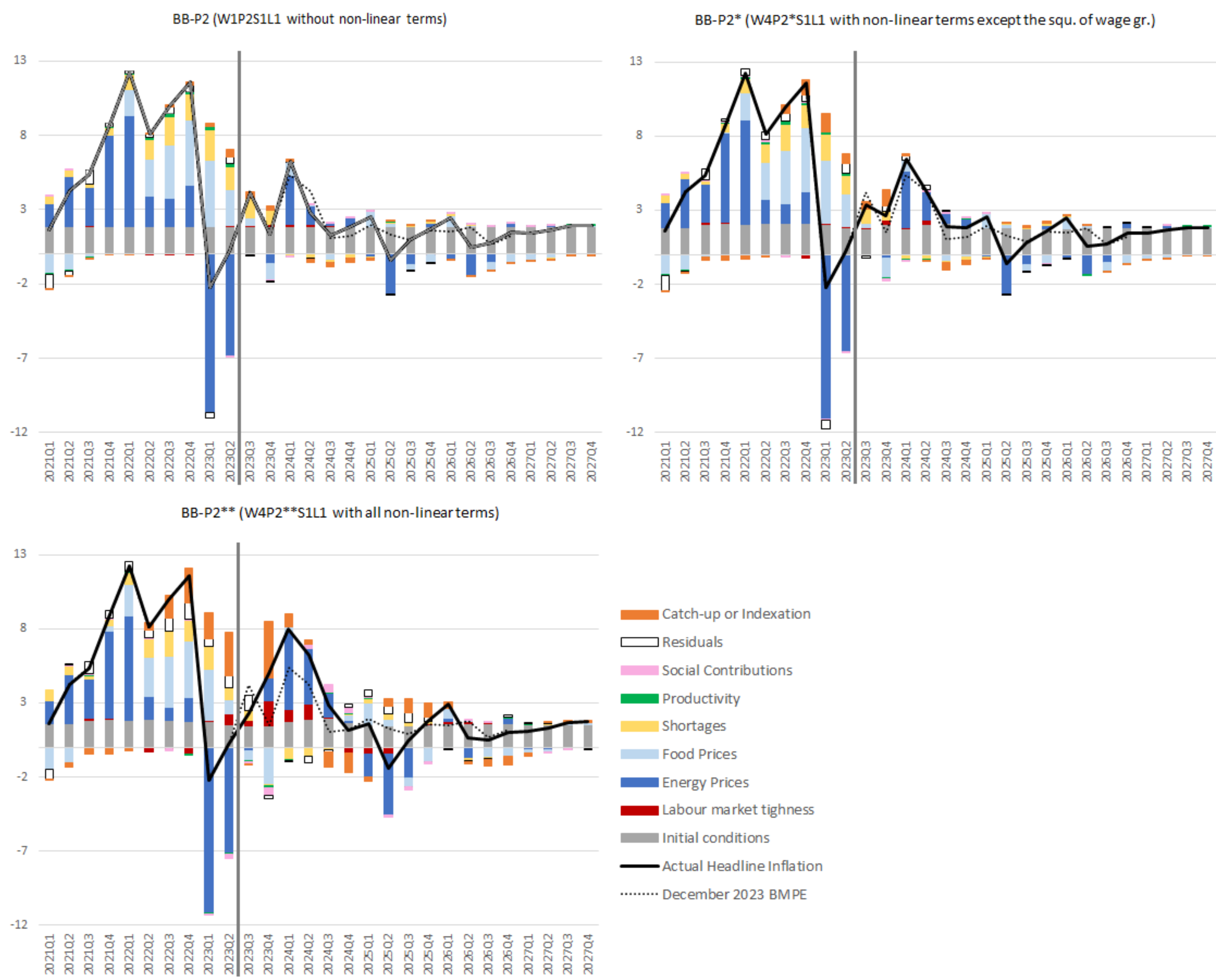
A shock decomposition for the period 2021Q1-2023Q2 (data) and for 2023Q2-2027Q4 (model projections) can be seen in Figure 8. The upper left panel is the model without non-linear terms nor the homogeneity constraint (BB-P2). The upper right and bottom charts show the results obtained when non-linear terms are included in the model without or with the square of wage growth (BB-P2* and BB-P2**, respectively). In these last two configuration, the version of the wage equation with realised QoQ inflation (W4) is used to better highlight the contribution of indexation terms to headline inflation.[32] These contributions are computed by treating the catch-up term or the realised price inflation in the wage equation as exogenous. For comparison purpose, the December 2023 BMPE forecast is reported in dotted lines.

Even in the specifications with non-linear terms, the major contributors of post-pandemic inflation continue to be energy, food and shortage factors. In the BB-P2 model, the contribution of the catch-up factor is negligible, even in the 2022Q2-2023Q2 episodes of high wage indexation. For instance, the peak contribution does not exceed 0.5% in 23Q2 while wage growth is 17% (with about 8% coming from the catch-up contribution to wage inflation). In the alternative BB-P2*, with the wage growth interacting with the dummy for a high inflation regime, the contribution of indexation becomes significant from the end of 2022Q2 and adds some extra inflationary pressure in the projection period. The largest positive contributions amounts to 1.23 and 1.74 percentage points in respectively 2023Q1 and 2023Q4. They are somewhat compensated by negative contributions from energy and food components, dampening the wage-price spiral.

The contribution of wage factors (indexation and labour market tightness) are more extreme in the configuration of the model with all non-linear terms - the wage growth squared included - as in BB-P2**. In this case, indexation leads to a significantly more persistent inflation in 2024. The larger effect of energy also fuels inflation more in this period compared to alternatives. The peak contribution of indexation observed in 2023Q4 comes from lags in the indexation mechanism (as reflected by the largest coefficient obtained for the third lag of realised inflation in the wage growth equation, see Table 5). As energy and food factors apply considerable dis-inflationary pressures in the year 2023, they drive the contribution of indexation in the opposite direction in the second part of 2024 and also limit the duration of the wage-price spiral in this more extreme alternative specification of the model.

[32] Note that, as previously mentioned, the decomposition and projection of the model with W4 and no non-linear terms - W4P2S1L1 - delivers very close results to the BB-P2 specification.

Figure 8: Shock decomposition of headline inflation (QoQ inflation rates, annualised) for 21Q1-27Q4. Model extended with non-linear terms.



The figure reports a shock decomposition of headline inflation, measured by annualised quarter-on-quarter inflation rates, from 2021Q1 to 2023Q2 (data, left of the vertical grey line) and from 2023Q3 to 2027Q4 (model projections, right of the vertical line). Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions, catch-up / indexation and productivity are measured as deviations of their values from the pre-covid sample mean.

11 Conclusion

This paper reports the outcomes of a replication of the Bernanke and Blanchard (2023) model applied to Belgian data. It is part of a joint project on the sources of inflation in the post-pandemic era, which involves Ben Bernanke and Olivier Blanchard and ten central banks. The main drivers of Belgian inflation in this period are found to be price-given-wage shocks: energy, food and product shortage. This is a common result emerging from the implementation of the model across different countries (Bernanke and Blanchard, 2024). Though the model predicts some role for labour market tightness in explaining Belgian wage growth fluctuations, it has a negligible role at the level of price inflation in both the historical decomposition and in projections.

Despite the presence of several endogenous channels, the model outcomes suggest that the persistence of inflation was mostly due to a sequence of temporary shocks in the 2021Q1-2023Q2 period. Long-term inflation expectations remained well-anchored in Belgium. There is some sensitivity of short-term inflation expectations, relevant for wage formation in the model, to realised inflation. A strong catch-up effect that reflects automatic wage indexation, is estimated in Belgian data. However, these two potential sources of inflation duration are significantly attenuated by a weak estimated wage-price pass-through. A third channel of persistence that arises from second-round effects and is reflected by the estimated coefficients on the lags of the inflation variable does not seem to find support in the data. As a result, model-based projections indicate a rather swift return of Belgian consumption price inflation below 2% in the future.

The Bernanke and Blanchard (2023) model is an interesting and well-suited tool to explain post-pandemic inflation developments and to assess the relative role of its main drivers. It consistently integrates a link between wage growth, inflation expectations and consumption price inflation. It may however be less conclusive on the origins of the variables taken as given and the role played by fiscal and monetary policy in their developments. For instance, what is the relative role of global supply chain disruption and demand factors in the fluctuations of the shortage variable? How would shortage and labour market tightness have evolved if monetary policy had been tighter? These questions require a more general equilibrium structure to be properly addressed. Besides, a more rigorous inclusion of relevant non-linearities, with a special focus on the wage-price pass-through, might be a path worth to be explored more deeply in future work.

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A Tables

Table 5: Detailed regression results - Wage inflation equations.

	Wage 1	Wage 2	Wage 3	Wage 4
wage inflation				
$t-1$	-0.40***	-0.41***	-0.44***	-0.45***
$t-2$	0.00	0.00	-0.03	-0.03
$t-3$	0.01	0.00	-0.03	-0.02
$t-4$	-0.03	-0.03	-0.03	-0.01
short-run infl. exp.				
$t-1$	0.87	1.05	2.04**	0.93
$t-2$	-1.70	-1.96	-3.07**	-2.93**
$t-3$	-0.15	0.26	0.87	0.30
$t-4$	2.40**	2.09	1.70	1.95**
lab. market tightn.				
$t-1$	-0.05	-0.04	-0.01	-0.02
$t-2$	0.11	0.05	-0.06	-0.05
$t-3$	0.05	0.06	0.09	0.01
$t-4$	0.83**	0.85**	0.87**	0.86**
catch-up				
$t-1$	0.86	0.25		
$t-2$	0.07	0.05		
$t-3$	0.01	-0.01		
$t-4$	-0.20	-0.33		
productivity				
$t-1$	0.01	0.07	0.19	0.15
social contrib.				
t	1.11**	0.98**	1.09**	1.18**
dQ1 x catch-up ($t-1$)	0.44	0.48		
price inflation (yoy)				
$t-1$		0.67		
$t-2$				
$t-3$				
$t-4$				
dQ1 x price infl. ($t-1$) (yoy)		-0.03		
price inflation (qoq)				
$t-1$			0.16	0.24
$t-2$			0.16	0.33
$t-3$			0.42**	0.60**
$t-4$			0.06	0.28
dQ1 x price infl. ($t-1$) (qoq)			0.18	0.19
constant	0.76**	-0.43	-0.83	0.19

Note: Statistical significance of the joint test is indicated by asterisks: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01.

Table 6: Detailed regression results - Price inflation equations.

	Price 1	Price 2	Price 3		Price 1	Price 2	Price 3
price inflation				food			
$t-1$	0.48***	0.25**	0.48***	t	0.24***	0.24***	0.24***
$t-2$	0.17	0.07	0.17	$t-1$	-0.11***	-0.04	-0.11***
$t-3$	0.18	0.07	0.18	$t-2$	0.02	0.03	0.02
$t-4$	0.08	-0.15	0.08	$t-3$	-0.03	0.00	-0.03
wage inflation				$t-4$	-0.07**	-0.02	-0.07**
t	0.33***	0.33***	0.33***	shortage			
$t-1$	-0.14**	-0.04	-0.14**	t	-0.02	-0.01	-0.02
$t-2$	0.02	0.05	0.02	$t-1$	0.07	0.05	0.07
$t-3$	-0.03	0.02	-0.03	$t-2$	-0.19	-0.18	-0.19
$t-4$	-0.08	-0.01	-0.08	$t-3$	0.38***	0.33**	0.38***
energy				$t-4$	-0.13	0.03	-0.13
t	0.11***	0.11***	0.11***	productivity	0.02	-0.06	0.02
$t-1$	-0.05***	-0.03**	-0.05***	constant	-0.02	0.75***	-0.02
$t-2$	-0.02	-0.01	-0.02				
$t-3$	-0.01	0.00	-0.01				
$t-4$	-0.02	0.01	-0.02				

Note: Statistical significance of the joint test is indicated by asterisks: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01.

Table 7: Detailed regression results - Inflation expectation equations.

	SR 1	SR 2	LR 1	LR 2
short-run infl. exp.				
$t-1$	0.86***	0.42***		
$t-2$	-0.42***	-0.01		
$t-3$	0.19	0.03		
$t-4$	0.03	0.22**		
long-run infl. exp.				
t	0.36	-0.11		
$t-1$	-0.29	0.92	0.69***	0.55***
$t-2$	-0.32	-0.39	0.37***	0.31***
$t-3$	0.01	1.12	-0.12	-0.11
$t-4$	0.37	-1.31**	0.05	0.06
price inflation				
t	0.12***	-0.01	0.00	0.00
$t-1$	0.06***	0.01	0.00	0.00
$t-2$	0.00	0.02	0.00	0.00
$t-3$	0.05**	0.12***	0.00	0.00
$t-4$	0.00	-0.01	0.01	0.01
target				0.17***

Note: Statistical significance of the joint test is indicated by asterisks: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01.

B Figures

Figure 9: Data plots - endogenous variables.

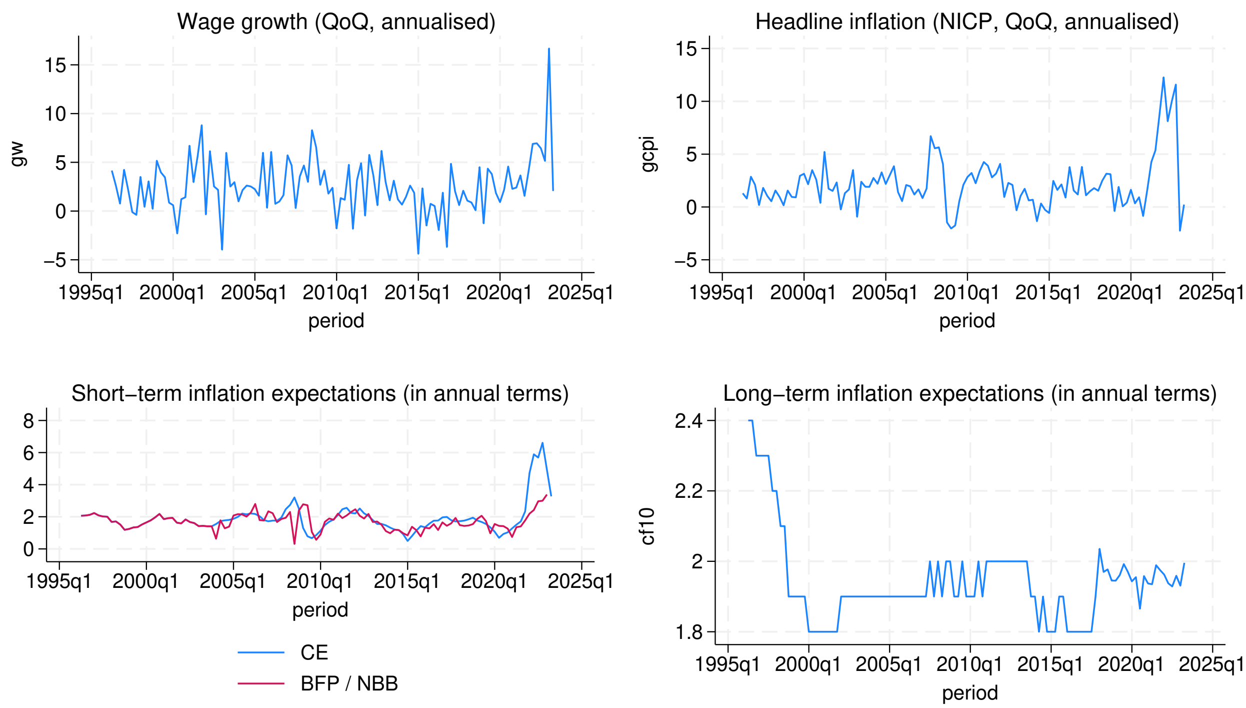


Figure 10: Data plots - main exogenous variables.

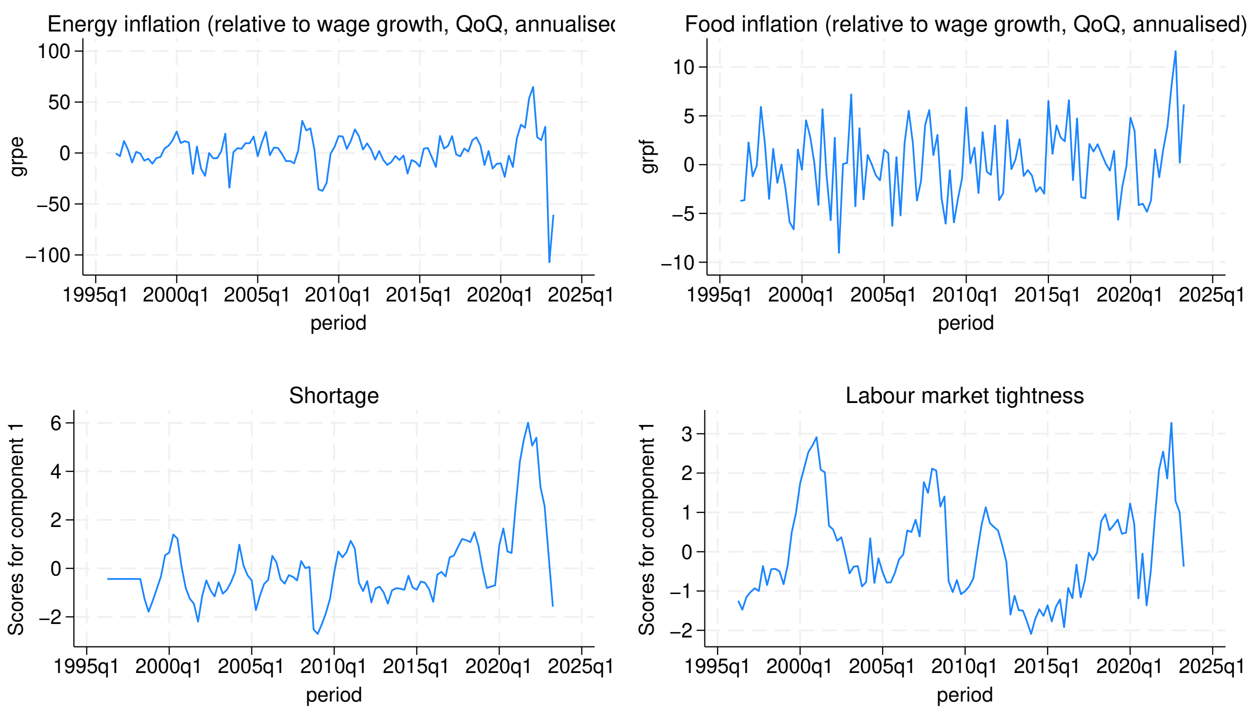


Figure 11: Model fit of the wage equation. Predicted values are one-period forecasts of the equation estimated on the full sample.

Figure 12: Model fit of the price inflation equation. Predicted values are one-period forecasts of the equation estimated on the full sample.

Figure 13: Model fit of the inflation expectation equations. Predicted values are one-period forecasts of the equation estimated on the full sample.

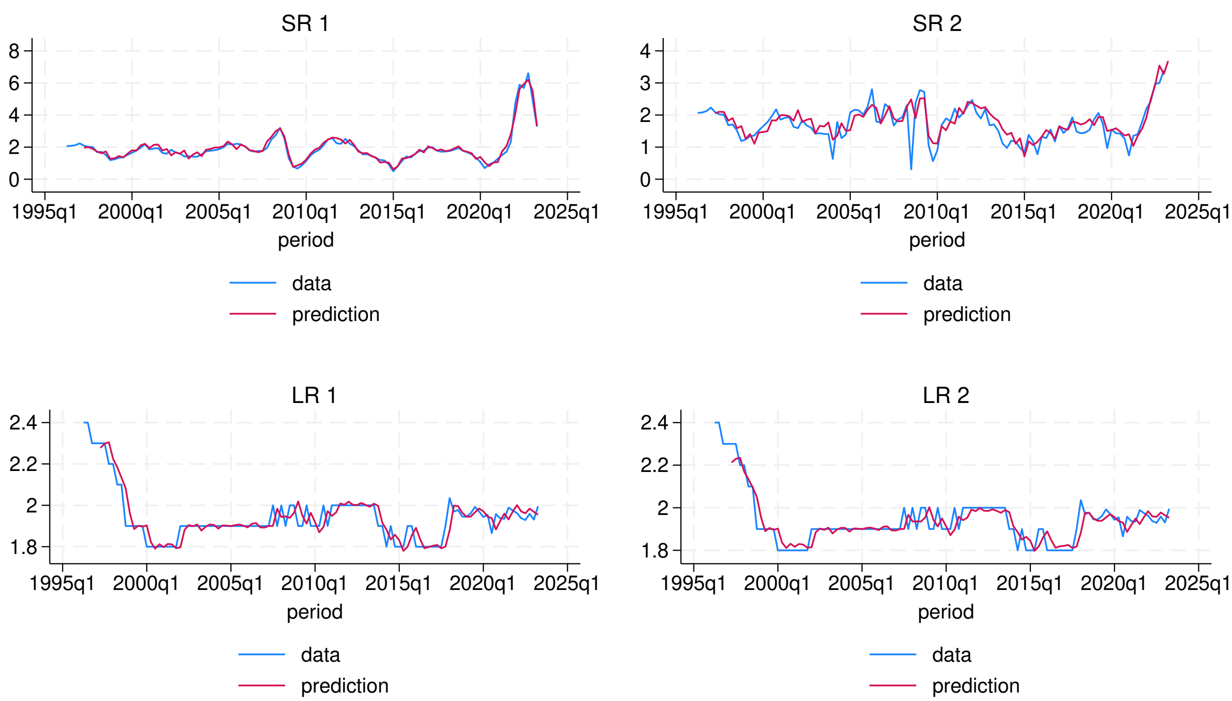
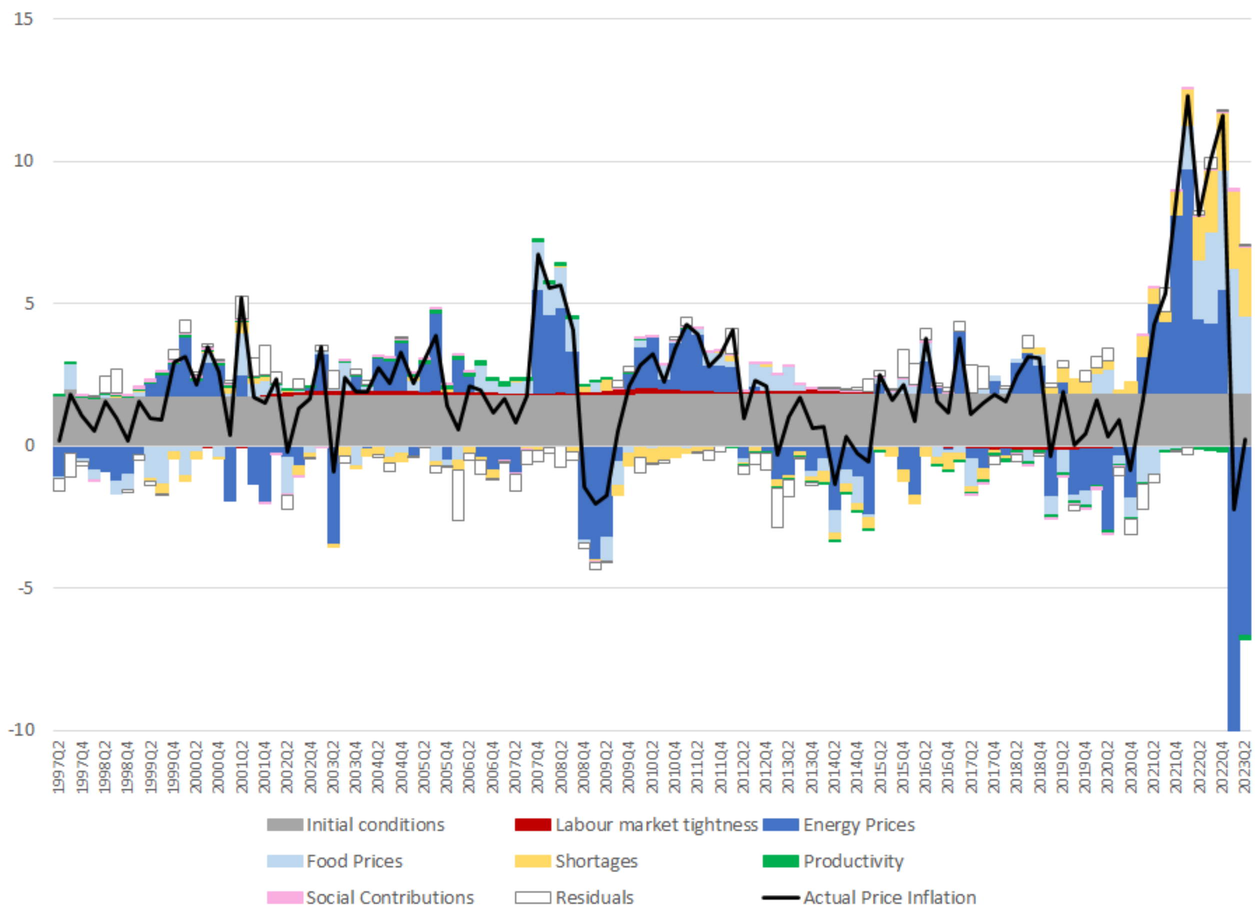
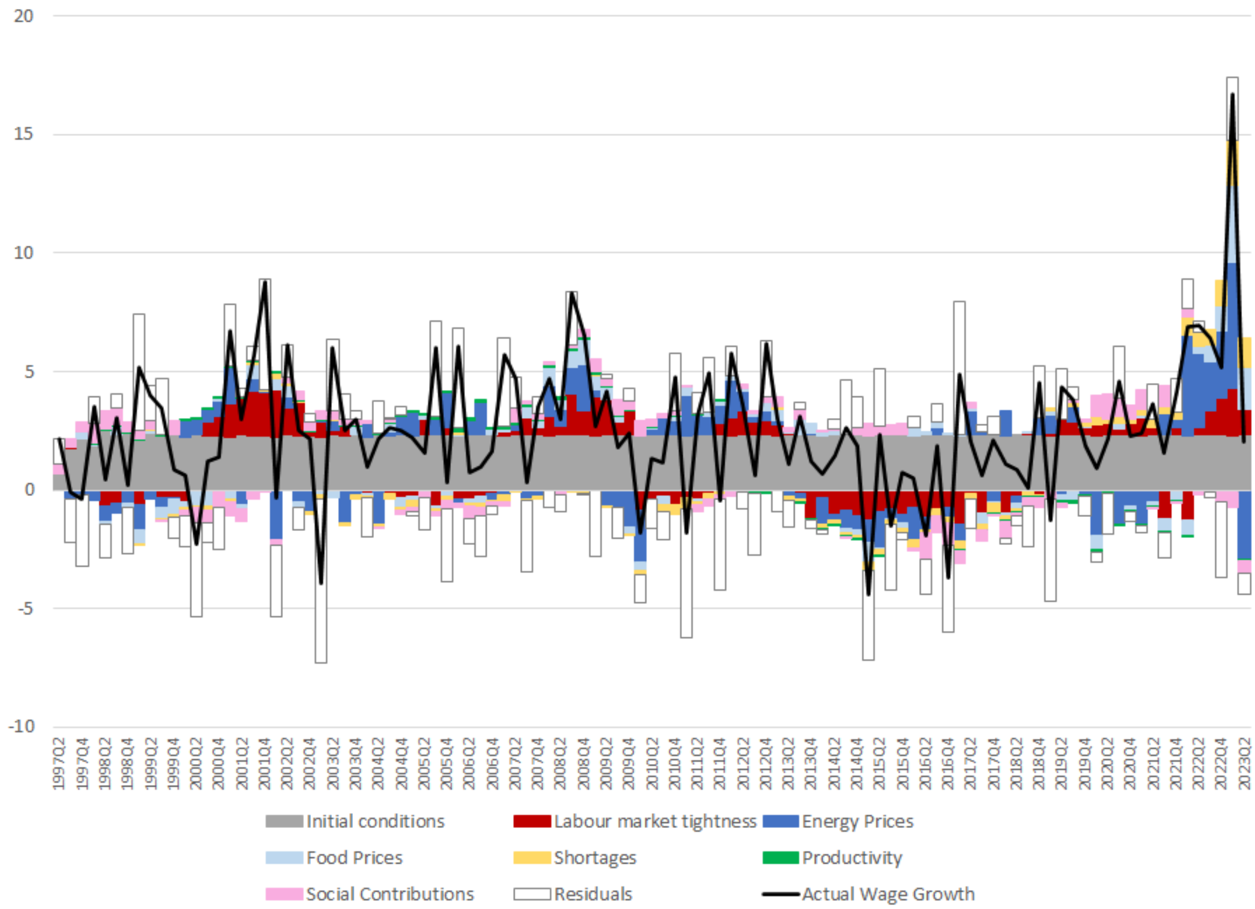


Figure 14: Historical shock decomposition of headline inflation (QoQ inflation rates, annualised). Full sample period.



The figure reports a shock decomposition of Belgian headline inflation, measured by annualised quarter-on-quarter growth rates of the National Index for Consumer Prices, from 1997Q2 to 2023Q2. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

Figure 15: Historical shock decomposition of wage growth (QoQ inflation rates, annualised). Full sample period.



The figure reports a shock decomposition of Belgian wage inflation, measured by annualised quarter-on-quarter growth rates, from 1997Q2 to 2023Q2. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

C Figures - year-on-year growth rates

Figure 16: Impulse responses of Belgian consumer price inflation (NICP, **year-on-year**).

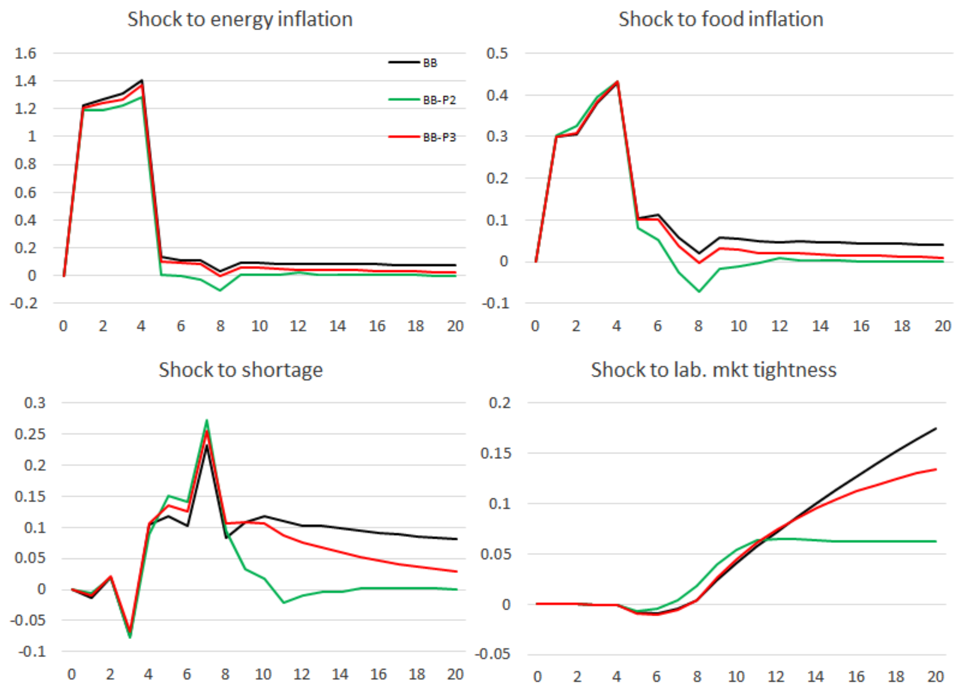
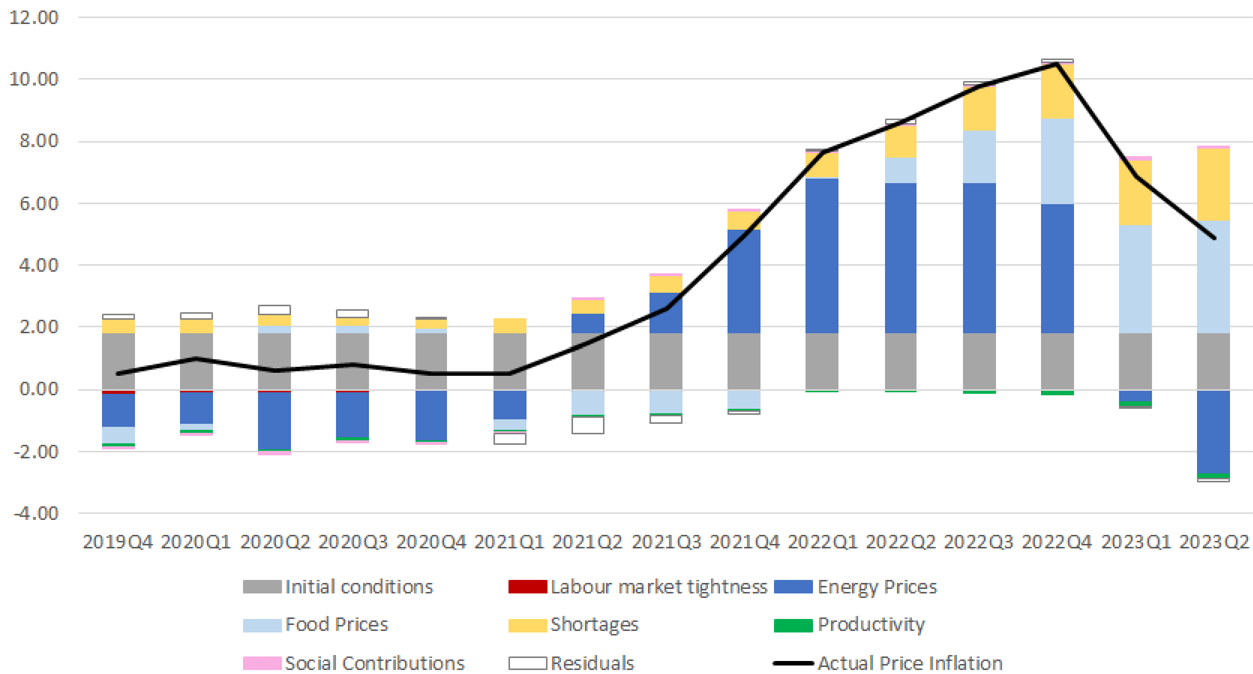
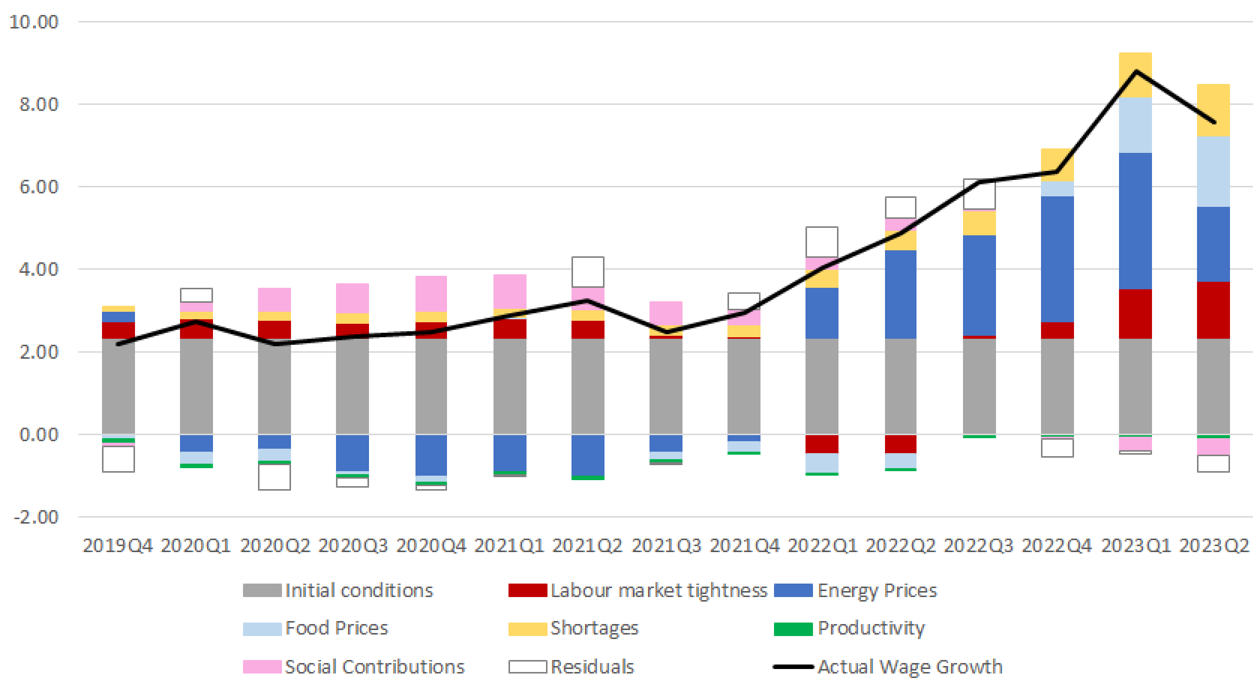


Figure 17: Historical shock decomposition of headline inflation (**YoY growth rates**).



The figure reports a shock decomposition of Belgian headline inflation, measured by year-on-year growth rates of the National Index for Consumer Prices, from 2019Q4 to 2023Q2. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

Figure 18: Historical shock decomposition of wage growth (**YoY growth rates**).



The figure reports a shock decomposition of wage inflation, measured by year-on-year growth rates, from 2019Q4 to 2023Q2. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

Figure 19: Model-based projections based on different paths for labour market tightness. Wage and price inflation are measured with **year-on-year growth rates**.

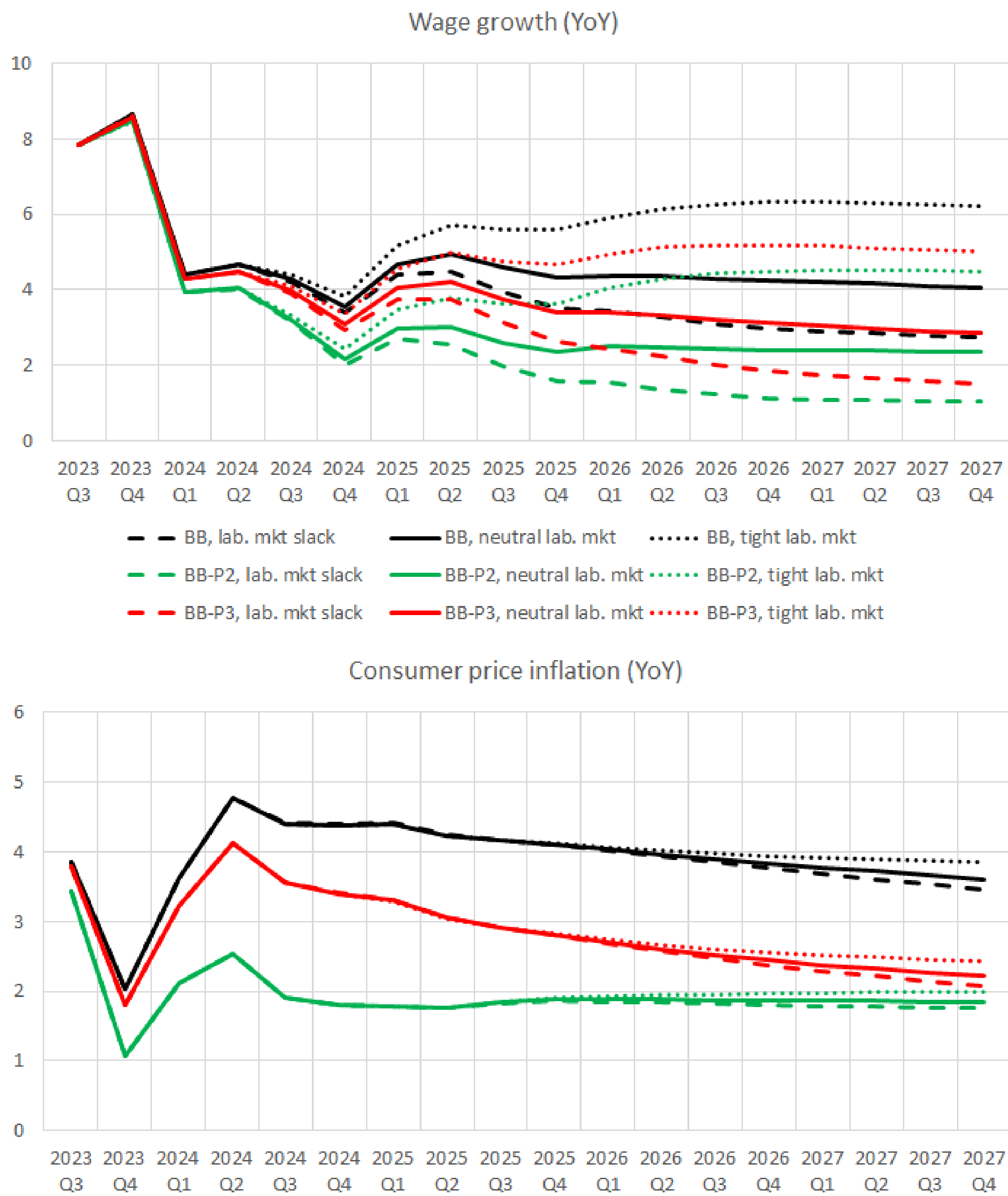
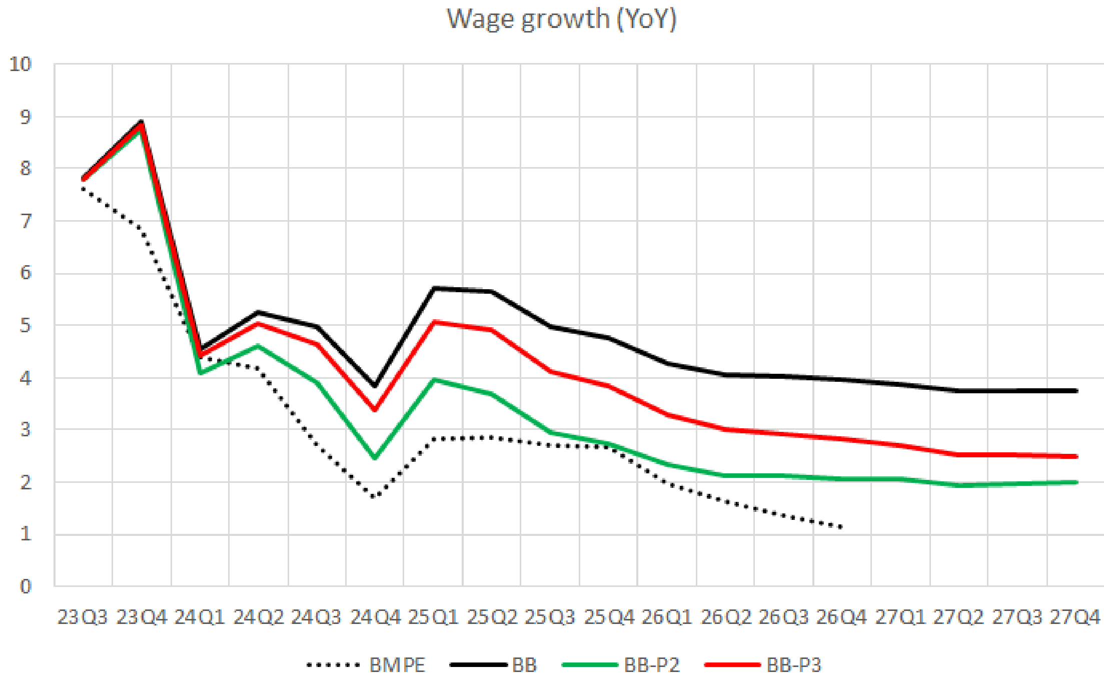
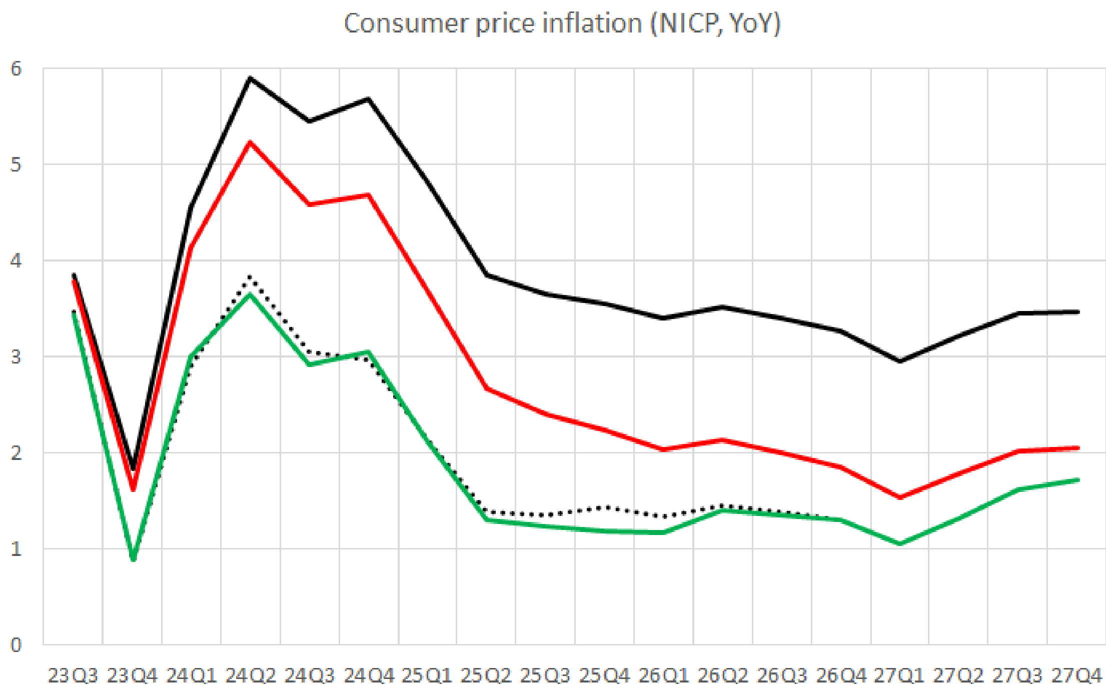


Figure 20: Model-based projections based on December 2023 BMPE assumptions. Year-on-year growth rates.





D An extension to core inflation

In this section, the potentially more intimate relationship between wage growth and the core component of NICP inflation, significantly less sensitive to volatile components such as energy and food inflation, is investigated. The Bernanke-Blanchard model is extended with an equation for the core inflation, Equation (11). Core inflation is regressed on wage growth, productivity and the shortage variable. The headline inflation equation is replaced by an accounting relationship - Equation (12) - between its core, energy and food components. The last two components are not taken relative to wage levels in this configuration of the model. An error term is added to the headline inflation equation to account for the effect of time-varying weights. The equations for wage growth and inflation expectations are not modified.

$$\pi_t^c = \theta^p + \sum_{i=1}^{4} \rho_i^c \pi_{t-i}^c + \sum_{i=0}^{4} \kappa_i^c \pi_{t-i}^w + \sum_{i=0}^{4} \tau_i^c s_{t-i} + \lambda^c \Lambda_t + \varepsilon_t^c \quad (11)$$

$$\pi_t = \vartheta^c \pi_t^c + \vartheta^e \pi_t^{enrg} + (1 - \vartheta^c - \vartheta^e)\, \pi_t^{food} + \varepsilon_t^p \quad (12)$$

As for the original Blanchard-Bernanke price inflation equation presented in the main text, we distinguish several alternatives which differ in terms of the homogeneity constraint and the addition or not of non-linear terms. The estimation results of these alternatives are presented in Table 8. In the specification Core 1, a homogeneity constraint is applied such that the sum of coefficients lagged core inflation and wage growth is equal to one, similar to the original setup. In Core 2, this constraint is relaxed, and a Wald test on the sum of the coefficients rejects the homogeneity assumption. In the third configuration Core 3, a homogeneity constraint is imposed but includes the productivity term in the constrained sum of coefficients. Finally, Core $2^{\star}$ stands for the regression without homogeneity constraint and with non-linear terms.[33]

The estimates for the coefficient on wage growth is robust across the alternatives without non-linear terms, with a sum around 0.10. When the homogeneity constraint is imposed, the core inflation process is highly persistent, similar to the finding obtained in the original

[33] Note that the inclusion of the square of wage growth leads to a negative sum of parameters, and generates negative effects of average and below average wage growth. We thus decided not to include them in the regression.

setup for headline inflation. Note however that this persistence will be reduced at the level of headline inflation by the share of core inflation in the total index. When no homogeneity constraint is applied, the sum of estimated lag coefficients on core inflation drops to 0.45. Not surprisingly, the constant term now turns significant and is estimated to 0.91, about a half of the average of core inflation on the sample period. Interestingly, the shortage variable is relevant to explain part of the fluctuation in core inflation. These findings are driven by the post-pandemic data points, as the coefficients of wage growth and shortage significantly drop in a regression on the pre-covid sample period only, not shown here for brevity. Finally, non-linear terms seem to help improving the core inflation regression, as indicated by significant coefficients and slightly higher R-squared measures. In times of high inflation, wage effects are more than doubled compared to the configuration without non-linear terms. In contrast, shortage effects are reduced with a sum of coefficient dropping from 0.37 to 0.26 in the model with non-linearities.

The estimation of the headline inflation Equation 12 - not reported in a table for brevity purposes - generates coefficients close to the historical average of the share of the different components. The core coefficient is equal to 0.67, and the parameters of energy and food components are estimated to be 0.11 and 0.22 respectively. The R-squared of this equation is very high, 0.98 for the pre-pandemic period and 0.99 for the full sample period.

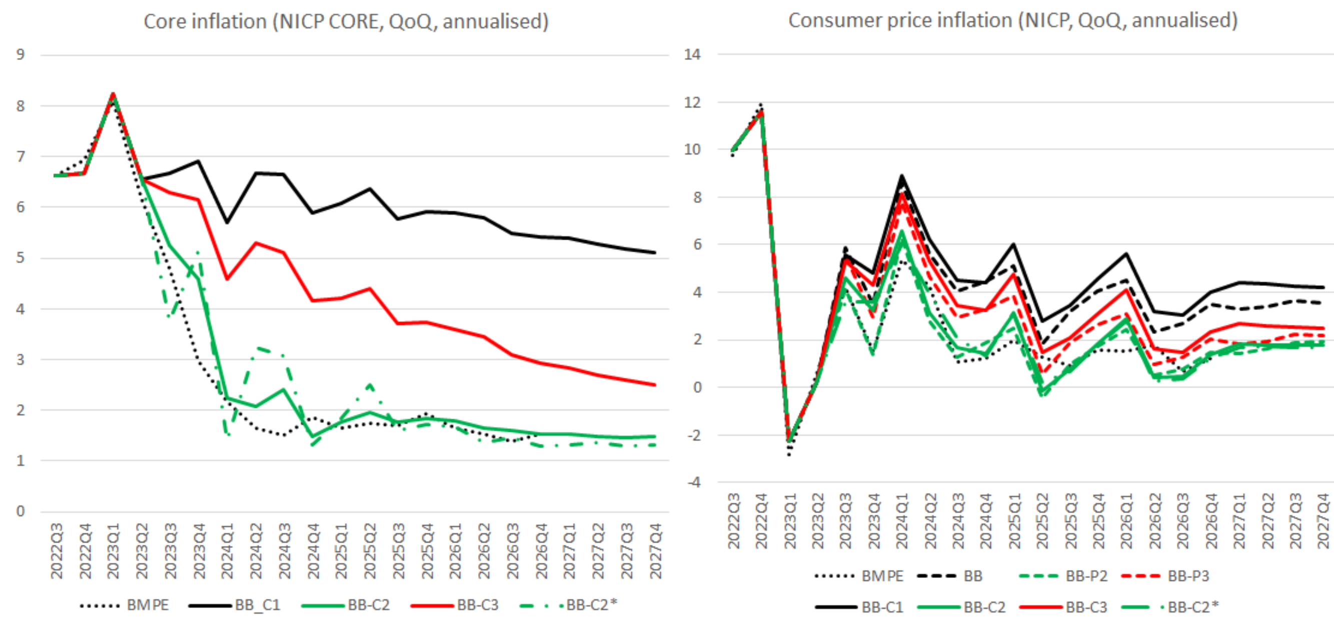
Table 8: Estimation of a core inflation equation.

	Core 1	Core 2	Core 3	Core 2⋆
core inflation	0.90***	0.45***	0.79***	0.38***
wage inflation	0.10	0.10	0.11	0.03*
wage infl x high price infl.				0.20***
shortage	0.23***	0.37***	0.30***	0.26***
productivity	-0.01	-0.13	0.11	-0.11
constant	0.03	0.91***	0.11	0.98***
homog. constraint?	yes	no (0.00)	yes	no
number of obs.	104	104	104	104
R^2 pre-covid	0.18	0.26	0.19	0.39
R^2 full sample	0.72	0.75	0.73	0.79

Note: Statistical significance of the joint test is indicated by asterisks: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01.

Model-based projections using Eurosystem's technical assumptions and under different configurations of the core inflation equation are shown in Figure 21. Specifications BB-C1, BB-C2, BB-C3 and BB-C2⋆ add respectively the core equation Core 1, Core 2, Core 3 and Core 2⋆ to the equations Wage 1, SR1 and LR1. The left panel plots the projections for core inflation, while those for headline inflation are on the right panel of the figure. For comparison purposes, December 2023 BMPE forecasts as well as projections of BB, BB-P2 and BB-P3 are reported. Compared to the projections reported in the main text for the original setup, similar conclusions emerge. Models with the homogeneity constraint in the core inflation generate more persistence in the core and headline inflation projected paths. For consumer price inflation, this persistence is slightly larger than what emanates in the projections of the original setup. Models without the homogeneity restriction approach the BMPE forecast. The inclusion of non-linear terms produces a rebound in the projections for core inflation for 2024Q2-Q3 and 2025Q2. This rebound is however more limited at the level of headline inflation by the share of the core in the total index.

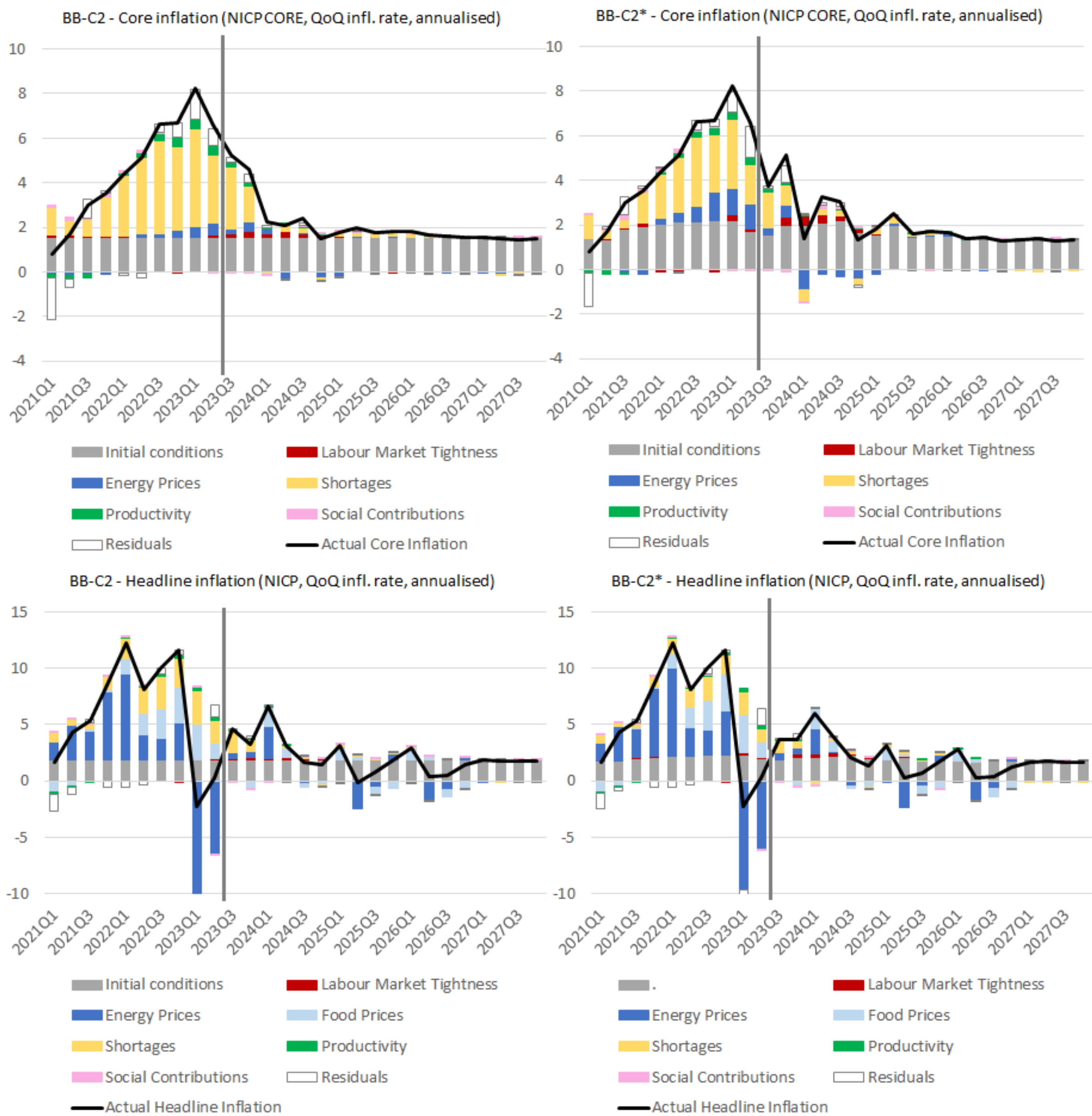
Figure 21: Model-based projections based on December 2023 BMPE assumptions.



BMPE = December 2023 exercise.

Historical and projection shock decompositions of core and headline inflation are shown in Figure 22, for BB-C2 and BB-C2* configurations. They convey the same message as for the outcomes of the original Bernanke-Blanchard model. The post-pandemic consumer price inflation in Belgium was mainly driven by price-given wage shocks: energy, food and shortage factors. The fact that these factors are also dominant for core inflation is a finding in line with the study of Bańbura et al. (2023) on euro area core inflation. Labour market tightness plays a relatively minor role both in the in-sample period and in the projection period. Its contribution to core inflation is stronger in the configuration of the model with non-linear terms in the core inflation equation, BB-C2*. In this specification, energy plays also a non-negligible role in explaining the core inflation variations. This stronger effect reflects the larger pass-through of indexation and changes in short-run expectations via wages to core prices in a period of high inflation. The shortage factor remains important but its role is somewhat limited in the model with the non-linear version of the core equation, consistent with the smaller estimated coefficients in this specification.

Figure 22: Shock decomposition of core and headline inflation (QoQ inflation rates, annualised). Model extended with a core inflation equation.



The figure reports a shock decomposition of Belgian core and headline inflation, measured by annualised quarter-on-quarter growth rates of the National Index for Consumer Prices, from 2021Q1 to 2023Q2 and model-based projections from 2023Q3 to 2027Q4 are on the right of the vertical grey line. Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

E Robustness analysis to the use of collectively agreed wage series

In this appendix, we test a model estimated based on a collectively agreed wage series,[34] instead of the hourly wage cost measure proposed in the main text. The collectively agreed wage is the direct outcome of the bargaining between social partners and is therefore a timely indicator. It includes wage indexation as well as agreed adjustments on top of it. In contrast to compensation of employees - used to compute our hourly wage cost measure - it excludes any increase and bonus granted by companies over collectively negotiated wage (which is part of the wage drift) and employers' social contributions. The collectively agreed wage is thus less volatile than the hourly wage cost variable, though the correlation between the two series is non-negligible (0.61 for the full sample period).

Tables 9 and 10 compare the regression results for the wage and price inflation equations when using alternatively hourly wage costs (i.e. the results reported in the main text) and collectively agreed wages. The wage equation fits the later time series better, probably in part due to its smoother variations. A negative dependence on its own lag however subsists. Labour market tightness remains important in explaining the fluctuations of collectively agreed wages. The sum of its coefficients is however smaller, which might be due to the absence of the wage drift, a component of hourly wage cost that is also likely to be sensitive to labour market developments. The catch-up term appears significant, with a similar total effect once one accounts for the interaction between its first lag and the dummy for the first quarter of the year.

The outcomes of the price inflation regressions featuring the wage series set by social partners is very similar to the ones with effective wage cost. In the model with the homogeneity restriction imposed, inflation persistence is estimated to be slightly smaller and wage inflation coefficients larger. When the homogeneity assumption is relaxed, the sum of coefficients obtained with collectively agreed wage is almost the same as for hourly wage costs.

These similarities in the estimation of the configurations with the different wage series imply that model outputs are also very similar to the ones reported in the text. Model-based projections using the negotiated wage series are alike the ones based on hourly wage costs, as can be seen in Figure 23. The shock decompositions of wage growth and headline inflation

[34] Source: NBB via the Federal Public Service of Employment, Labour and Social Dialogue

data and projections, reported in Figure 25, bring the same takeaways as in the analysis outlined in the primary content of the paper. Concerning the growth of collective agreed wages, the model captures pretty well - though not entirely - the two hikes in 2022Q1 and 2023Q1 coming mainly from automatic wage indexation in the first quarter. The contribution of labour market tightness is still present in 2022-2023 - despite the absence of negotiation margins - though to a lower extent than for the growth rate of hourly wage costs, which includes the effect of wage drift.

Table 9: Estimation of the wage inflation equation using collectively agreed wages (second column).

	Hourly wage cost	Collectively agreed wages
	Wage 1	Wage 1
wage inflation	-0.43***	-0.50
short-run infl. exp.	1.43***	1.50***
lab. market tightn.	0.94***	0.65***
catch-up	0.73***	0.32**
productivity	0.01***	-0.003
social contributions	1.11**	
dQ1 x catch-up	0.44	1.03***
constant	0.76***	0.49**
homog. constraint?	yes	yes
number of obs.	105	105
R^2 pre-covid	0.37	0.56
R^2 full sample	0.56	0.84

Note: Statistical significance of the joint test is indicated by asterisks: * p-value $<$ 0.10, ** p-value $<$ 0.05, *** p-value $<$ 0.01.

Table 10: Estimation of the price inflation equation using collectively agreed wages (third and fourth columns).

	Hourly wage cost		Collectively agreed wages	
	Price 1	Price 2	Price 1	Price 2
price inflation	0.91***	0.25*	0.85***	0.26
wage inflation	0.09***	0.34***	0.15***	0.35***
energy component	0.01***	0.08***	0.01***	0.07***
food components	0.04***	0.21***	0.06***	0.22***
shortage	0.11*	0.22***	0.10*	0.20**
productivity	0.02	-0.06	0.01	-0.07
constant	-0.02	0.75***	-0.01	0.73***
homog. constraint?	yes	no (0.00)	yes	no (0.00)
number of obs.	105	105	105	105
R^2 pre-covid	0.92	0.94	0.92	0.94
R^2 full sample	0.97	0.97	0.97	0.97

Note: Statistical significance of the joint test is indicated by asterisks: * p-value < 0.10, ** p-value < 0.05, *** p-value < 0.01.

Figure 23: Model-based projections based on December 2023 BMPE assumptions. Analysis with collectively agreed wages (dashed lines).

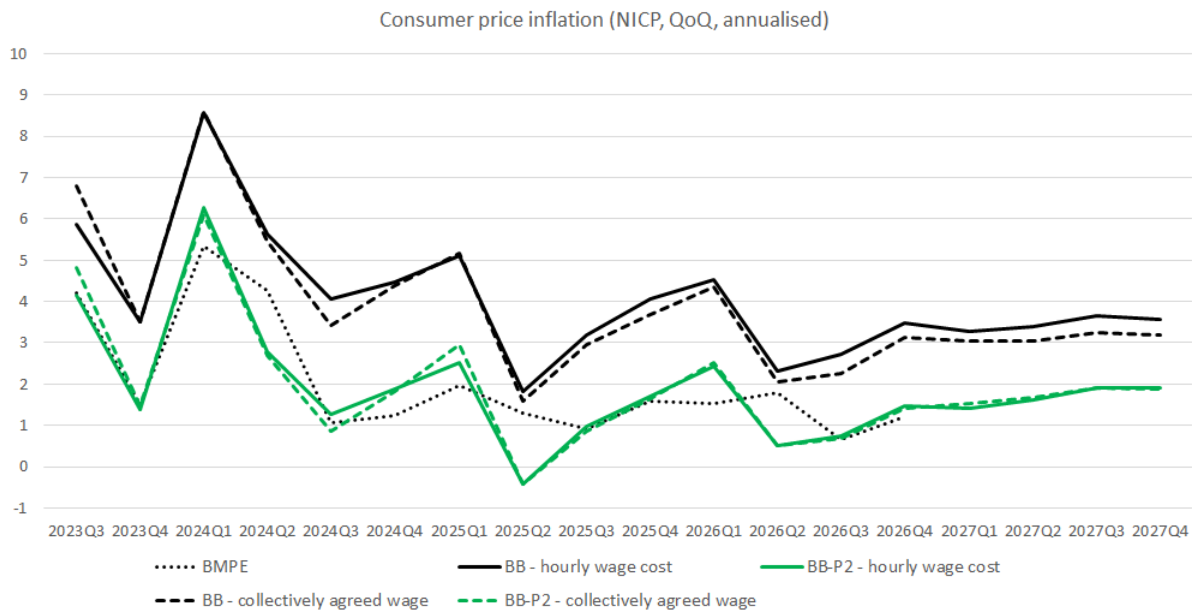
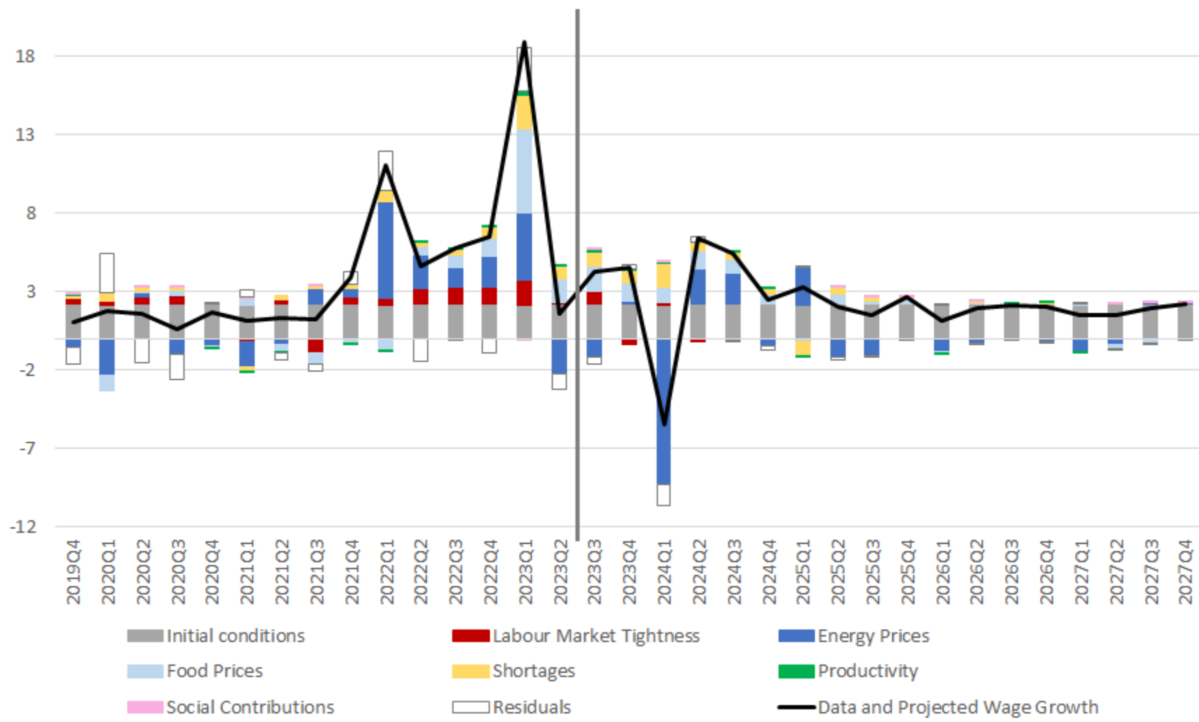
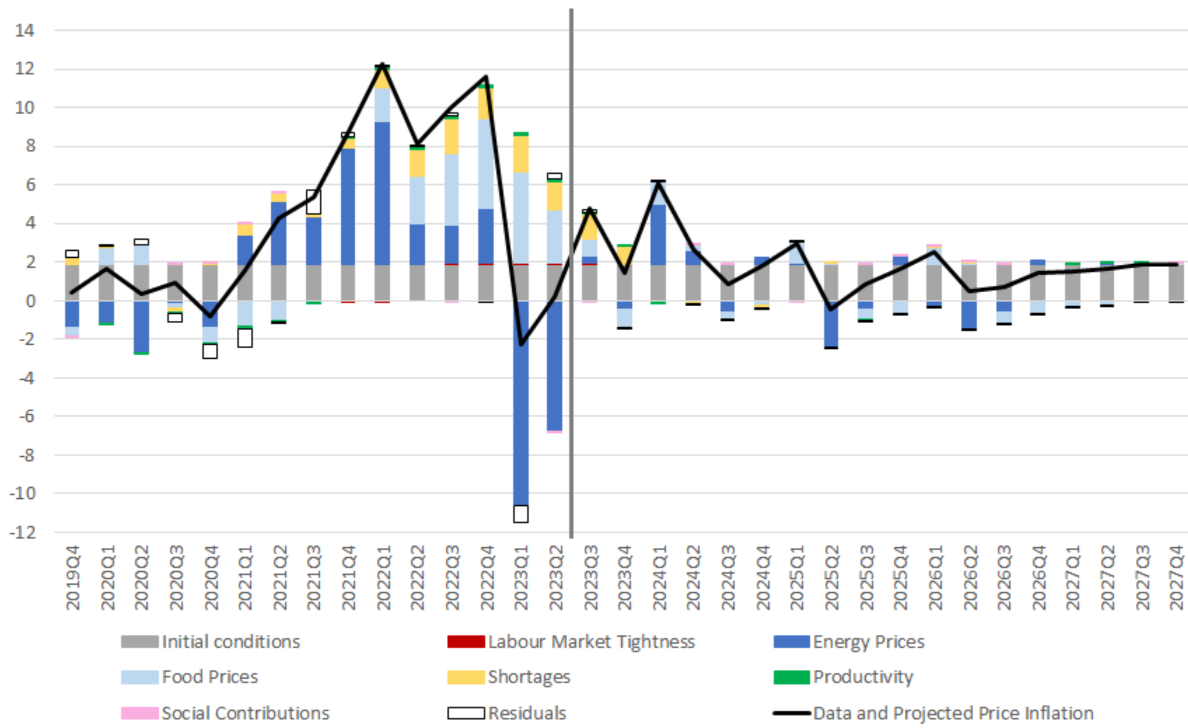


Figure 24: Shock decomposition of nominal wage growth (QoQ inflation rates, annualised) for 19Q4-27Q4, measured using collectively agreed wages. Model configuration P2 (without homogeneity constraint in the price infl. equation).



The figure reports a shock decomposition of nominal wage growth, measured by annualised quarter-on-quarter inflation rates, from 2019Q4 to 2023Q2 (data, left of the vertical grey line) and from 2023Q3 to 2027Q4 (model projections, right of the vertical line). Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

Figure 25: Shock decomposition of headline inflation (QoQ inflation rates, annualised) for 19Q4-27Q4. Model using collectively agreed wages and configuration P2 (without homogeneity constraint in the price infl. equation).



The figure reports a shock decomposition of headline inflation, measured by annualised quarter-on-quarter inflation rates, from 2019Q4 to 2023Q2 (data, left of the vertical grey line) and from 2023Q3 to 2027Q4 (model projections, right of the vertical line). Grey bars indicate the initial conditions, that is the contribution of deduced pre-sample information. White bars show the contribution of the residuals of the four equations of the model. Each of the other bars represents the contribution of a shock to the fluctuation of the data. For each period, all bars sum to the data value. Relative energy and food price shocks are deviations of their values from zero. Shocks to shortage, labour market slack, social contributions and productivity are measured as deviations of their values from the pre-covid sample mean.

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