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An Analysis of Pandemic-Era Inflation in 11 Economies

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Abstract

We recently proposed a simple model of the inflation process, estimated it on post-1990 US data, and used the results to identify the shocks and transmission mechanisms that have determined US inflation since 2019 (Bernanke and Blanchard 2023, hereafter BB). Ten central banks expressed interest in using our model to study the recent inflation in their own economies, and we agreed to do a joint project. This paper summarizes and discusses in broad terms the results of the project, leaving details to papers and reports produced by staff at the cooperating central banks.

The BB model was intended to capture the joint dynamics of consumer prices, wages, and short- and long-run inflation expectations, conditional on the shocks to inflation (from energy prices, food prices, and sectoral shortages) and on the degree of tightness in the labor market. Our conclusions were that the pandemic-era inflation in the United States was initially the result of a series of adverse relative price shocks and sectoral shortages, each of which had a strong but largely transient effect on inflation. The labor market had little effect on inflation early on, but increased tightness eventually produced limited but sustained pressure on inflation. As the effects of relative price shocks and shortages stabilized or reversed, inflation declined, and the role of labor market tightness became increasingly important, suggesting that some slowing of activity might be necessary to get US inflation all the way back to target.

In some cases, the application of the BB model by the country teams required modifications, reflecting factors such as data availability and institutional differences. With that caveat, estimation and simulation of the model for each of the ten economies has produced results broadly similar to our findings for the United States: Relative price shocks and sectoral shortages drove the initial surge in inflation, but as these effects have reversed, tight labor markets in most (although not all) countries have become a relatively more important factor. Despite the broad similarities to the US story, the details—for example, the relative importance of energy shocks, price shocks, and shortages in driving inflation—differ by country. There is also considerable variation across countries in the estimated effect of labor market pressure on wage inflation and thus on price inflation.

Differences across countries have implications for the costs of returning inflation to target from current levels (the “last mile”). Most countries saw labor markets tighten over the period. Those that did not and those where the effects of labor market tightness on wages have been weak may achieve their inflation targets without an increase in unemployment. However, some countries may need some loosening of labor market conditions to achieve their inflation targets.

Overall, the episode stands in sharp contrast to the persistent effects of relative price shocks in the 1970s. The more transient effects of price shocks this time around are traced in large part in the model to more anchored inflation expectations and to limited catch-up of real wages. The first is likely due to higher credibility of monetary policy; the second is likely due, in good part, to the disappearance of wage indexation.

A side effect of the project was to demonstrate the benefits of central bank cooperation and of looking at inflation through similar lenses and learning from each other. Several central banks have adopted the BB model as part of their forecasting framework.

Introduction

As inflation came and (so far only partly) went, many explanations have been offered for the pandemic-era surge in prices. Some point to strong aggregate demand, supported by the buying power of pent-up savings accumulated during lockdowns, expansionary fiscal policy (especially in the United States), accommodative monetary policies, and, as the pandemic waned, a global recovery that came earlier and was stronger than many expected. Others emphasize supply-side factors, including sharp increases in the prices of key commodities (notably energy and food), disruptions of global supply chains, reductions in labor supply (e.g., due to early retirements and declines in participation rates), and instances of "greed" (i.e., opportunistic increases in margins by some firms in the inflationary environment).

Beyond the sources of the inflation, much discussion has also focused on transmission mechanisms, that is, on the channels by which the shocks hitting the economy affected inflation. Consider the sharp rise in energy prices, for example. Increases in prices for energy products, such as gasoline, directly affect inflation, of course. But higher energy prices have indirect effects as well, for example, by increasing costs of production of non-energy goods and services or by motivating workers to press for compensation for unexpected past losses in their purchasing power. Indirect effects may also operate through short- and long-run inflation expectations. For example, higher gas prices may lead people and firms to increase their short-run inflation expectations, raising wage and price pressures. If expectations are not well anchored, these dynamics can lead to the possible emergence of wage-price or price-wage spirals.

Since the inflation began, disagreements over its sources and transmission mechanisms have led to conflicting conclusions and policy implications. At the start, two "teams" emerged. Following the early view of Federal Reserve officials that the inflation would be transitory, economists belonging to "Team Transitory" argued that the increase in inflation was due mostly to supply factors that were likely to reverse relatively quickly. Standard central banking doctrine holds that, so long as inflation expectations are reasonably well anchored, there is a case for "looking through" temporary supply shocks rather than responding to the short-run increase in inflation. A smaller group, "Team Permanent," held that, to the contrary, exceptionally strong demand, arising from large fiscal programs and other factors, would put sustained upward pressure on inflation.[1]

Today, with inflation well off its peak but still higher in most countries than central bank targets, the focus of the discussion has turned to the problem of the "last mile," that is, what it will take and what it will cost to get inflation durably back to central bank targets. One point of view is that many countries are already there or soon will be, and the fight against inflation has largely been won. An opposing view is that the decrease in inflation to date has been due mostly to the reversal of supply shocks, a process that is now running its course, and that the desired further reduction in inflation may require further substantial cooling of the labor market and an increase in unemployment. Deciding who is (and was) right in these debates requires a close empirical analysis of the sources of recent global inflation and disinflation.

In an earlier paper (Bernanke and Blanchard, June 2023, BB in what follows), we developed a small model to assess empirically the relative roles of the various shocks and transmission mechanisms in driving inflation, and we fit it to US data. A number of central banks around the world found our

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1. For an example of the first view, see Reifschneider and Wilcox (2022). For examples of the second view, see Blanchard (2021) and Summers (2021).

approach attractive and decided to apply our model to their own economies. To benefit from each other's insights, we and the central bank teams agreed to a joint project to investigate the applicability of the BB model to other economies. The teams worked both independently and in collaboration over the second half of 2023, using national data that in most cases ran through 2023Q2. The ten non-US central banks participating in the project were the European Central Bank (ECB), the Bank of England, the Bank of Japan, the Bank of France, the Bundesbank, the Bank of Spain, the Bank of Italy, the National Bank of Belgium, the Bank of the Netherlands, and the Bank of Canada (note that the project included both the ECB as well as several national central banks within the Eurosystem). The US Federal Reserve engaged with the project as an observer, but the US results come from an updated version of our work in BB. The two of us coordinated the project and consolidated and compared the results. This paper is a cross-country summary that presents the main conclusions of the studies by these ten central banks and our own work for the United States, focusing on commonalities and differences across economies.

Generally speaking, we find that the commonalities dominate the differences. Consistent with the original BB findings for the United States, there is wide agreement among the teams that the pandemic-era burst of global inflation was due primarily to a succession of adverse shocks to prices—notably global increases in energy and food prices and supply disruptions in key sectors. As of this writing (March 2024), these shocks have receded substantially, accounting for most of the global cooling of inflation. The prominence of shocks to prices does not preclude a role for labor markets, however: Also consistent with the BB results, in many, although not all, countries, postpandemic labor markets became quite tight, presumably reflecting strong aggregate demand together with constraints on labor supply. Tight labor markets in turn contributed to wage inflation, and consequently to price inflation. Importantly, although the inflationary effects of tight labor markets were initially much smaller than the effects of shocks to prices, they were more persistent. Thus, as the shocks to prices faded or reversed, wage inflation has become the larger factor behind the remaining price inflation, which may make further reductions in inflation more difficult to achieve. The inflation story is not complete as of this writing, however, and the ultimate outcomes remain to be seen.

The paper is organized as follows. Section 1 presents an overview of the basic BB model. Section 2 presents the main findings from the cross-country work applying that model. Section 3 concludes and suggests directions for further research. An appendix presents the BB model in more detail, as well as detailed estimation results for each country. This paper is of necessity only a summary, which hits some highlights but cannot cover all the detailed findings of the country teams. More extended discussions of the country results are available in papers written by the individual teams; the list of available country-level papers, with links, is given in the bibliography.

I. The Basic Model

In specifying the model used in this project, we made the following choices.

We chose to base our analysis on a simple model, plausibly but not explicitly based on microeconomic foundations. We believed that a simpler model could provide useful insights into the sources of inflation and on policy debates without sacrificing transparency or ease of replication.[2] Other analyses have taken more formal, structured approaches (see, for example, Baqaee and Farhi 2022). We see room for both

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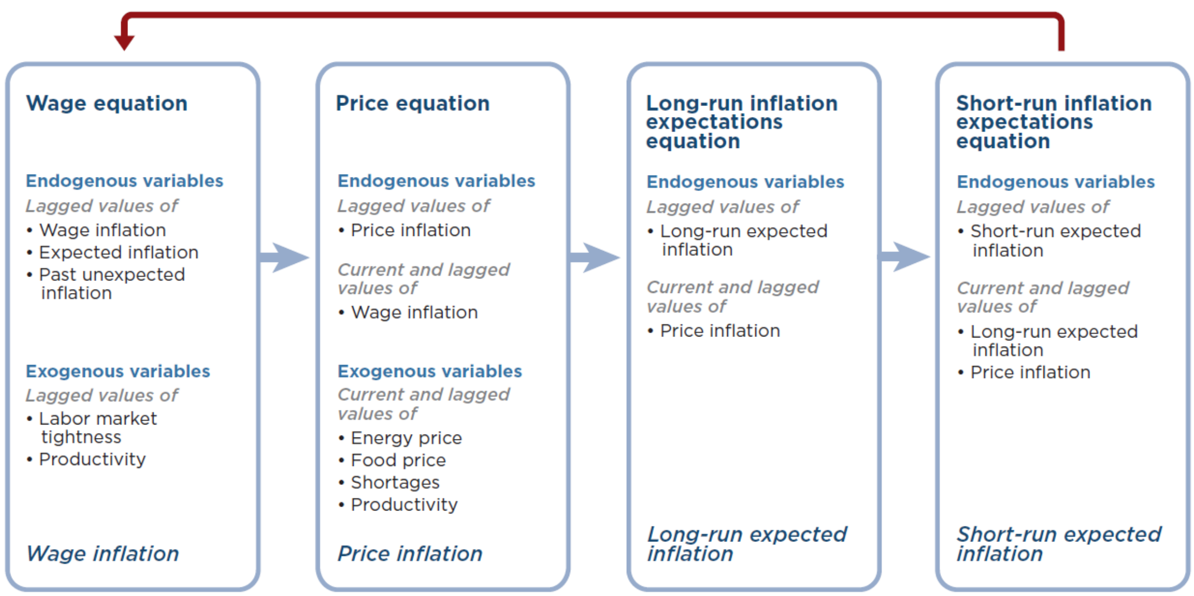
2. Large-scale models typically used by central banks have a significant advantage in terms of comprehensiveness. But central banks have a responsibility to explain their analyses and forecasts to the public, especially during a crisis, and an additional advantage of simple models is that they provide a narrative that aids in the banks' communication.

research strategies, as a portfolio of approaches provides the best test of the robustness of the results. In this instance, it appears that most research has led to largely similar conclusions.

We decided to focus on four endogenous variables: price inflation, wage inflation, long-run and short-run inflation expectations. Given the discussions on the potential strength of wage-price or price-wage interactions, we believed it was important to look at wage and price evolutions separately. Other work has focused directly on price inflation, or used a different decomposition than ours, for example, separating headline inflation between median inflation and the deviation of headline from median inflation (Ball, Leigh, and Mishra 2022; Dao, Gourinchas, Leigh, and Mishra 2024) or breaking down inflation into services and goods components (di Giovanni et al. 2023).

We proceeded in two steps, first writing down and solving a simple analytical model, and then estimating an empirical counterpart of the model, based on the same analytical structure but with more generous dynamics. Figure 1 shows the structure of the empirical model, inclusive of lags. The model has four equations, corresponding to the four endogenous variables; the precise equations in the analytical and empirical versions of the model are given in the appendix.

Figure 1. Structure of the Bernanke-Blanchard (2023) empirical model



What follows is an informal description of the model and its basic implications, as well as of its adaptation for this multicountry project.[3] We begin with the equation describing the behavior of nominal wages, then turn to the equations for consumer prices, long-run inflation expectations, and short-run inflation expectations.

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3. For a more extended discussion of the assumptions and the implications of the model, see BB.

The Wage Equation

In the analytical model, we specified wage inflation as depending on labor market tightness, expected short-run inflation, and a catch-up variable. The first two terms are standard and need no explanation. The third term, which is typically missing from wage Phillips curve specifications but should not, reflects the fact that to the extent that past unexpected inflation has led to a decrease in workers' real wages, they may try to "catch up" by pushing for higher nominal wages, all else equal.[4] Note that, in contrast to expected inflation, which is forward-looking, the catch-up variable is backward-looking. Thus, the specification allows both past unexpected price inflation and future expected price inflation to affect wage inflation.

In the empirical counterpart of the model, we allowed for a richer lag structure, with wage inflation depending on its own lagged values and lagged values of the other determinants (see figure 1). As a measure of labor market tightness, in BB we used the ratio of vacancies (job openings) to the number of unemployed persons. The argument for using this ratio rather than the unemployment rate alone (as in the traditional wage Phillips curve) is that, relative to the unemployment rate, this ratio arguably better reflects conditions on both the demand (vacancies) and supply (unemployed persons) sides of the labor market.[5] We leave a discussion of the relation between the unemployment rate and the vacancy-unemployment ratio to section 3, but, as we shall see, this relation matters in thinking about what increase in the unemployment rate may be needed to return inflation to target. As a measure of catch-up, we used the sum over the previous four quarters of unexpected inflation (the difference between realized inflation in each quarter and the rate of inflation that had been expected). To measure short-run inflation expectations, we used, alternatively, one-year inflation expectations as constructed by the Federal Reserve Bank of Cleveland or one-year inflation forecasts from the Survey of Professional Forecasters.

We added a trend productivity growth variable, defined as an eight-quarter moving average of productivity growth, with productivity measured as the ratio of nonfarm business value added to nonfarm employee hours. As the second and third quarters of 2020 (the onset of the pandemic) were associated with an exceptional increase in US unemployment and only a moderate downward effect on wage growth, presumably due to a combination of strong fiscal support and worker resistance to nominal wage cuts (a de facto zero lower bound on nominal wage changes), we allowed for quarterly dummies for 2020Q2 and 2020Q3 as a simple way of capturing the unusual episode and avoiding contaminating other coefficients. Our results were not substantially affected by the inclusion of those two dummies.

The Price Equation

In the analytical model, we specified price inflation as simply depending on wage inflation and generic price shocks, that is, factors leading to increases in prices given wages.

In the empirical counterpart, we allowed for a richer lag structure, again allowing for both lagged values of the dependent variable and current and lagged values of the other determinants. We introduced three variables to capture price shocks: the relative price of energy (relative to wages), the relative price of

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4. This is also sometimes referred to as real wage rigidity. Its role in the inflation of the 1970s was examined by, among others, Bruno and Sachs (1985).

5. Two labor markets with the same unemployment rates but low or high vacancies obviously have very different implications for wage evolutions. The vacancy-unemployment ratio, unlike the unemployment rate, is a good indicator of labor market tightness when there are shifts in the relation between vacancies and unemployment (the Beveridge curve). We discuss the role of Beveridge curve shifts in the conclusion.

food, and a measure of sectoral shortages. What has been specific to this inflation episode has been the large supply disruptions and the associated price spikes in certain sectors, potentially leading in some cases to a price far above the usual marginal cost.[6] Several proxies for shortages are available. In BB we used the number of Google searches for the term "shortage" as a proxy for supply disruptions, but alternative measures lead to similar conclusions.[7] We included the productivity growth variable in the price equation, as higher productivity reduces unit costs, all else equal.

The Equation for Long-Run Inflation Expectations

In the analytical model, we specified long-run inflation expectations as depending on themselves lagged and on lagged inflation. One can think of the coefficient on inflation as reflecting the degree of anchoring of long-run expectations. A coefficient of zero would imply complete anchoring of long-run inflation expectations (that is, long-run expectations would not depend on inflation).

In the empirical counterpart, we included the same variables but with a richer lag structure, thereby allowing unanchoring effects to work with a lag. We measured long-run inflation expectations alternately by the Cleveland Fed's ten-year inflation expectations measure or the Survey of Professional Forecasters' forecast of inflation over the subsequent ten years.

The Equation for Short-Run Inflation Expectations

In the analytical model, we specified short-run inflation expectations as depending on themselves lagged, on current long-run expectations, and on lagged inflation. As in the other equations, in the empirical counterpart we allowed for a richer lag structure.

Homogeneity, Subsample Stability, and Identification

In BB we estimated the model for the United States using quarterly data for the period 1990Q1 to 2023Q2. In the empirical version of the model we allowed for four lags for all variables included in each equation. The lag structures were left free except for homogeneity restrictions, which imply there is no long-run tradeoff between the labor market measure and inflation (a vertical long-run Phillips curve). As a result, for given values of the exogenous variables, the estimated model delivers a unique "natural" vacancy-unemployment ratio, analogous to the natural unemployment rate in traditional specifications. In most cases the homogeneity restrictions had little effect on the estimates. We used whole-sample estimates to compute impulse responses and historical decompositions of inflation (see below), but we also estimated the model using data from 1990Q1 to 2019Q4 to check for subsample stability. In the US data and for most other countries there was little evidence of major changes in the coefficients post-2019.[8] Finally, identification was achieved through restrictions on contemporaneous coefficients (as in a

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6. Shortages can lead to an increase in profit if firms, which are suddenly constrained, face a demand function with a short-run elasticity less than one. We suspect that much of the increase in profits in some sectors has come from such a mechanism, rather than from greed, i.e., from an increase in margins by monopolistic firms using the noisier environment as cover.

7. For example, the New York Fed's supply chain index gave results largely similar to ours. Lewis Alexander (personal communication) finds good results by applying a large language model to the Fed's Beige Books to identify periods of shortages.

8. The results of homogeneity and subsample stability tests are given in the appendix for each equation and each country. One note: Subsample stability of the price equation is strongly rejected in most countries. The origin of the rejection, however, is not a substantive change in coefficients but a larger standard deviation of residuals in the post-2019 sample.

structural VAR), notably the assumption that wage inflation does not react to contemporaneous movements in its determinants.

Extension to the Other Economies

In extending the model to other economies, to facilitate comparisons the country teams tried to stay as close as possible to the model as laid out in the BB paper. However, data availability and other factors led in some cases to estimation on a shorter sample, or the use of an alternative observable variable. For example, some teams used the Federal Reserve of New York supply chain index or a composite of several supply disruption measures, rather than the Google trends variable. As we shall discuss, in most cases the general specification fits the country data reasonably well and delivered clear conclusions. Some teams also explored alternatives to the basic specification, motivated by cross-country differences in institutions and pandemic-era policies. For example, some teams explored the role of the fiscal measures used to limit energy price increases in their countries. The Japanese team emphasized the unique nature of their country's labor market, using a specification that allowed for different behavior of wages for part-time contract workers and full-time workers. Some teams explored the role of import prices, as most of the economies in the project are smaller and more open than the United States. The reader is referred to the country-specific papers for more details.

One important caveat is needed before moving on to the results. Because we decided to treat several variables in our model as unexplained, the model does not provide a full general equilibrium account of the origins of the inflation. As noted above, we took the relative price of energy, the relative price of food, the measure of shortages, productivity growth, and the degree of labor market slack as given. Clearly, a more ambitious project would be to trace these variables back to their primitive determinants, including the role of fiscal and monetary policies, the intensity of the global pandemic, and Russia's war on Ukraine. For example, fiscal policies (especially in the United States) that increased aggregate demand may not only have tightened labor markets but also put upward pressure on global food and energy prices, allowed for a stronger passthrough of sectoral price shocks to price inflation, and (by increasing consumer demand for goods) worsened sectoral shortages. A different view might hold that the economic effects of COVID (together with government responses to the pandemic) and Russia's war on Ukraine were the more important sources of the rise in commodity prices and (because of the disruption of supply chains) of the shortages of many goods, notably durable goods. Our model cannot settle these issues, which we leave to future research.[9]

Basic Implications: Shocks and Transmission Mechanisms

Although parsimonious, the four relations of the analytical model capture the key shocks and transmission mechanisms identified and discussed in the literature. Repeating an analysis presented in BB, we can summarize the main implications of the analytical model through two impulse response functions,[10] to which we shall compare the impulse response functions implied by the estimated country models later.

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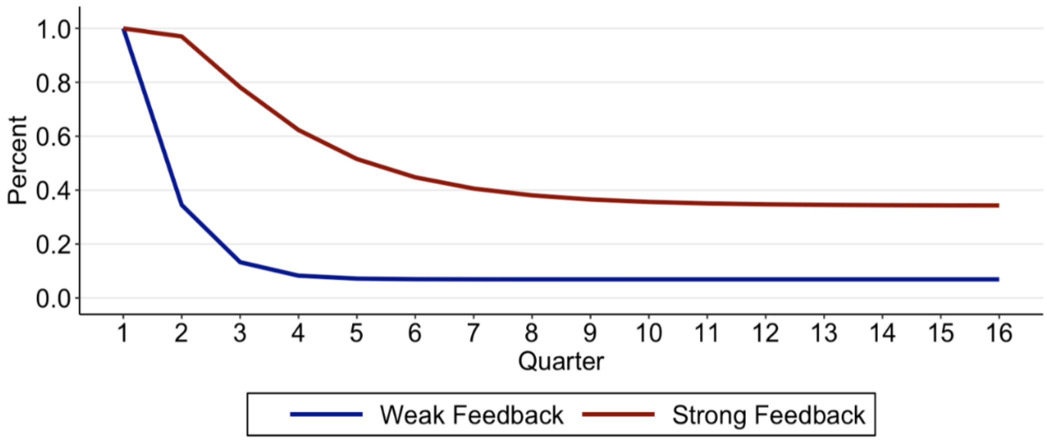
9. As discussed in BB, if one assumes that the price of specific commodities is the result of a largely common demand factor and largely idiosyncratic supply shifts, the fact that the first common component of a large set of commodity prices went up substantially from 2020Q1 to 2022Q2 suggests the relevance of aggregate demand.

10. See BB for further details on the construction of figures 2 and 3.

Figure 2 shows the model-predicted effects on inflation of a generic adverse price shock—for example, a permanent increase in the relative price of energy, or equivalently, a one-time increase in the growth rate of the relative price of energy.

Figure 2. Dynamic effects on inflation of a permanent increase in the relative price of energy



Source: Bernanke and Blanchard (2023).

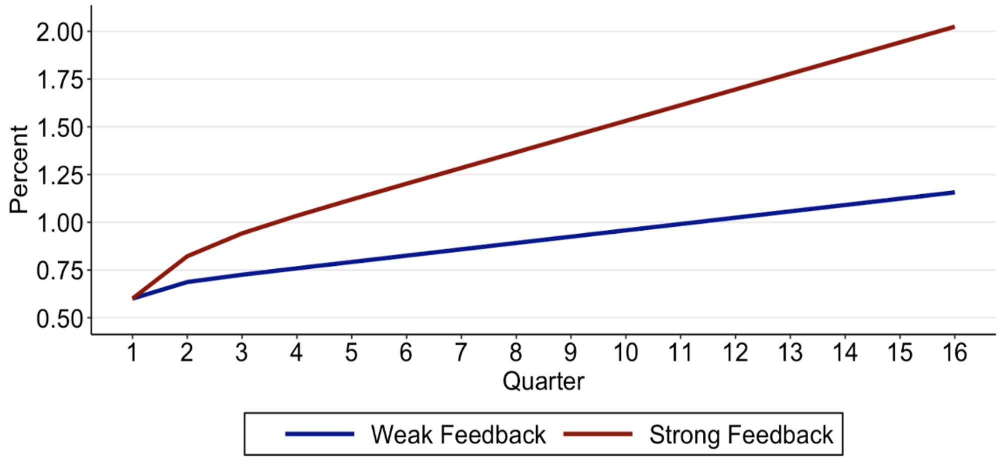
The figure's two lines correspond to alternative (hypothetical) choices of parameters. The direct, immediate effect of the energy price shock on inflation is normalized to be the same in both cases. The dynamic effects of the price shock on inflation differ in the two scenarios, however, with the difference reflecting five factors.

First, the effect of the energy price shock (or any shock to prices) on inflation depends not only on its direct impact on consumer prices (e.g., the price of energy goods such as gasoline) but also on its effect on nonenergy goods and services, reflecting the fact that energy is an important input to production. Second, the initial inflation shock caused by higher energy prices affects inflation expectations, which, third, affects nominal wage demands. Fourth, to the extent that the inflation shock was unanticipated, wage inflation may be further increased, as workers try to recoup previous losses in their purchasing power ("catch-up"). Fifth, wage inflation raises production costs, feeding back to price inflation.

The overall dynamic effect of an energy price shock on inflation depends on the strengths of each of these five effects. If the effects are relatively weak, then the dynamic effects will be weaker and shorter, as captured by the lower line ("weak feedback") in figure 2. Symmetrically, the stronger these effects, the larger and more persistent will be the dynamic impact of the energy price shock on inflation, as captured in the upper line ("strong feedback") in the figure. As we shall show below, in all countries the empirical evidence is much more consistent with the story told by the lower line in figure 2 than by the upper line. That is, in the recent episode, energy price shocks and other supply shocks had large contemporaneous effects on inflation but, because the channels described above were weak, these effects tended to reverse relatively quickly, barring new shocks.

To draw an important contrast, figure 3 shows the dynamic effect on inflation of a permanent increase in labor market tightness, to a level above its long-run sustainable ("natural") value. As in figure 2, we compare results for two sets of hypothetical model parameters.

Figure 3. Dynamic effects on inflation of a permanent increase in labor market tightness



Source: Bernanke and Blanchard (2023).

Four factors determine the size and persistence of the inflationary effect of a tight labor market. First, labor market tightness has a direct effect on wage inflation, via the wage Phillips curve. Second, the effect on consumer price inflation depends on the speed with which wages pass through to prices. Third, the induced inflation affects inflation expectations. Fourth, higher expected inflation affects wage inflation, and in turn price inflation.

As in the case of a shock to prices, if these transmission effects are relatively weak, the dynamic effects of tight labor markets on inflation will be smaller (the lower line in figure 3), and if they are strong the effects will be larger (the upper line). As we shall see below, the empirical evidence is that the response of inflation to a tighter labor market looks much more like the lower line in the figure. That is, the initial build-up is limited and thereafter inflation increases slowly over time. An important distinction between figures 2 and 3 is evident: The effects of price shocks on inflation tend to be transitory while the effects of an overheated labor market are more persistent.[11]

II. The Cross-Country Evidence

As the impulse response functions illustrate, in an economy in which there are both large price shocks (e.g., shocks to energy or food prices) with limited dynamic effects and an increasingly tight labor market, our model predicts that quarter-to-quarter inflation will be dominated early on by the price shocks. However, behind the scenes, the overheated labor market will be leading to slowly increasing and persistent wage inflation. Thus, the contribution of tight labor conditions to inflation, small in the short run, becomes more important as price shocks die away. This pattern, which BB found for the United States, appears to characterize most of the other economies studied in this project as well.

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11. Indeed, as the model has the property that there is a natural vacancy-unemployment ratio, any permanent increase in this ratio implies steadily increasing inflation. In a full general equilibrium model, this inflation would eventually be brought under control through appropriate policies, leading the ratio to go back to its natural value.

Wage Inflation, Price Inflation, and the Labor Market

Before showing results based on the estimated models, it is useful to start with two figures showing some raw facts.

Figure 4 shows the evolution of wage inflation (in blue) and price inflation (in red) for each economy included in the project, starting in 2019Q1. The two series show quarterly rates of change, annualized.[12]

Figure 4. Wage and price inflation since 2019Q1, quarter-over-quarter annualized percent changes

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12. We report (annualized) quarter-to-quarter movements because the estimations are done using quarterly data. Note, though, that the quarterly data are noticeably more volatile than the more familiar and more frequently reported annual or four-quarter changes.

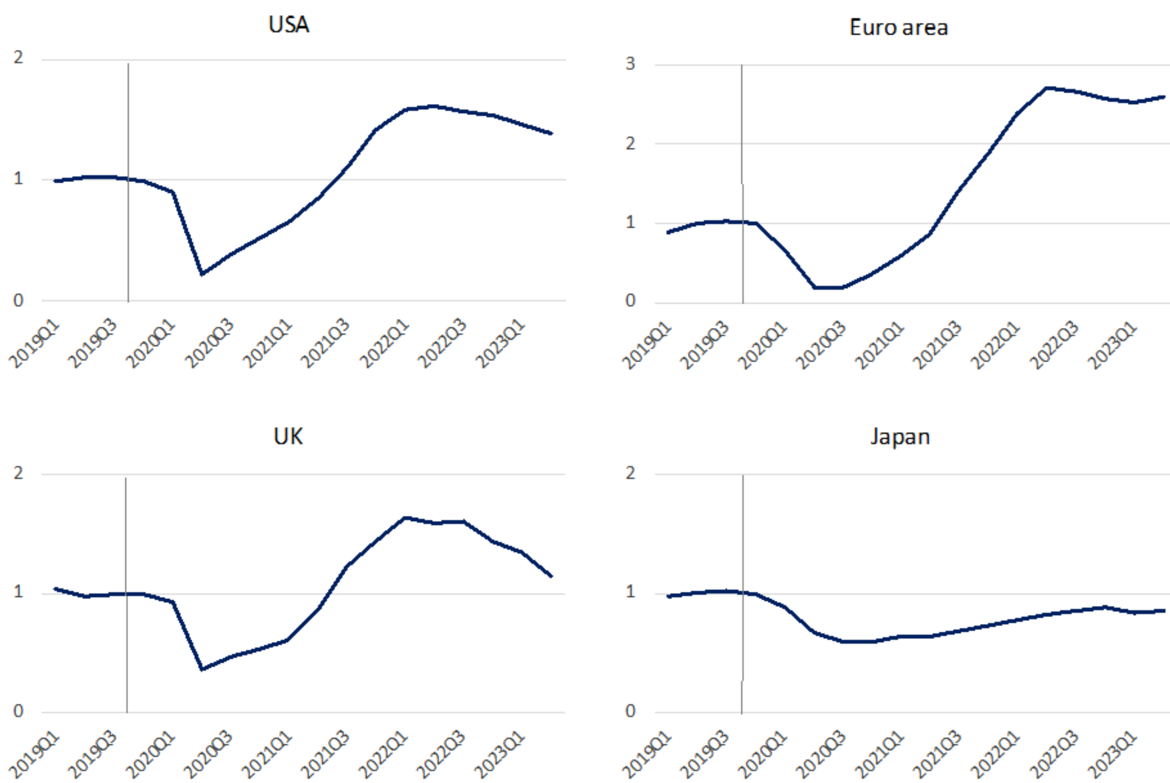
Sources: National statistics and authors' calculations.

For all countries, the price series is the local measure of consumer price inflation (the Harmonized Index of Consumer Prices for euro members). The wage series is that used in estimation in each country. For reasons of both data availability and institutional differences, the wage measures used in estimation differed somewhat across countries, including for example compensation per employee, compensation per hour, and new wage settlements, with nonwage benefits included in some cases but not in others. Because of the large shocks to hours per employee due to COVID and the different treatments of partial employment across countries, alternative wage measures in a given country were sometimes quite different and the teams had to decide which one to use in their baseline estimations; details and results using alternative wage series are given in the respective country papers. For the purposes of the comparison in figure 4, the differences are relatively unimportant, and the key conclusion would be the same if we plotted other measures of wages.

Figure 4 has two key messages: First, across countries, price inflation in recent years has been much more volatile than wage inflation. Second, wage inflation has been comparatively smooth, while showing in most although not in all countries some increase over time. By the end of our sample, 2023Q2, in nearly all countries the decrease in price inflation and the slow increase in wage inflation were such that wage inflation exceeded price inflation, implying rising real wages. These observations are consistent with the characterization of inflation being driven in the short run by volatile price shocks and in the longer run by a slow but persistent increase in wage inflation.

In the BB model, wage inflation is driven by the tightness of the labor market, as well as inflation expectations. For context, figure 5 shows the evolution, also starting in 2019Q1, of each economy's measure of tightness of the labor market, which, in most cases, is the ratio of measured vacancies to unemployed persons. (In some countries, because of data limitations, the variable is defined slightly differently but captures the same concept.) In countries for which available data allow the construction of vacancy-unemployment ratios, there are some surprisingly large differences in average values of the ratio over the sample. Presumably, these differences reflect in large part differences in data definitions and coverage, particularly of vacancies.[13] Given our focus on the dynamic behavior of this ratio, these level differences are less important, and, for clarity, figure 5 shows vacancy-unemployment ratios normalized to one in 2019Q4.

Figure 5. Labor market tightness since 2019Q1, index (2019Q4 = 1)



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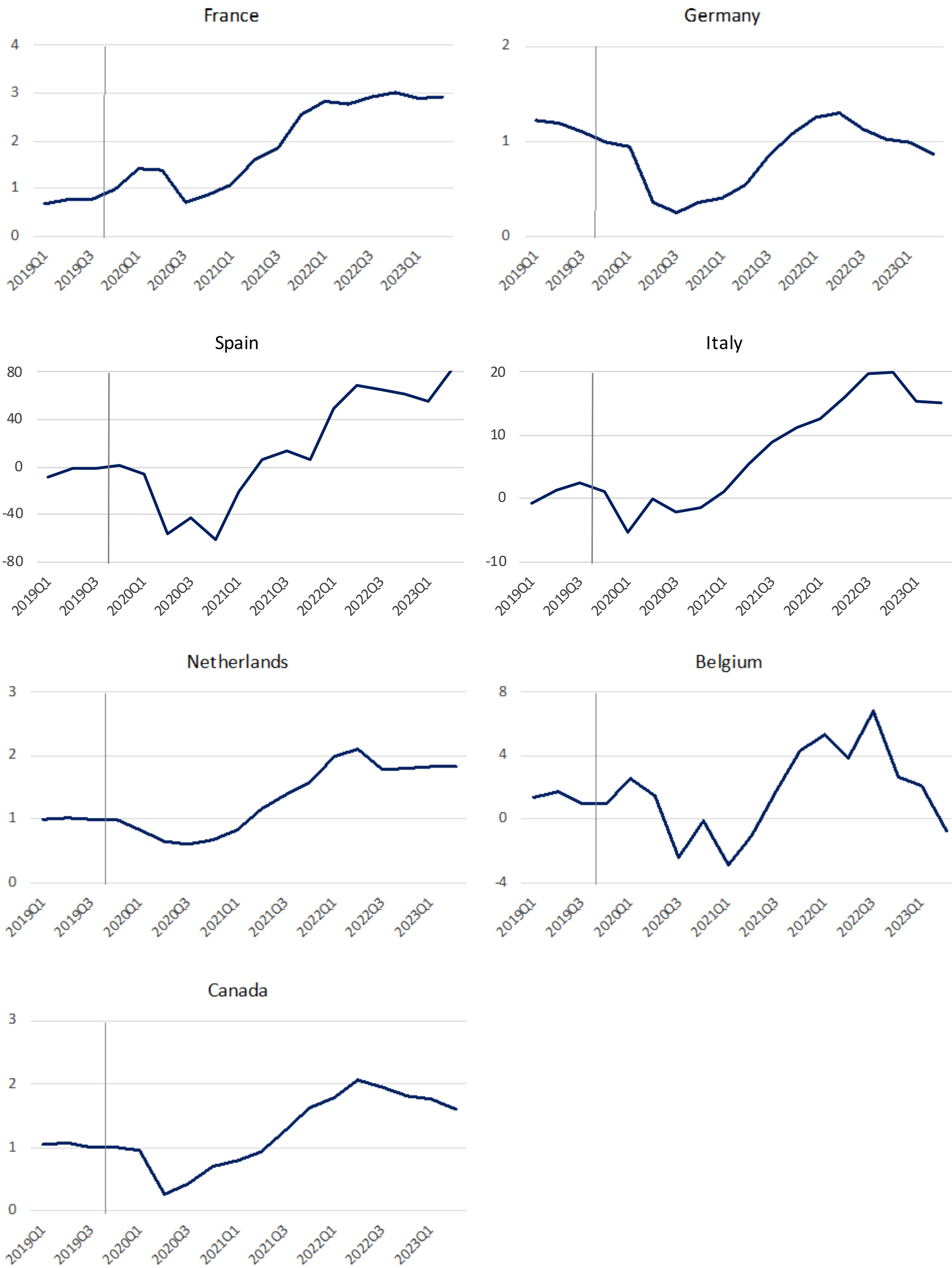
13. Understanding level differences between vacancy measures across countries should be high on the research agenda.



Sources: National statistics and authors' calculations.

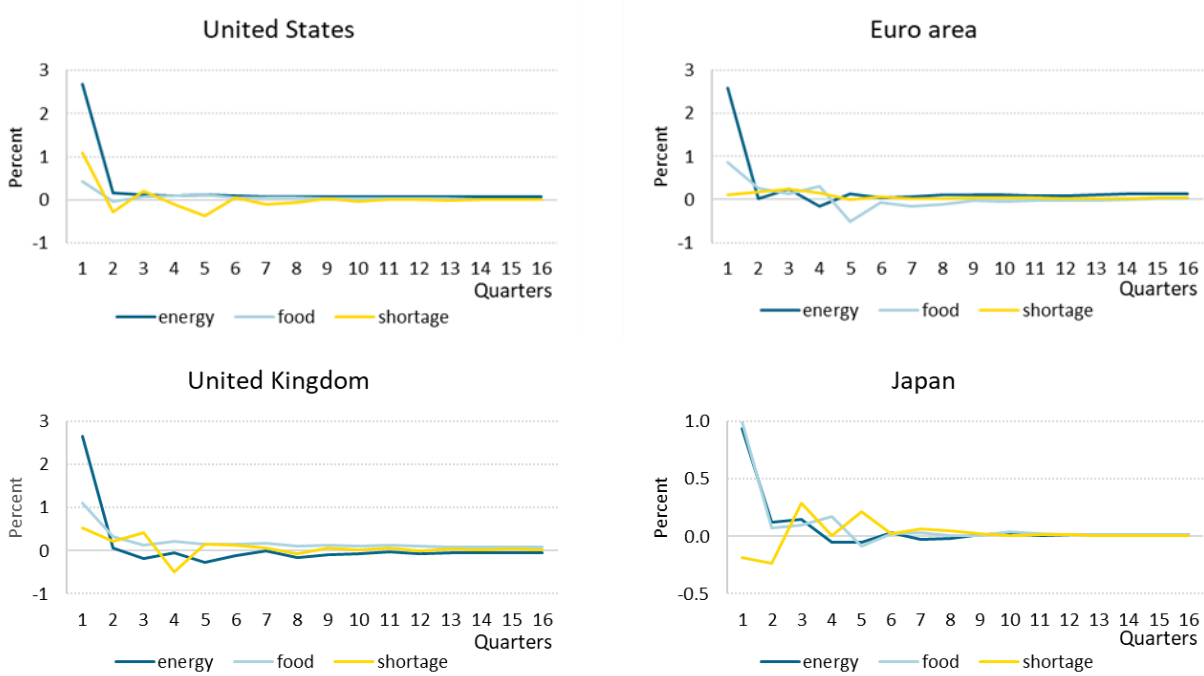
Once again, the data tell a clear and common story. After a sharp drop at the beginning of the pandemic, the vacancy-unemployment ratio steadily increased in most economies. Indeed, in all countries except Japan, Germany, and Belgium, the ratio was higher in 2023Q2 than it was in 2019Q4, suggesting that in most countries the labor market was substantially tighter at the end of our sample than immediately before the pandemic. For the unemployment rate, the more conventional measure of labor market tightness, the picture (not shown here) is largely the same, with the unemployment rate lower in 2023Q2 than in 2019Q4 in all but two countries (Japan and Belgium). This suggests that there is more to the inflation story than just price shocks and suggests the potential relevance of the labor market for the recent inflation.

Impulse Response Functions

Rather than reporting the detailed estimates for each country, the better way to summarize the estimation results for each is to show the impulse response functions implied by those estimates. The estimated impulse response functions can then be compared with those derived from the analytical model earlier. Note that the impulse response functions shown below are system outcomes of the estimated models, that is, they use all the estimated equations simultaneously in solving for dynamic responses.

Figure 6 shows the dynamic effects (impulse response functions) on inflation of a one-time permanent increase in the relative price of energy (dark blue), in the relative price of food (light blue), and in the measure of shortages (yellow), using the empirically estimated parameters and data choices for each country.[14] The initial increases in each of the price shocks are chosen to equal a one-standard-deviation change in each of the three variables, computed over the post-2019Q4 sample.

Figure 6. Impulse responses of inflation to relative price shocks, percent



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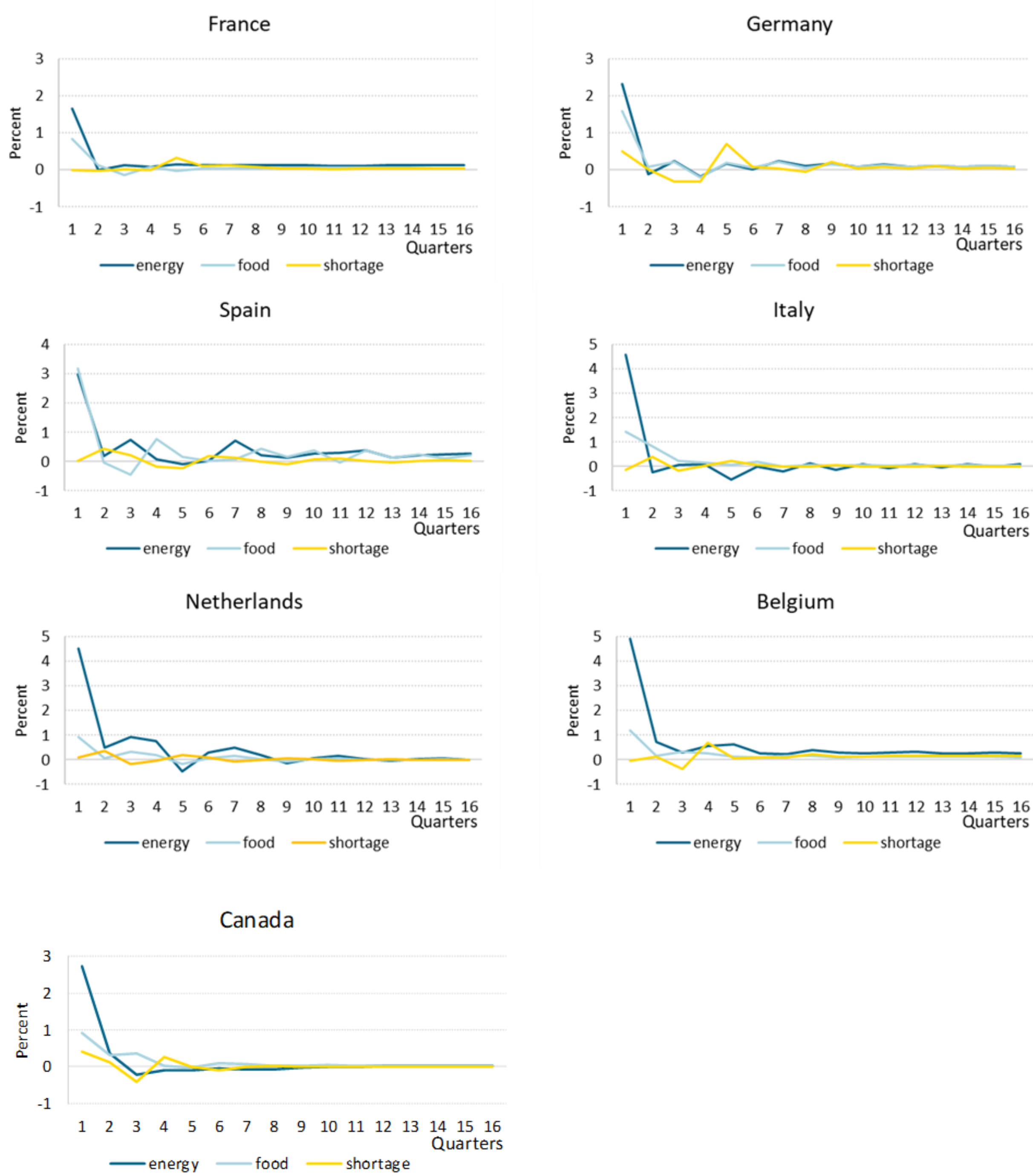
14. While we replicated the estimation results of the country teams, we did not replicate the simulation results in figures 6 to 8, relying on the simulation results reported by each country team.



Note: The figure shows the full-model, dynamic responses of inflation to a one-standard-deviation positive shock to relative energy prices, relative food prices, and the shortage variable.

Sources: Bernanke and Blanchard (2023), Arce et al. (2024), Nakamura et al. (2024), Haskel, Martin, and Brandt (2023), Aldama, Le Bihan, and Le Gall (forthcoming), Menz (2024), Gomi, Hurtado, and Montero (2024), Pisani and Tagliabracci (forthcoming), Bonam, Hebbink, and Pruijt (2024), de Walque and Lejeune (2024), and Fares, Roc, and Zhang (2023).

The shapes of the estimated responses are very similar across countries, with the sharp initial effects of price shocks subsiding quickly. This pattern is qualitatively similar to that shown by the weak feedback case in figure 2. The limited dynamic effects of price shocks in most countries reflect all five factors described earlier (see also estimation results in the appendix).

First, weak price-price effects: In most cases, the estimated effect of shocks to the prices of energy or food, taking into account the lags, is only slightly larger than the share of energy or food prices in the overall consumer price index, implying small second-round effects on other (non-energy, non-food) prices.

Second, dynamic effects are limited by well-anchored inflation expectations, with relatively small and slow effects of inflation on both short-run and (especially) long-run inflation expectations.

Third, the "catch-up" effect, the tendency of workers to press for compensation for earlier unexpected price increases, appears limited in practice, with the estimated coefficient on the catch-up variable in the wage equation close to zero in most countries.[15]

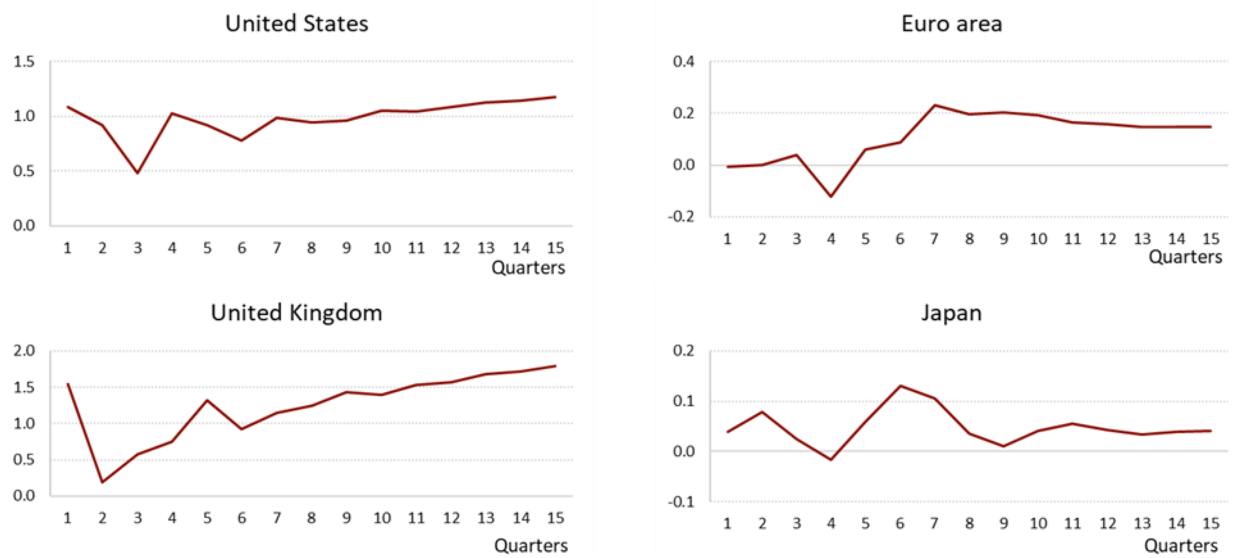
Fourth, wage inflation appears to adjust slowly to increases in inflation expectations.

Fifth, empirically, wage inflation feeds into price inflation relatively slowly in most countries.

In combination, these factors explain the absence of a price-wage spiral in the economies studied in this project, a sharp difference from, for example, the inflation of the 1970s, when (presumably) inflation expectations were poorly anchored and wage indexation automatically increased the importance of catch-up effects.[16]

Similarly, we can use the country estimates to examine the response of inflation to a hot labor market. Figure 7 shows the dynamic effects of a permanent increase in labor market tightness, again using the empirically estimated parameters for each economy. In the simulations, the increase in tightness is assumed to be equal to a one-standard-deviation increase in the vacancy-unemployment ratio over the post-2019Q4 sample.

Figure 7. Impulse responses of inflation to labor market tightness, percent



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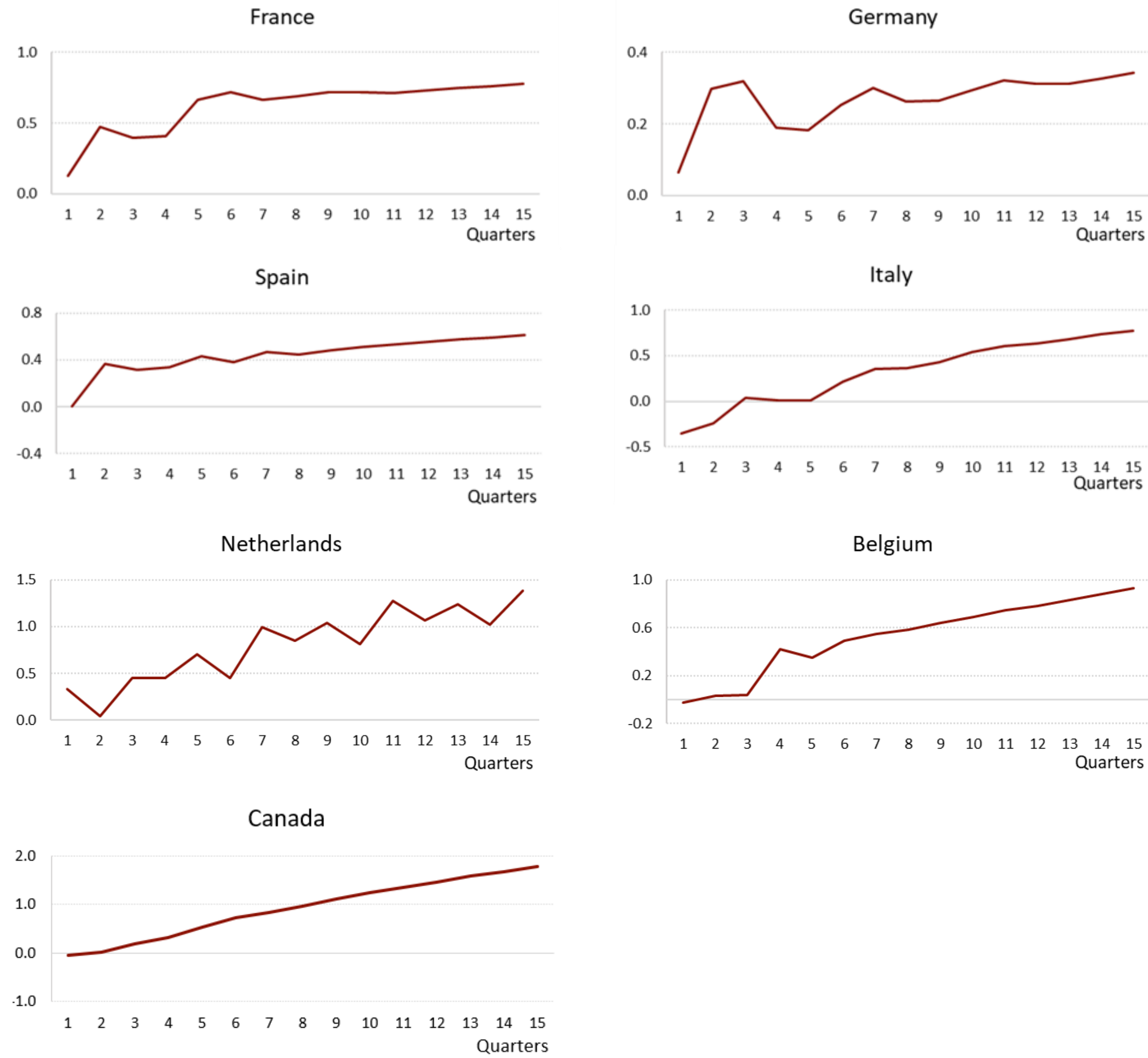
15. An exception is Belgium (and to a much lesser extent, Spain). We return to it later.

16. For evidence along these lines, see Blanchard and Riggi (2013).



Note: The figure shows the full-model, dynamic responses of inflation to a one-standard-deviation positive shock to the labor market tightness variable.
Sources: Bernanke and Blanchard (2023), Arce et al. (2024), Nakamura et al. (2024), Haskel, Martin, and Brandt (2023), Aldama, Le Bihan, and Le Gall (forthcoming), Menz (2024), Gomi, Hurtado, and Montero (2024), Pisani and Tagliabracci (forthcoming), Bonam, Hebbink, and Pruijt (2024), de Walque and Lejeune (2024), and Fares, Roc, and Zhang (2023).

Recall that the analytical model (figure 3) predicts that a tightening of the labor market leads to an initial increase in inflation, with inflation continuing to increase over time as dynamic effects come into play. For most economies in the project, the empirical impulse responses roughly fit the theoretically predicted pattern, but two characteristics of the empirical responses are worth noting.

First, the initial responses of inflation are often jagged, and second, they are small in many cases. The jagged initial responses can be interpreted as reflecting the fact that both the level and the rate of change of the measure of labor market tightness affect wage inflation.[17] The small initial response reflects the small sum of coefficients on the labor market variable in the wage equation, that is, in many countries the wage Phillips curve appears to be relatively flat.[18] For example, after four quarters (to look beyond the initial jagged pattern), the estimated effect of a one-standard-deviation increase in the vacancy-unemployment ratio on inflation varies from from 0.0 percent for Japan to 1.0 percent for the United States.[19]

The amplification mechanisms, which determine how fast inflation increases after the initial effects of the tightening of the labor market, are also empirically weak in most countries, so that inflation increases only slowly following a labor market tightening. Again, the amplification mechanisms can be enumerated (also see estimation results in the appendix):

First, empirically, expected inflation adjusts slowly to actual inflation, implying that inflation expectations remain largely anchored. Second, wage inflation adjusts only slowly to the increases in inflation expectations that occur. Third, there is again little or no evidence of the catch-up phenomenon. Fourth, wage inflation appears, empirically, to pass through only slowly to price inflation.

So, while the model is constructed so that it has a natural rate property (in this case, for the vacancy-unemployment ratio), which implies that a vacancy-unemployment ratio that remains above its natural rate leads to ever increasing inflation, empirically, in many economies, the implied increase in inflation is very slow. Indeed, the estimated parameters for the euro area imply that a steady increase in inflation to a tight labor market is not visible even after four years, although beyond this horizon (and not shown in the figure) simulated inflation increases steadily but slowly when labor markets remain tight.

In short, small direct and indirect effects of labor market tightness imply an impulse response function similar to the weak feedback case shown in figure 3, that is, a relatively small and slow increase in wage inflation, implying a small and slow increase in the price inflation induced by wage increases.

Historical Decompositions

Estimation and (system) simulations of the model allow us to decompose inflation in each quarter and for each country into components due to each of the exogenous variables and the equation residuals, with dynamic effects of exogenous shocks taken fully into account. Obtaining these decompositions for each of the eleven economies (figure 8) is the main contribution of this research project, as the decompositions both explain the sources of inflation in each country and provide a basis for policy recommendations.

The way to read figure 8 is as follows:

In each diagram, the solid black line shows actual (quarter on quarter, annualized) inflation. The different color bars show the contributions of various factors to inflation in each quarter, with bars extending below the x-axis corresponding to negative contributions. The contributions of the equation

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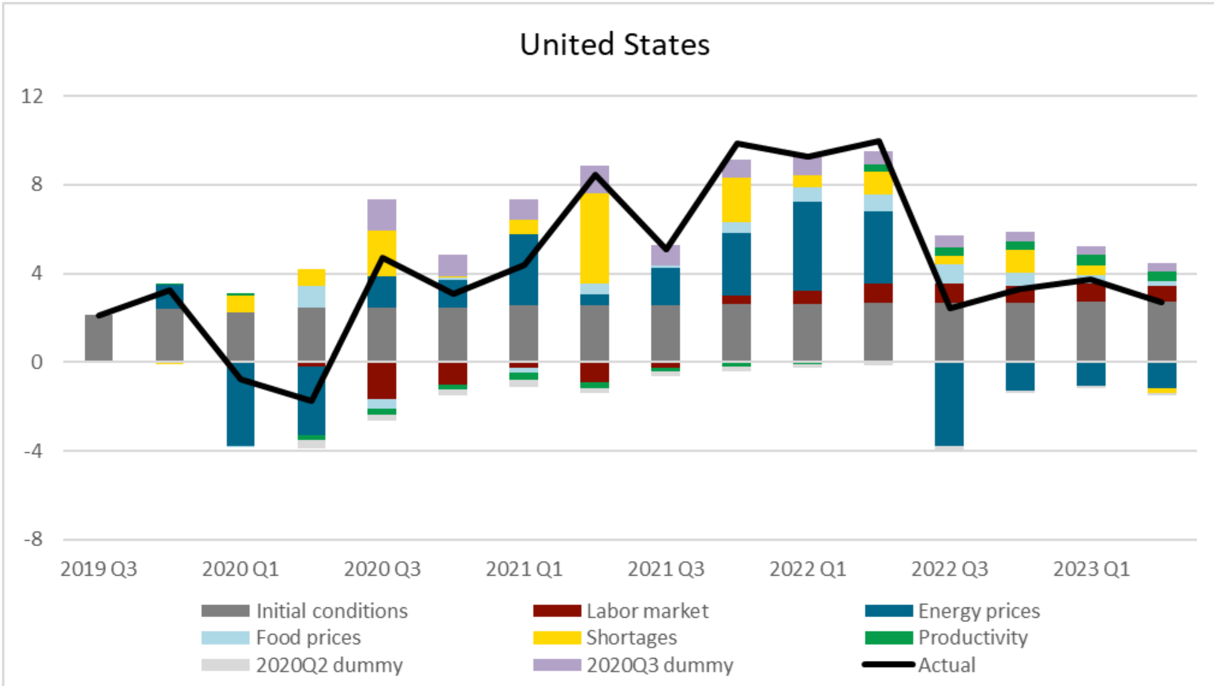
17. This is not specific to the use of the vacancy-unemployment ratio as the labor market variable. The same is true if one uses the unemployment rate. Traditional wage Phillips curve specifications often find an effect of not just the level but also the change in the unemployment rate on wage inflation.

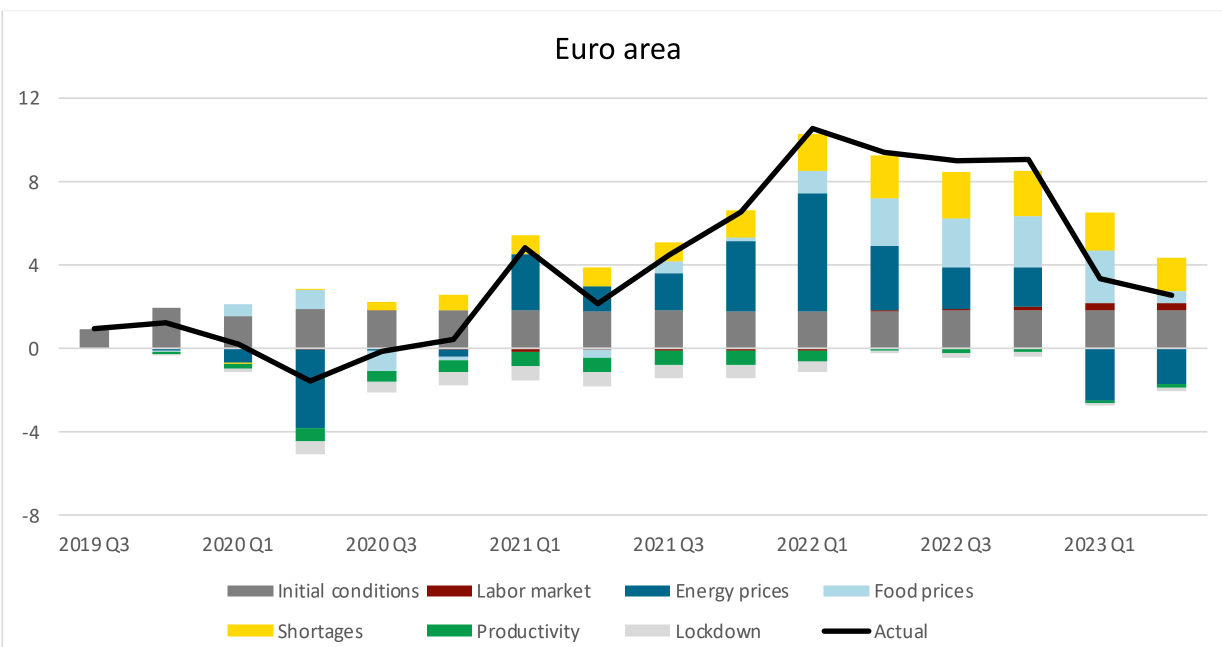
18. Estimation results suggest that the effect of labor market tightness on wage inflation is small but statistically significant; in 7 of the 11 economies, the sum of coefficients on the labor market variable in the wage regression is significant at the 5 percent level, and there is no evidence of a change in this sum during the pandemic, that is, after 2019Q4.

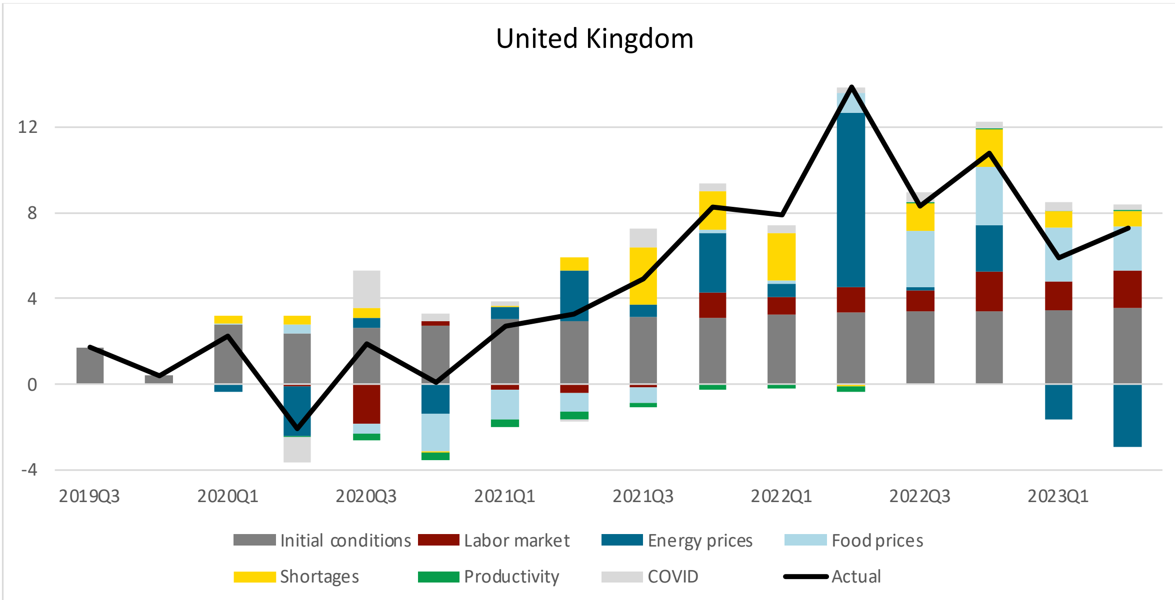
19. A one-standard-deviation increase in the vacancy-unemployment ratio is 0.26 for the United States. Based on the estimated coefficient of the vacancy-unemployment ratio in a regression of the unemployment rate on the vacancy-unemployment ratio over the 1990Q1 to 2019Q4 sample, −4.0, this implies a one-standard-deviation decrease in the unemployment rate of about 1 percentage point.

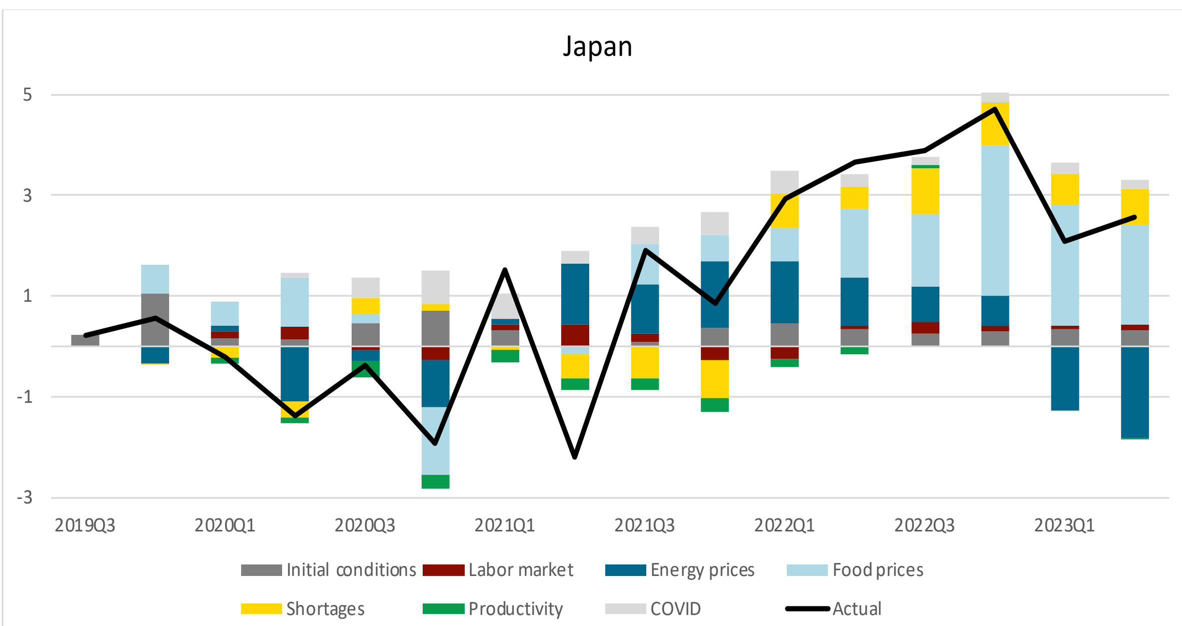
residuals are not shown, as they would be hard to interpret; if they were included, the estimated components of inflation would sum exactly to actual inflation.

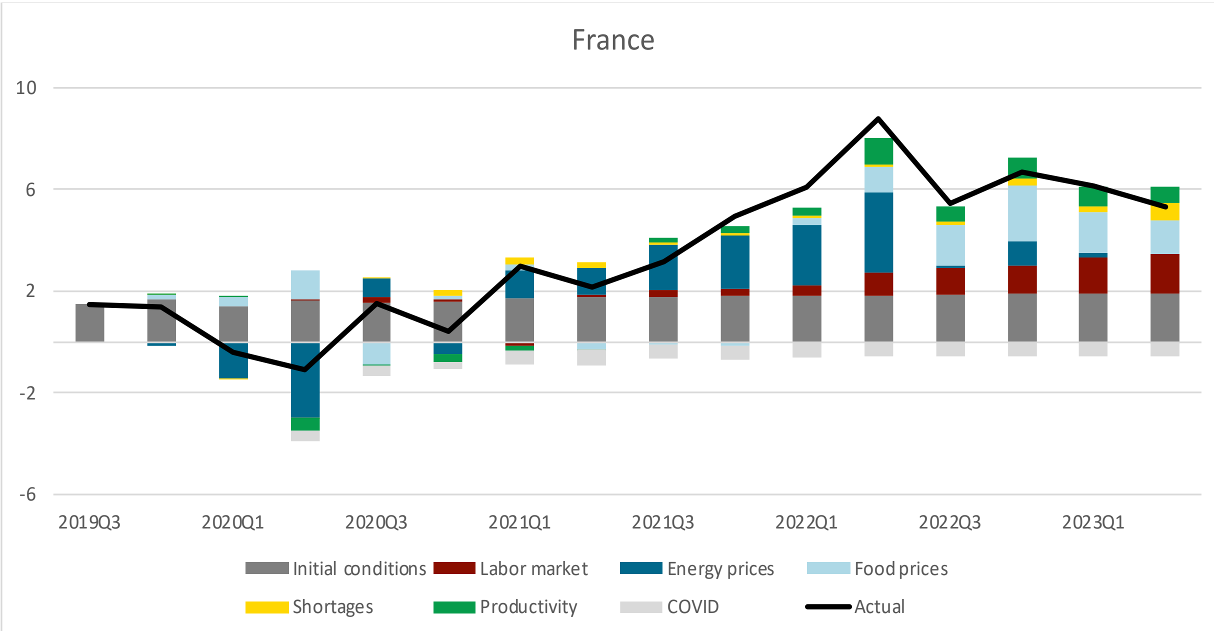
Figure 8. Historical decompositions of inflation, 2019Q3–2023Q2, percentage points

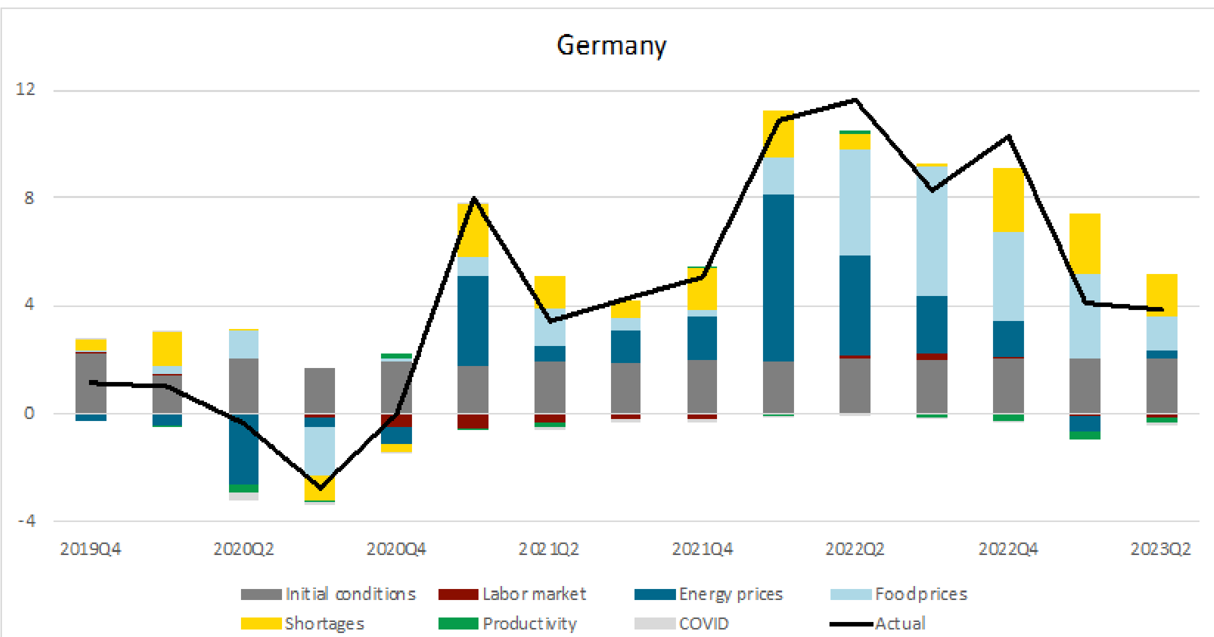





United Kingdom
12
8
4
0
-4
2019Q3
2020Q1
2020Q3
2021Q1
2021Q3
2022Q1
2022Q3
2023Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
COVID
Actual


Japan
5
3
1
-1
-3
2019Q3
2020Q1
2020Q3
2021Q1
2021Q3
2022Q1
2022Q3
2023Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
COVID
Actual


France
10
6
2
-2
-6
2019Q3
2020Q1
2020Q3
2021Q1
2021Q3
2022Q1
2022Q3
2023Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
COVID
Actual


Germany
12
8
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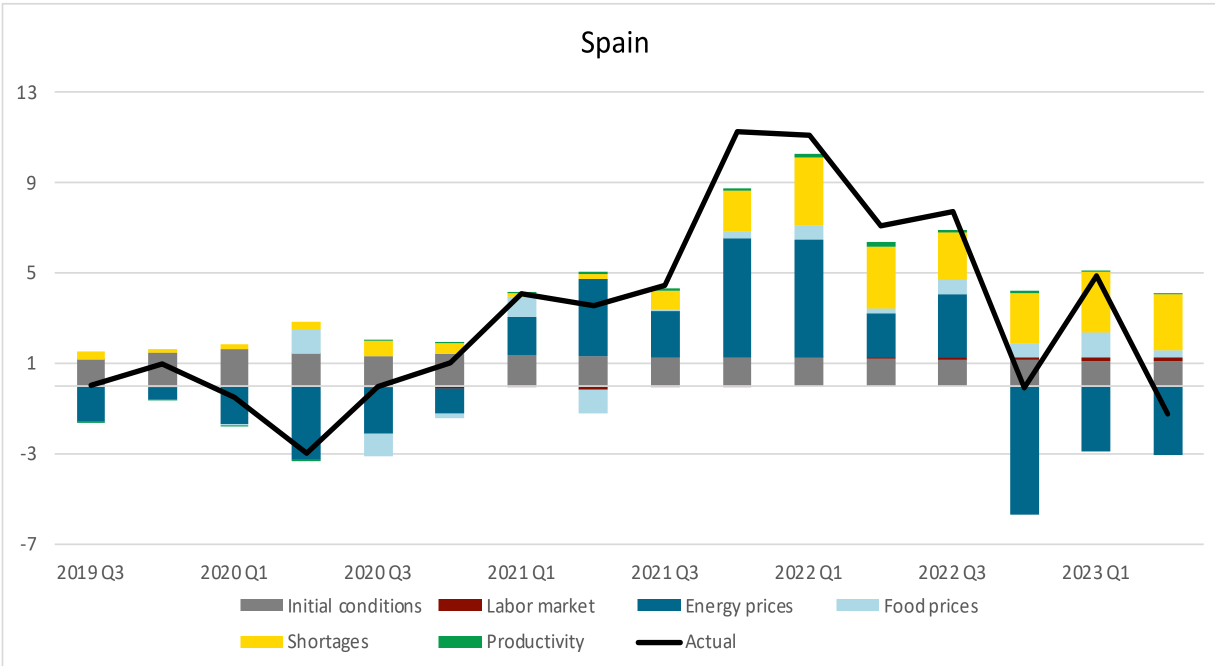
0
-4
2019Q4
2020Q2
2020Q4
2021Q2
2021Q4
2022Q2
2022Q4
2023Q2
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
COVID
Actual


Spain
13
9
5
1
-3
-7
2019 Q3
2020 Q1
2020 Q3
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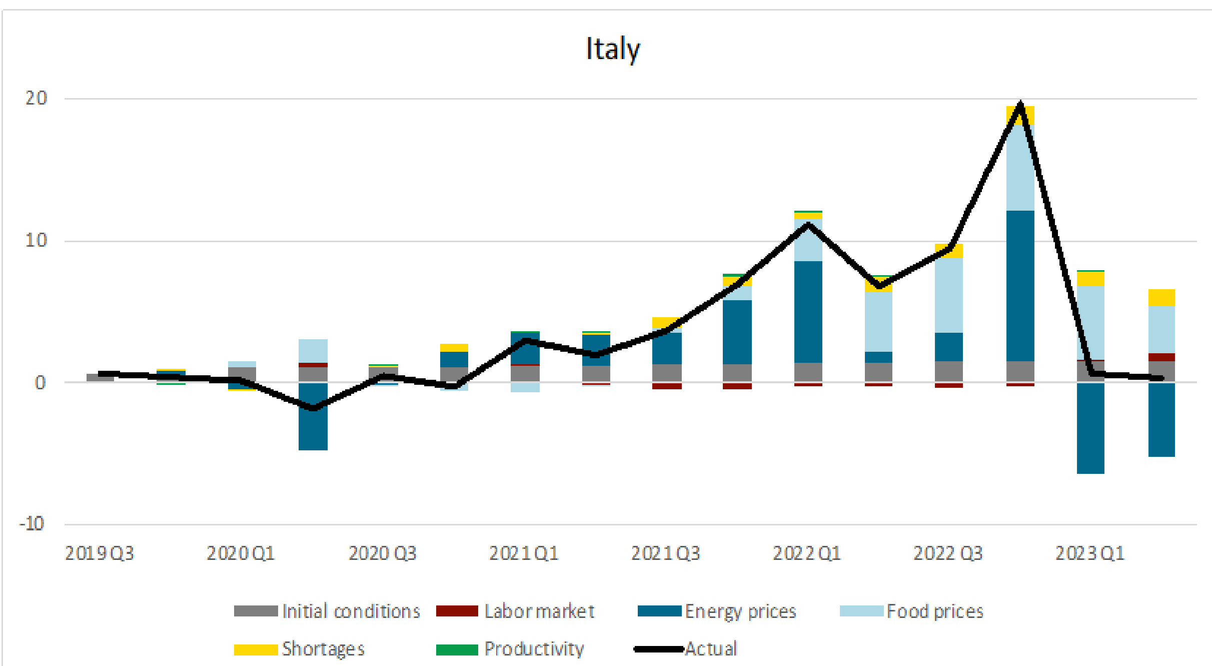
2021 Q3
2022 Q1
2022 Q3
2023 Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
Actual


Italy
20
10
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-10
2019 Q3
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2020 Q3
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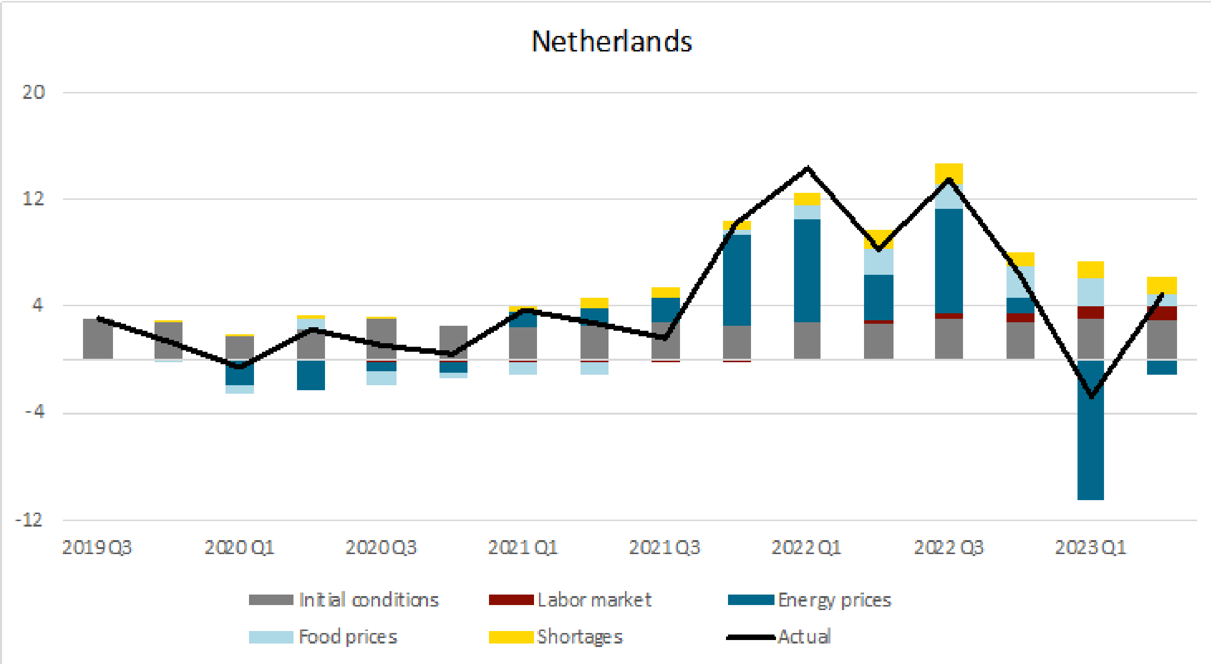
2021 Q3
2022 Q1
2022 Q3
2023 Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
Actual


Netherlands
20
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-12
2019 Q3
2020 Q1
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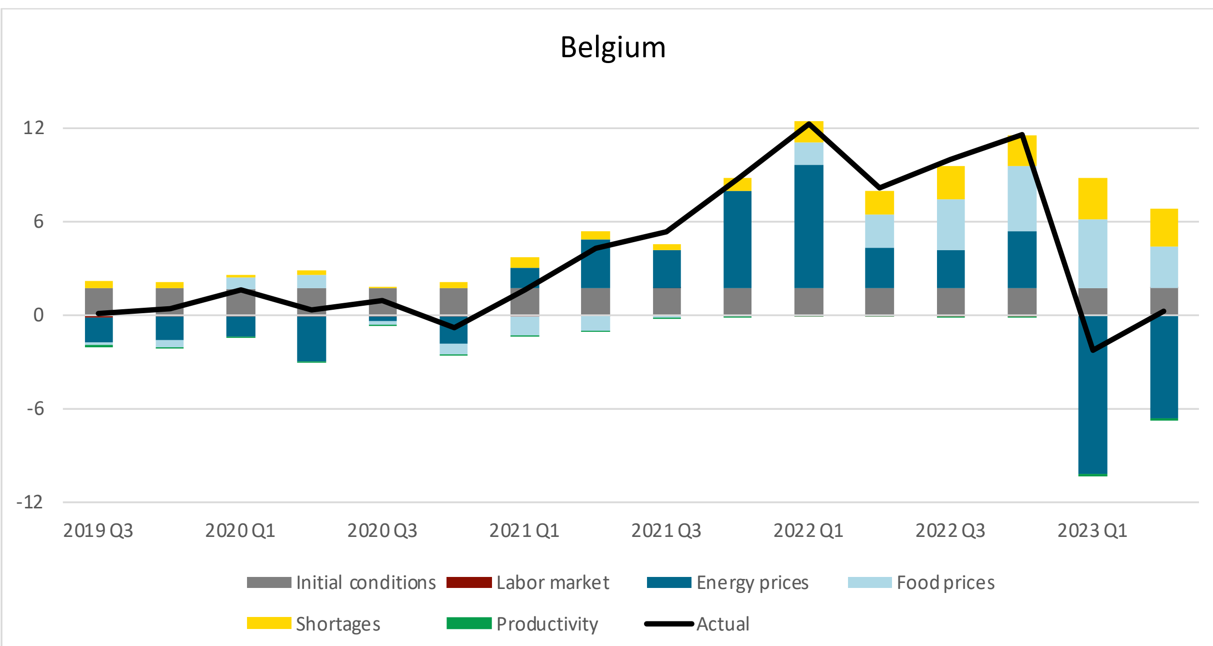
2021 Q1
2021 Q3
2022 Q1
2022 Q3
2023 Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Actual


Belgium
12
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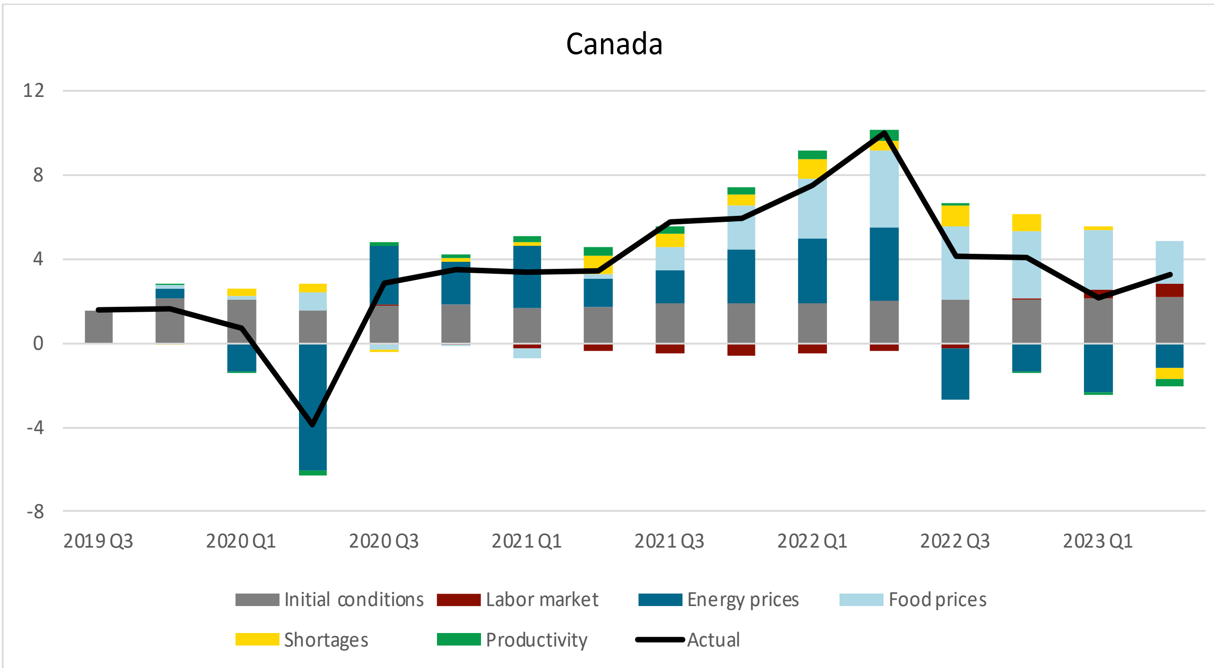
0
-6
-12
2019 Q3
2020 Q1
2020 Q3
2021 Q1
2021 Q3
2022 Q1
2022 Q3
2023 Q1
Initial conditions
Labor market
Energy prices
Food prices
Shortages
Productivity
Actual



Sources: Bernanke and Blanchard (2023), Arce et al. (2024), Nakamura et al. (2024), Haskel, Martin, and Brandt (2023), Aldama, Le Bihan, and Le Gall (forthcoming), Menz (2024), Gomi, Hurtado, and Montero (2024), Pisani and Tagliabracci (forthcoming), Bonam, Hebbink, and Pruijt (2024), de Walque and Lejeune (2024), Fares, Roc, and Zhang (2023).

The dark gray bars reflect the role of initial conditions, that is, what the model predicts would have happened if there had been no shocks from 2020Q1 on. Specifically, the component of inflation shown by the dark gray bar is what would have been expected if the relative prices of energy and food had remained the same as they were in 2019Q4, the measure of sectoral shortages had remained equal to its average value pre-COVID, productivity growth had not changed from its average value pre-COVID, and the vacancy-unemployment had remained equal to its value in 2019Q4.

Because the four equations of the model determine together a unique value of the vacancy-unemployment ratio consistent with constant inflation (absent shocks), the evolution of the dark gray bars in figure 8 tells us, for each country, where (according to the model) that ratio was relative to its natural rate before COVID struck. In most cases, the heights of the dark gray bars are nearly constant over time, implying that the vacancy-unemployment ratio for the economy in question was close to its natural level before the pandemic.[20] The main exception is the United Kingdom, where the effect on inflation of the initial conditions increases, suggesting that the UK economy was already overheating to some degree in 2019Q4. The United States and Canada show some small increase in inflation in the no-shock baseline.

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20. The usual warning about the precision of these conclusions applies here and below. The implicit assumption is that the estimated equations remained stable throughout the estimation period. Small missing trends in any of the equations, for example, might well lead to a different estimate of the implicit natural ratio in 2019Q4, and thus a different evolution of the contribution of initial conditions.

The other bars in the diagrams reflect the effects on inflation over time of shocks to the various exogenous variables. Again, the bars, being based on system impulse response functions, reflect both the direct and indirect effects of each of these variables on inflation over time. The dark blue bars represent both the direct and indirect effects of the rate of change of the relative price of energy on inflation; the light blue bars represent the effects of the relative price of food; the yellow bars capture the effects of shortages (measured as deviations from the pre-COVID sample mean); the green bars represent the effects of productivity growth (also as a deviation from its pre-COVID sample mean); and the red bars show the effects on inflation of labor market conditions, measured as the deviation of the vacancy-unemployment ratio from its 2019Q4 value. When the wage equation includes dummy variables for 2020Q2 and 2020Q3, their effects are also reported in the decomposition.

As the black line in each graph shows the actual path of the country's inflation rate, the differences between the vertical sums of the bars (some of them negative) and the black lines reflect the combined direct and indirect effects of the four equation residuals. As can be seen, that difference is typically small, reflecting a good fit of the estimated equations and thus a reasonably comprehensive accounting of the sources of inflation in each economy.

Commonalities

Our main conclusions are that (i) with some adjustments for institutional and policy differences, the basic model works reasonably well for all economies and (ii) estimation of the model produces surprisingly similar decompositions across economies. In particular, in each of the participating economies, the model implies that the inflation dynamics of recent years have been dominated by repeated price shocks—most importantly, energy price shocks. Energy prices typically contributed negatively to inflation in 2020, very positively in 2021 and most of 2022, and negatively thereafter. Interestingly, food price shocks have had a different pattern: their contributions to inflation were small until 2022, then consistently positive in 2022 and even more so in 2023.

One might have expected that supply disruptions and shortages would play an important role during the acute COVID phase, with less effect thereafter. However, for most countries the estimation results suggest that supply problems and shortages had little effect on inflation in 2020 but have made consistently positive contributions thereafter. Indeed, supply issues were still making significant contributions to inflation in 2023Q2, the last quarter covered by the decompositions.

As noted above, as the pandemic-induced disruptions dissipated, the labor market in many countries became tighter—in nearly all cases, tighter than the pre-COVID period by the end of the sample. Nevertheless, the decompositions show that, the labor market generally played a limited role in the evolution of price inflation. The contributions of labor market conditions to inflation, shown by the red bars in figure 8, are consistently smaller than those of price shocks, typically near zero or negative in 2020, then positive but small by 2022 and 2023. Indeed, the contribution of labor market tightness to inflation is found to be nearly equal to zero in five countries: Germany, Italy, Japan, Spain, and Belgium. The relatively weak effect reflects primarily the flatness of wage Phillips curves in the participating economies, discussed earlier.[21]

The decompositions also serve as a warning about extrapolating inflation based on quarter-to-quarter movements. The shocks to inflation, especially price shocks, are volatile, and their effects—both direct and indirect—can obscure lower-frequency trends. For example, in the United States in 2023Q2, energy price

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21. In the case of Belgium, the effect of the vacancy-unemployment ratio on wage inflation is relatively large and significant. But, as discussed below, there is limited pass-through of wage inflation to price inflation, so the effect on price inflation is small.

declines accounted for a 1.2 percentage point drop in inflation (at annual rates) while higher food prices worked the other way; in Japan, for the same quarter, the effect of the energy price decline (1.8 percentage points) was fully offset by an increase in food prices (which made a contribution to inflation of 2.0 percentage points); in Italy, the contributions to inflation in that quarter were −5.2 percentage points from energy but 3.6 percentage points from food! Discerning the inflation trend through this noise requires close attention to the composition of the shocks to the price level.

To repeat the main theme of this paper, the historical decompositions for most countries point to sequences of strong price shocks with limited dynamic effects as explaining most of the increase and later decrease in the recent inflation. Labor market tightness, together with a small increase in long-run inflation expectations, has led, in some countries, to a slow buildup of wage inflation. As price shocks have partly reversed, the contribution of the labor market has become relatively larger, although inflation is still buffeted by positive and negative price shocks.

An encouraging finding is that there is little evidence, in any economy, that a wage-price or price-wage spiral emerged. In this sense, the episode is clearly different from the high-inflation episodes of the 1970s, when increases in the prices of oil and other commodities led to demands for higher nominal wages, which in turn led to high and persistent inflation. Presumably, the credibility of central banks and institutional factors such as the absence of indexation in nearly all countries made this inflation episode very different from that of 50 years ago.[22]

Returning to the debate with which we introduced the paper: Who was right, Team Transitory or Team Permanent? Team Transitory was right that shocks to prices (e.g., for energy and food) would have short-lived effects on inflation, but it did not anticipate the sequence of large price shocks that together created an extended period of inflation. Team Permanent was right to worry about labor market tightness but significantly overestimated its likely contribution to the inflation early on. As price shocks have receded, inflation has indeed fallen substantially; but, with labor markets not yet back in balance, the worries of Team Permanent may yet become relevant, as we discuss in the next section.

Differences

We have so far focused on commonalities, but there are interesting differences across economies as well.[23]

For example, countries started with very different initial conditions, including inherited inflation levels. We saw that the United Kingdom showed signs of overheating even before COVID. In most countries, however, the estimation results suggest that labor market conditions were roughly at their sustainable ("natural") level in 2019Q4, though the associated levels of inflation before the pandemic were quite different. Notably, based on its estimated initial conditions, Japan entered the pandemic with an inherited inflation rate of 0.5 percent, helping to explain why Japanese inflation remained below 5 percent throughout the period.

Some have suggested that, notwithstanding the dominance of price shocks, labor market tightness was more important in the United States than in the euro area where inflation was mostly imported. The decompositions support this distinction, with a very limited role of labor market conditions in the euro area.

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22. Note that our estimation sample starts in 1990 and so cannot directly address the inflation of the 1970s. It would be interesting to estimate the same model on the earlier sample and compare coefficients, although data issues (e.g., lack of data on inflation expectations) pose an important barrier.

23. The same warning as before: Some of the differences may reflect noise in estimation rather than true underlying differences.

In contrast, the contributions of energy prices have been rather similar, although results for the euro area as a whole hide substantial differences among euro members, differences that appear to reflect in large part differences in fiscal subsidies intended to cap energy prices. For example, in the first three quarters of 2022, the sum of the contributions (direct and indirect) of energy prices to inflation was 5.6 percentage points for France, 12.1 percentage points for Germany, and 9.9 percentage points for Italy. These differences suggest that understanding cross-sectional differences in inflation behavior requires a closer look at the effects of energy subsidies and other fiscal policies aimed at limiting costs to households and firms.[24]

Japan has had lower inflation, as noted; it also had a smaller *increase* in inflation, an increase that appears to have been almost entirely imported. The labor market has played little or no role in Japanese inflation, with no increase in the vacancy-unemployment ratio, and, based on the country team's estimates, a very flat wage Phillips curve (for full time workers).

In contrast to the other countries, the main price shocks in Japan have come from the price of food rather than the price of energy, especially since the end of 2022. This difference reflects both the government's measures to directly limit the increase in the price of gas and electricity during this period and the large share of food in the Japanese CPI (25 percent). Because Japan imports much of its food, those prices were also increased by the large depreciation of the yen (by nearly 50 percent against the dollar since the start of the pandemic), although of course that factor affected the prices of energy and other imports as well. Note also that inflation has subsided in Japan even though the central bank did not raise interest rates, suggesting a nearly pure scenario of price shocks, with limited dynamic effects.

Belgium is also an interesting case in that it is the only country in the panel to still have widespread wage indexation. Based on the experience of the 1970s, one would have expected this institutional feature to result in a stronger wage-price interaction and higher inflation, but this has not been the case. Cumulative wage inflation in Belgium has indeed been higher than for the euro area: 17.8 percent over the period 2019Q4 to 2023Q2, versus 7.5 percent for the euro area over the same period. But cumulative price inflation has been roughly the same, 15.6 percent in Belgium versus 15.8 percent in the euro area. Put another way, the increase in wage inflation in Belgium has been accompanied by a substantial decrease in profit margins. The inability of Belgian firms to raise prices by as much as wages likely reflects the fact that Belgium is a small open economy operating under fixed exchange rates in the euro area. (The ratio of Belgian exports to GDP is 95 percent, and 65 percent of exports are to the rest of the European Union.[25]) The decrease in profit margins may, however, affect investment and have longer-lasting effects than our analysis can capture.

III. Implications and Conclusions

For the last part of the project, each team performed a conditional forecast exercise, starting from the positions of their respective economies in 2023Q2. Assuming that, starting in 2023Q3, there would be no further price shocks and that shortages and productivity growth would equal their pre-COVID average,

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24. This issue is explored in Dao et al. (2023).

25. Our conclusion of limited pass-through is in contrast with Gagliardone et al. (2023), who, using a panel dataset for 1999–2019 (i.e., pre-COVID), conclude that the pass-through from marginal cost to production prices in manufacturing was high in Belgium during that period. Differences in the period examined—in wage versus marginal cost, production prices versus consumption prices, and manufacturing versus the whole economy—may explain the difference.

the country teams used their estimated models to forecast inflation, based on initial conditions in 2023Q2 and the values of the vacancy-unemployment ratio prevailing in each country at that time.

The conclusion for most countries was that the vacancy-unemployment ratio had to decrease substantially (that is, labor markets had to come into better balance) to bring inflation to target. For example, for the United States, assuming that the ratio remained the same as in 2023Q2 implied that inflation would stabilize at 3.5 percent; in contrast, a decrease in the ratio to its pre-COVID value of 1.2 percent would lead to a decrease in inflation to 2.8 percent at the end of 2024. A further decrease would be needed to get inflation down to 2 percent by the end of 2024. (Note that these figures refer to CPI inflation; the Fed targets a different measure of inflation that tends to run a bit lower.) For the euro area, while inflation was projected by the estimated model to dip temporarily to 2 percent in 2024, the model suggested that maintaining that level would also require a decrease in the vacancy-unemployment ratio below its pre-COVID value for some time. The reason that further reductions in labor market tightness were required in these two regions and in other economies, according to the model, was again the flatness of the wage Phillips curve. Tight labor markets had not contributed very much to the increase in inflation in most economies, but, symmetrically, looser labor markets would not reduce inflation very quickly.

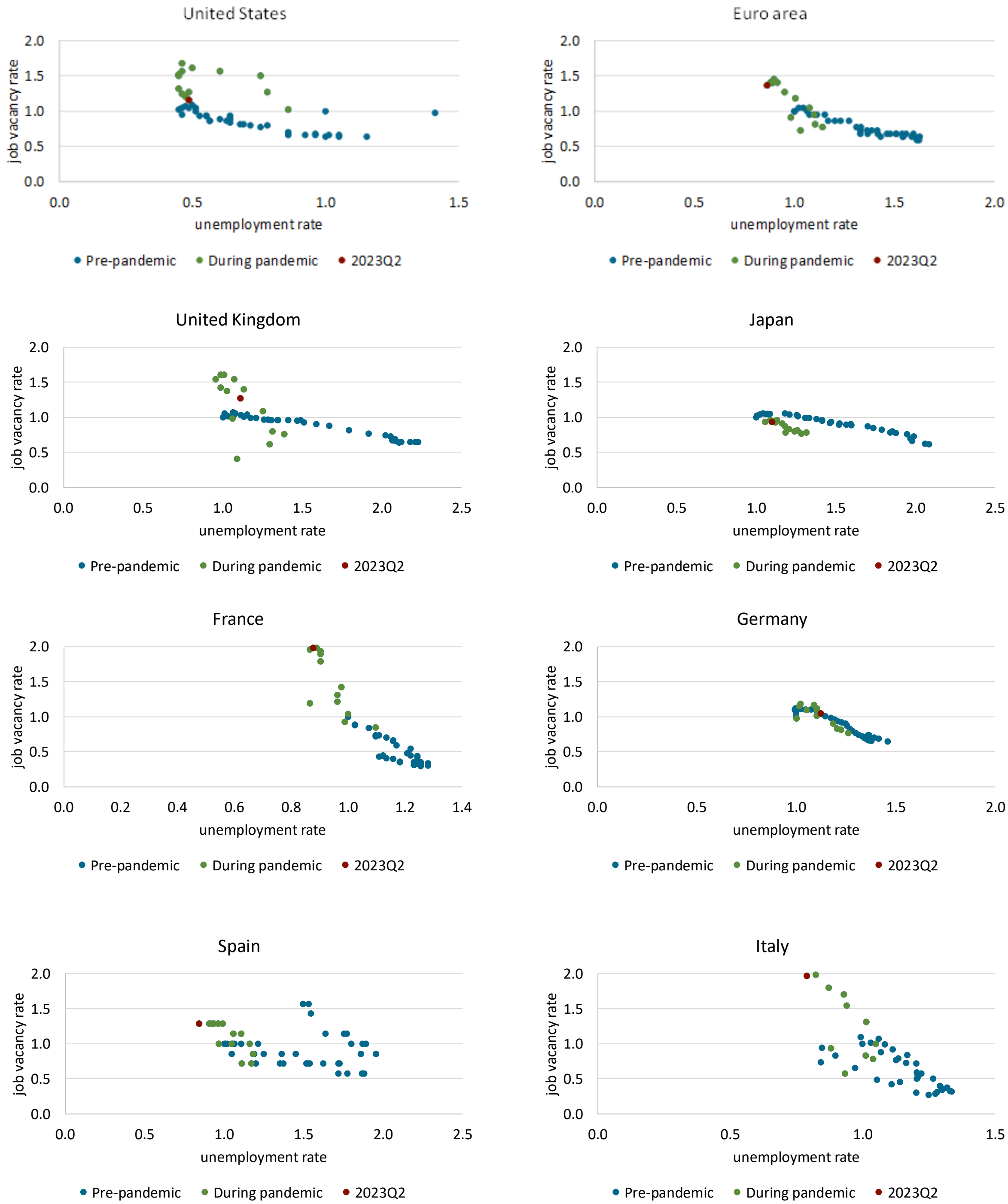
These conditional forecasts are now more than nine months old and thus obsolete. But they raise an important issue that is still relevant at the time we write. The issue is that most of the decrease in inflation from its peak has been due to the reversal of shocks to prices rather than cooling in labor market conditions. To the extent that wage inflation was still too high in mid-2023 to be consistent with central bank targets, and that wage inflation is relatively sticky, the last mile might be more difficult to achieve than the earlier gains against inflation.

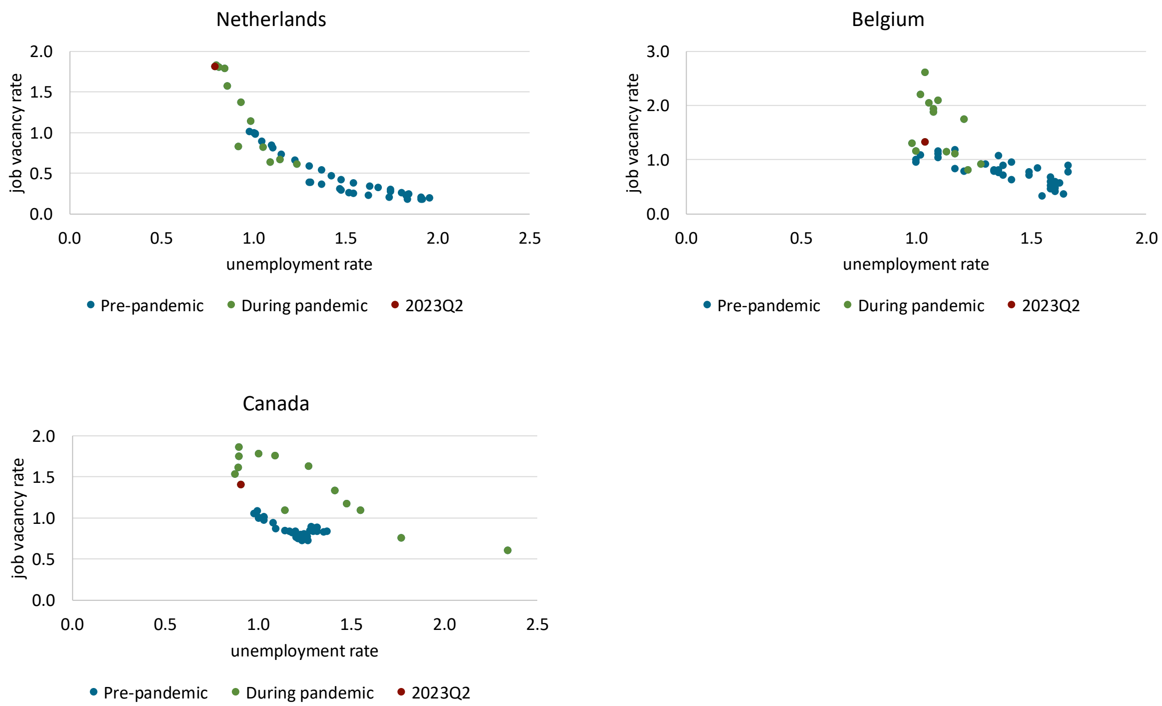
Precisely how costly the last mile might be is not yet resolved. In several, although not all, countries, the decrease in inflation in the second half of 2023 was larger than projected by the model's conditional forecasts or by professional forecasters outside of central banks. In the United States in particular, productivity growth has recently been strong, making higher wage inflation potentially more consistent with price inflation at target. We have not extended the project to assess how much of the decrease in inflation since mid-2023 can be attributed to better productivity growth, more favorable price shocks, or unexplained residuals, in particular in the wage equation. Doing so will have to wait until the inflation episode is fully behind us.

Suppose we stipulate nevertheless, per the model, that returning inflation the rest of the way to target will require further decreases in the ratio of vacancies to unemployment. The question is what that decrease implies for the unemployment rate itself, which is the variable most observers care about.

The relation between vacancies and unemployment (and thus between the vacancy-unemployment ratio and the unemployment rate) is known as the Beveridge curve. This curve, drawn in vacancy-unemployment space, is typically convex and downward sloping: a decrease in vacancies typically comes with an increase in unemployment. Equivalently, a decrease in the ratio of vacancies to unemployment, characteristic of looser labor market conditions, typically comes with both a decrease in vacancies and an increase in unemployment. One of the contributions of this project has been to examine the Beveridge curve relation in each economy. The evidence is shown in figure 9, which plots the vacancy rate against the unemployment rate (both normalized) for each participating country. The blue dots correspond to the period 2011Q1 to 2019Q4, the green dots to 2020Q1 to 2023Q1, and the red dot to 2023Q2.

Figure 9. Beveridge curves, pre-pandemic (2011Q1–2019Q4), during pandemic (2020Q1–2023Q1), and 2023Q2





Note: Both vacancy rate and unemployment rate are normalized to 1 at 2019Q4.
Sources: National statistics, Eurostat, and authors' calculations.

As the figure shows, there is a striking difference in the behavior of the Beveridge curve in the United States and Canada on the one hand, and in the other economies on the other. The United States and Canada both experienced large increases in their unemployment rates at the start of COVID, and then a movement back along a higher Beveridge curve than before. That is, both countries showed a strong upward shift in the Beveridge relation during the pandemic, implying that a given unemployment rate corresponded to a higher vacancy-unemployment ratio than before the pandemic. The other economies in our panel do not show comparable shifts. For example, the Beveridge relation in the euro area seems to have remained roughly unchanged, and in Japan, if anything, the curve seems to have shifted slightly lower during the pandemic. We are not aware of any systematic attempt yet to explain these differences. One place to look for an explanation might be in the differences in labor market policies pursued by various countries during the pandemic.

As of 2023Q2, then, the question in the United States and Canada was a straightforward one: Would the shifts in the Beveridge curve be permanent or temporary? If the original shifts upward proved permanent, then reducing the vacancy-unemployment ratio by enough to bring inflation to target could involve a significant increase in unemployment. In contrast, if the Beveridge curve shifts reversed, reducing the unemployment rate associated with any given vacancy-unemployment ratio, then bringing down that ratio might be done with little impact on unemployment.

The evidence since mid-2023 suggests that, in Canada and the United States, the initial shift has largely reversed, as vacancy rates have decreased while unemployment rates have remained roughly stable.[26] If the shift fully reverses (i.e., the two Beveridge curves return to their prepandemic positions) then the cooling of labor markets, as measured by the decrease in the vacancy-unemployment ratio, needed to return inflation to 2 percent may require only a limited increase in unemployment. Coupled with higher-than-expected sustained productivity growth, it might even require no increase in unemployment. The evolution of the shift in the Beveridge curve, and the persistence of higher productivity growth, are two of the most important dimensions of uncertainty facing the Fed today. In contrast, in economies where the Beveridge curve has remained stable but a meaningful decrease in the vacancy-unemployment ratio is needed to control inflation, successfully navigating the last mile may require accepting an increase in unemployment, at least for some time.

Conclusions and Extensions

Our joint project with ten central banks, unprecedented to our knowledge, has cast light on some important aspects of the recent inflation episode. The inflation appears explainable by a simple model, and for most economies, the model tells a consistent story. In sum, early on, the sharp inflation experienced by most countries was accounted for by shocks directly and indirectly affecting price levels, including rising commodity prices, shortages of specific goods, and, in some cases, reduced labor supply. Labor markets became tight almost everywhere but played almost no role in the inflation takeoff. However, the inflation effects of tight labor markets are persistent, so that, as the shocks to prices (e.g., for energy and food) have reversed, the wage pressures from hot labor markets have become a more important source of inflation. In most countries, traversing the last mile back to central bank inflation targets will likely require bringing labor markets into better balance by reducing vacancy-unemployment ratios. The extent to which labor market cooling results in higher unemployment depends importantly on both the slope of the wage Phillips curve and the slope and position of the Beveridge curve. In countries such as the United States, where the Beveridge curve appears to be shifting down toward its prepandemic position, the unemployment costs of the last mile could be limited.

Future research might profitably concentrate further on the differences among the participating economies as well as the commonalities. For example, it would be interesting to better understand how inflation was affected by differences in government policies regarding energy subsidies and caps, and by policies for supporting workers and firms during the pandemic.

Another direction for future research is to model the role of key variables that we have treated as exogenous in this iteration of the model. For example, had fiscal policy in various countries (most notably the United States) been less generous, would global energy and food prices have been noticeably lower and shortages less severe? How much higher would unemployment have been?

Of more narrow interest would be the reconciliation of the estimates for the euro area as a whole and those of euro area member countries. Estimated wage equations differ substantially across the countries, suggesting that aggregation may be misleading. A first step toward resolving the issue was taken by the German team, who used a panel data approach with country fixed effects (the results are reported in their paper). But panel estimation with fixed effects may not go far enough if, for example, the response of wage inflation to labor market tightness or other variables varies significantly across countries.

Finally, it would be worth digging further into the role of productivity growth. Our decompositions did not attribute much inflation or disinflation to productivity growth, but this may be an artifact of a

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26. One of the authors (Blanchard) is on record as arguing that much of the shift would likely remain, and he has been proven wrong. The origins of the shift and of its reversal, as well as the absence of such a shift in other countries, is still to be determined.

poor specification. Productivity growth has differed across countries, with the United States in particular emerging from the pandemic with higher productivity growth than in the prepandemic period, whereas productivity growth has remained low in much of Europe. Whether these productivity trends persist will be an important factor in the evolution of unit labor costs and thus, indirectly, a key determinant of the costs of the last mile back to inflation targets.

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APPENDIX

The analytical model in BB is composed of four equations.

The wage equation has two components.

The first gives the nominal wage w, as a function of the expected price level p^e, and the aspiration real wage ω^A, all in logs, and a generic measure of labor market tightness x:

$$w = p^e + \omega^A + \beta x$$

The second gives the aspiration wage ω^A as a linear combination of the lagged aspiration wage, $\omega^A(-1)$, the actual lagged real wage $w(-1) - p(-1)$, and a generic wage shock z_w:

$$\omega^A = \alpha\omega^A(-1) + (1-\alpha)\big(w(-1) - p(-1)\big) + z_\omega$$

Combining the two gives the wage equation:

(1) $w - w(-1) = \big(p^e - p(-1)\big) + \alpha\big(p(-1) - p^e(-1)\big) + \beta\big(x - \alpha x(-1)\big) + z_w$

The price equation gives the price level p as a function of the nominal wage w, both in logs, and a generic measure of price shocks z_p:

$$p = w + z_p$$

Taking first differences gives the price equation:

(2) $p - p(-1) = (w - w(-1)) + (z_p - z_p(-1))$

Short-run inflation expectations $\big(p^e - p(-1)\big)$ are assumed to be a function of long-run inflation expectations $\pi^*$and of past inflation:

(3) $p^e - p(-1) = \delta\pi^* + (1-\delta)(p(-1) - p(-2))$

Long-run inflation expectations are assumed to be a function of themselves lagged and of past inflation:

(4) $\pi^* = \gamma\pi^*(-1) + (1-\gamma)(p(-1) - p(-2))$

Given wage and price shocks and labor market tightness, these four equations determine the dynamics of price and wage inflation as well as short- and long-run inflation expectations.

The impulse response presented in figure 2 shows the response of inflation to a positive price shock, for example an increase in the relative price of energy, for two different sets of values of the parameters. The impulse response presented in figure 3 shows the response of inflation to a tightening of the labor market, again for two different sets of values of the parameters.

The **quarterly empirical model** that we estimated in BB and in this project has the same structure, but a more generous lag structure.

The **wage inflation equation** is

$$gw_t = \alpha + \sum_{k=1,2,3,4} \alpha_k^{gw} gw_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{gpesr} gpesr_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{VU} (v/u)_{t-k}$$
$$+ \sum_{k=1,2,3,4} \alpha_k^{catchup} catchup_{t-k} + \alpha_{pty} mapty_{t-1} + \alpha_{d1} D2020{:}\,2 + \alpha_{d2} D2020{:}\,3 + u_t^{gw}$$

Wage inflation depends on lagged wage inflation, lagged expected short-run inflation, the lagged ratio of vacancies to unemployment (or, for countries for which this ratio is not available, a closely related variable), taken as the measure of labor market tightness, the lagged catch-up variable, constructed as the sum of unexpected inflation over the previous 4 quarters, an 8-quarter moving average productivity growth, and, in some countries, two dummies to capture the unusual movements in wages in 2020Q2 and 2020Q3.

The **price inflation equation** is

$$gp = \beta + \sum_{k=1,2,3,4} \beta_k^{gp} gp_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{w} gw_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{shortage} shortage_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpe} grpe_{t-k}$$
$$+ \sum_{k=0,1,2,3,4} \beta_k^{grpf} grpf_{t-k} + \beta_{mapty} mapty_{t-1} + u_t^{gp}$$

Price inflation depends on lagged price inflation, lagged wage inflation, a moving average of productivity growth, and three measures of price shocks: the rate of growth of the price of energy relative to the wage, the rate of growth of the price of food relative to the wage, and a measure of shortages, based on Google trends (or, in some countries, alternative variables or synthetic measures).

The **short-run inflation expectation equation** is

$$gpesr_t = \sum_{k=1,2,3,4} \phi_k^{gpesr} gpesr_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gpelr} gpelr_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gp} gp_{t-k} + u_t^{gpesr}$$

Short-run inflation expectations depend on themselves lagged, on lagged long-run expectations, and on current and lagged actual inflation. There is no constant term.

The **long-run inflation expectation equation** is

$$gpelr_t = \sum_{k=1,2,3,4} \theta_k^{gpelr} gpelr_{t-k} + \sum_{k=0,1,2,3,4} \theta_k^{gp} gp_{t-k} + u_t^{gpelr}$$

Long-run inflation expectations depend on themselves lagged, and on current and lagged actual inflation. There is no constant term.

The four equations are constrained by homogeneity restrictions, which imply no long-run tradeoff between inflation and activity:

$$\sum_{k=1,2,3,4} \alpha_k^{gw} + \sum_{k=1,2,3,4} \alpha_k^{gpesr} = 1$$

$$\sum_{k=1,2,3,4} \beta_k^{gp} + \sum_{k=0,1,2,3,4} \beta_k^{w} = 1$$

$$\sum_{k=1,2,3,4} \theta_k^{gpelr} + \sum_{k=0,1,2,3,4} \theta_k^{gp} = 1$$

$$\sum_{k=1,2,3,4} \phi_k^{gpesr} + \sum_{k=0,1,2,3,4} \phi_k^{gpelr} + \sum_{k=0,1,2,3,4} \phi_k^{gp} = 1$$

The results of estimation of each equation are given in the following four tables. In some cases, the country team explored several specifications (e.g., alternative choices of the wage variable). The tables present the results of the specification emphasized by the country team and used to construct the impulse response functions and decompositions shown in the text. The reader is referred to the country papers for more details.

For each equation and variable, the tables give the estimated sum of coefficients and the *p*-value associated with the hypothesis that the sum or the set of coefficients is equal to zero. For each equation, they also give the *p*-value associated with the homogeneity hypothesis and with subsample stability. Table A1 reports two wage equations for Japan, for full- and part-time workers; the equation used in the model simulations is based on a regression of a weighted average of both wages on its determinants.

Table A1. Wage growth regressions

	United States	Euro area	United Kingdom	Japan (full-time)	Japan (part-time)	France	Germany	Spain	Italy	Netherlands	Belgium[a]	Canada
Lagged wages												
sum of coefficients	0.544	0.309	0.602	0.778	0.177	0.781	0.305	0.680	0.455	0.048	-0.425	0.836
p (sum)	0.000	0.126	0.000	0.000	0.251	0.000	0.113	0.000	0.021	0.874	0.074	0.000
p (set)	0.004	0.285	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000
Expected inflation												
sum of coefficients	0.456	0.691	0.398	0.222	0.823	0.219	0.695	0.320	0.545	0.952	1.425	0.164
p (sum)	0.003	0.001	0.000	0.003	0.000	0.113	0.000	0.013	0.006	0.002	0.000	0.015
p (set)	0.035	0.000	0.001	0.073	0.000	0.011	0.006	0.000	0.052	0.001	0.000	0.140
Labor market variable												
sum of coefficients	0.688	0.064	2.364	-0.070	0.934	0.056	0.256	-0.006	0.399	0.034	0.944	1.533
p (sum)	0.012	0.566	0.016	0.636	0.003	0.552	0.101	0.985	0.030	0.005	0.001	0.024
p (set)	0.000	0.147	0.007	0.841	0.028	0.000	0.113	0.228	0.023	0.000	0.013	0.193
Catch-up												
sum of coefficients	-0.021	0.066	0.088	-0.022	-0.202	0.061	0.011	0.263	-0.137	-0.275	0.735	-0.018
p (sum)	0.727	0.595	0.510	0.797	0.219	0.510	0.952	0.050	0.292	0.155	0.093	0.831
p (set)	0.886	0.003	0.260	0.608	0.234	0.969	0.823	0.016	0.250	0.270	0.374	0.833
Productivity												
coefficient	0.038	0.075	0.210	0.060	0.061	0.032	0.184	-0.086	0.098	0.208	0.011	0.081
p (coeff)	0.517	0.288	0.093	0.348	0.581	0.531	0.185	0.589	0.402	0.099	0.967	0.029
Dummy 2020Q2												
coefficient	-1.064	0.505	-2.786	0.049	0.239	-1.312	-0.802	n/a	n/a	n/a	1.106	-0.338
p (coeff)	0.157	0.402	0.115	0.928	0.814	0.008	0.532	n/a	n/a	n/a	0.039	0.509
Dummy 2020Q3												
coefficient	3.762	1.850	4.997	1.708	-2.311	-0.463	-0.098	n/a	n/a	n/a	n/a	-0.304
p (coeff)	0.001	0.017	0.050	0.009	0.065	0.451	0.964	n/a	n/a	n/a	n/a	0.662
p (homogeneity)	0.008	0.158	0.919	0.771	0.001	0.532	0.006	0.001	0.435	0.246	0.794	0.487
p (sample stability)	0.445	0.033	0.006	0.313	0.005	0.018	0.712	0.035	0.550	0.018	0.954	0.698
R^2	0.660	0.722	0.597	0.765	0.602	0.747	0.276	0.584	0.526	0.775	0.552	0.702
number of observations	134	89	134	119	117	114	110	94	90	90	105	118

a. Belgium uses employers' social contributions instead of dummies.

Sources: National statistics, authors' calculations, Nakamura et al (2024).

Table A2. Price growth regressions

	United States	Euro area	United Kingdom	Japan	France	Germany	Spain	Italy	Netherlands	Belgium	Canada
Lagged price											
sum of coefficients	0.333	0.687	0.703	0.295	0.436	0.657	0.940	0.346	0.436	0.908	0.576
p (sum)	0.037	0.000	0.000	0.198	0.002	0.000	0.000	0.165	0.005	0.000	0.000
p (set)	0.063	0.001	0.000	0.110	0.001	0.006	0.000	0.513	0.005	0.000	0.000
Wage											
sum of coefficients	0.667	0.313	0.297	0.705	0.564	0.343	0.060	0.654	0.564	0.092	0.424
p (sum)	0.000	0.060	0.000	0.002	0.000	0.063	0.672	0.010	0.000	0.274	0.002
p (set)	0.000	0.115	0.000	0.000	0.000	0.000	0.331	0.005	0.011	0.000	0.004
Energy prices											
sum of coefficients	0.066	0.038	0.005	0.046	0.066	0.047	0.031	0.058	0.074	0.012	0.030
p (sum)	0.000	0.040	0.768	0.019	0.000	0.044	0.218	0.028	0.001	0.309	0.136
p (set)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Food prices											
sum of coefficients	0.126	0.013	0.131	0.240	0.095	0.119	0.026	0.422	0.136	0.044	0.197
p (sum)	0.049	0.872	0.013	0.002	0.022	0.255	0.765	0.007	0.067	0.455	0.032
p (set)	0.048	0.000	0.000	0.000	0.000	0.000	0.213	0.000	0.001	0.000	0.000
Shortages											
sum of coefficients	0.019	0.210	0.036	0.043	0.183	0.261	0.173	0.275	0.007	0.114	0.004
p (sum)	0.225	0.034	0.375	0.153	0.186	0.076	0.259	0.071	0.060	0.075	0.778
p (set)	0.000	0.050	0.030	0.008	0.773	0.003	0.124	0.335	0.342	0.069	0.614
Productivity											
coefficients	-0.144	0.073	-0.221	n/a	-0.106	0.103	0.005	-0.008	-0.014	0.020	-0.031
p (coeff)	0.025	0.213	0.002	n/a	0.005	0.255	0.950	0.922	0.900	0.758	0.593
p (homogeneity)	0.459	0.515	0.659	0.495	0.117	0.000	0.018	0.426	0.167	0.000	0.001
p (sample stability)	0.000	0.000	0.753	0.000	0.000	0.000	0.000	0.000	0.001	0.039	0.629
R^2	0.947	0.974	0.888	0.838	0.944	0.911	0.831	0.956	0.870	0.965	0.865
number of observations	134	90	134	117	129	110	109	90	102	105	118

Sources: National statistics, authors' calculations, Nakamura et al (2024).

Table A3. Inflation expectations regressions, 1 year

	United States	Euro area	United Kingdom	Japan	France	Germany	Spain	Italy	Netherlands	Belgium	Canada
Lagged 1-year expectations											
sum of coefficients	0.295	0.719	0.841	0.981	0.805	0.297	0.823	0.816	0.762	0.649	0.588
p (sum)	0.032	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
p (set)	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000
10-year expectations											
sum of coefficients	0.569	0.079	0.143	0.018	-0.013	0.378	-0.187	0.128	0.188	0.120	0.256
p (sum)	0.000	0.022	0.012	0.154	0.752	0.000	0.154	0.071	0.009	0.006	0.000
p (set)	0.000	0.285	0.000	0.000	0.694	0.000	0.329	0.175	0.044	0.058	0.000
Price											
sum of coefficients	0.136	0.202	0.015	0.001	0.208	0.325	0.364	0.055	0.050	0.231	0.156
p (sum)	0.000	0.000	0.519	0.979	0.000	0.000	0.025	0.079	0.021	0.000	0.000
p (set)	0.000	0.000	0.027	0.016	0.000	0.000	0.001	0.000	0.000	0.000	0.000
p (homogeneity)	0.244	0.002	0.323	0.154	0.173	0.587	0.837	0.017	0.135	0.000	0.019
p (sample stability)	0.324	0.000	0.747	0.585	0.000	0.000	0.066	0.000	0.000	0.000	0.157
R^2	0.910	0.984	0.831	0.975	0.829	0.901	0.883	0.821	0.860	0.965	0.939
number of observations	134	93	134	123	110	110	94	93	110	109	118

Sources: National statistics, authors' calculations, Nakamura et al (2024).

Table A4. Inflation expectations regressions, 10 years

	United States	Euro area	United Kingdom	Japan	France	Germany	Spain	Italy	Netherlands	Belgium	Canada
Lagged 10-year expectations											
sum of coefficients	0.975	0.988	0.994	0.994	0.989	0.988	0.992	0.994	0.999	0.994	0.997
p (sum)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p (set)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Price											
sum of coefficients	0.025	0.012	0.006	0.006	0.011	0.012	0.008	0.006	0.001	0.006	0.003
p (sum)	0.040	0.005	0.640	0.396	0.054	0.038	0.005	0.059	0.840	0.071	0.404
p (set)	0.000	0.000	0.000	0.004	0.032	0.431	0.001	0.023	0.765	0.510	0.274
p (homogeneity)	0.116	0.851	0.078	0.646	0.336	0.446	0.712	0.855	0.209	0.129	0.633
p (sample stability)	0.465	0.134	0.717	0.829	0.001	0.021	0.073	0.295	0.362	0.607	0.854
R^2	0.932	0.830	0.944	0.908	0.863	0.826	0.894	0.913	0.752	0.853	0.893
number of observations	134	93	134	123	110	110	94	93	110	109	118

Sources: National statistics, authors' calculations, Nakamura et al (2024).

Table A5. List of variables, endogenous and exogenous

		United States	Euro area	United Kingdom	Japan
Endogenous variables					
gp	Price inflation	Quarterly annualized rates of change in the Consumer Price Index (CPI), Bureau of Labor Statistics (BLS)	Quarterly annualized rates of change in the quarterly average in the euro area (changing composition), Harmonized Index of Consumer Prices (HICP) Overall index, European Central Bank (ECB)	Quarterly annualized rates of change in the "All Items" CPI, seasonally adjusted by Bank of England (BoE) staff before changes calculated	Quarterly annualized rates of change in the CPI, Statistics Bureau of Japan
gw	Wage inflation	Rate of growth of nominal wages, quarterly and annualized, as measured by the rate of change in the BLS Employment Cost Index (ECI)	Rate of growth of nominal wages, quarterly and annualized, as measured by the rate of change in euro area (changing composition) negotiated wage growth (seasonally adjusted)	Quarterly and annualized changes in average weekly earnings. The team uses series for pay growth that has been adjusted for the furlough scheme to capture wage growth over the pandemic period	*Full-time:* Nominal wage per month (scheduled cash earnings), quarterly annualized change *Part-time:* Nominal wage per month (scheduled cash earnings/hours worked), Monthly Labor Survey, Ministry of Health, Labor, and Welfare of Japan

cf1	Short-term inflation expectation	Measured by 1-year inflation expectations as constructed by the Federal Reserve Bank of Cleveland	Measured by the quarterly average of 1-year-ahead inflation expectations from the monthly consensus survey	Based on a BoE summary measure of 1-year-ahead annual inflation expectations across households, businesses, and professional forecasters; extended historically by Thomas and Dimsdale (2017), and extended forward using a household expectations measure from the BoE Inflation Attitudes Survey	Synthetic indicator of 1-year inflation expectation across firms, households, and experts, annual change; nonpublic data, calculated by BOJ staff
cf10	Long-term inflation expectation	Measured by the Cleveland Fed's 10-year inflation expectations series	Measured by the longer-term (5-year-ahead) annual HICP inflation forecast of the ECB Survey of Professional Forecasters (SPF)	Long-run annual inflation expectation (5–10 years), summary measure across households, professionals, and markets; extended historically by Thomas and Dimsdale (2017); extended forward using an average of various measures	Synthetic indicator of 10-year inflation expectation across firms, households, and experts, annual change; nonpublic data, calculated by BOJ staff

catch-up	Losses to workers' purchasing power due to inflation	Losses to workers' purchasing power due to inflation, measured by the 4-quarter average of CPI inflation minus the 1-year inflation expectation 4 quarters earlier; catch-up is a linear combination of past *gp* and *cf1*	Losses to workers' purchasing power due to inflation, measured by the 4-quarter average of HICP inflation minus the 1-year inflation expectation 4 quarters earlier; catch-up is a linear combination of past *gp* and *cf1*	Annual inflation minus 1-year inflation expectations 1 year ago	
Exogenous variables					
grpe	Rate of growth of the relative price of energy	Quarterly and annualized, measured as the rate of change of the ratio of CPI energy prices to the ECI	Quarterly and annualized, measured as the rate of change of the ratio of HICP energy prices to the compensation per employees	Quarterly and annualized change in ratio of energy price to wage index consistent with *gw*. Combined "energy" prices cover household energy bills (natural gas and electricity) and vehicle fuels (petrol, diesel) from the UK CPI, Office for National Statistics (ONS)	Ratio of CPI energy prices to scheduled cash earning, annualized quarterly change. CPI by the Statistics Bureau of Japan, and Monthly Labor Survey by the Ministry of Health, Labor, and Welfare

grpf	Rate of growth of the relative price of food	Rate of growth of the relative price of food, quarterly and annualized, measured as the rate of change of the ratio of CPI food prices to the ECI	Rate of growth of the relative price of food, quarterly and annualized, measured as the rate of change of the ratio of HICP food prices to compensation per employee	Quarterly and annualized change in ratio of food price to wage index; measure of food prices covers food and nonalcoholic beverages from the UK CPI (seasonally adjusted by team), ONS	Ratio of CPI food prices to scheduled cash earning, annualized quarterly change. CPI by the Statistics Bureau of Japan and Monthly Labor Survey by the Ministry of Health, Labor, and Welfare
v/u	Labor market variable/ratio of job vacancies to unemployme nt	Ratio of job vacancies to unemployment, from the BLS job openings and labor turnover survey and BLS Employment Report; pre-2001 data from Barnichon (2010)	Ratio of job vacancies to unemployment, backcast using EU Commission survey-based measure of labor shortage as a factor limiting production in industry, working day and seasonally adjusted	Vacancies from ONS Vacancy Survey (of businesses); backcast using Job Centre vacancies with official linking factor sourced from Thomas and Dimsdale (2017). Unemployment from official ONS labor market statistics derived from Labor Force Survey (of households). Not adjusted for furlough.	Ratio of job vacancies and unemployment, Monthly Labor Survey by the Ministry of Health, Labor, and Welfare
shortage	Index of shortages based on Google searches	Index of shortages based on Google searches	Global Supply Chain Pressure Index, first lag, Federal Reserve of New York	Google trends results for *shortage* in UK. Average of months to create quarterly series. Pre-2004 series set to = 4, approx. equal to average 2004–07.	Number of Google searches with the term *supply shortage* in Japanese

gpty	Trend productivity growth	Measured by the 8-quarter moving average of log changes of nonfarm business value added divided by nonfarm employee hours, from the BLS	Long-term productivity growth, measured by the change in the 8-quarter moving average of the quarterly change of gross value added divided by total employment, from Eurostat	Moving 8-quarter average of quarterly market sector productivity growth, annualized. Productivity index smoothed before growth rates taken, given volatility especially during COVID period. Smoothing helps the fit.	Real GDP/(work hour * number of employed persons), annualized quarterly change, 8-quarter average; National Accounts of Japan (SNA) Cabinet Office, Monthly Labor Survey by the Ministry of Health, Labor, and Welfare

		France	Germany	Spain	Italy
Endogenous variables					
gp	Price inflation	Annualized quarterly log-difference of total HICP (seasonally adjusted), National Institute of Statistics and Economic Studies (Insee)	HICP, seasonally and calendar adjusted, Destatis	General HICP including food and energy prices, National Accounts, National Statistics Institute	Consumer price inflation, as measured by quarterly annualized rates of change in the HICP, SA, ECB
gw	Wage inflation	Basic monthly wage, measured by the annualized quarterly growth rate, an employee's gross wage before deduction of contributions and excluding bonuses or remuneration for overtime (seasonally	Negotiated wages, basic salaries (*Grundvergütungen*), excluding lump-sum payments (e.g., vacation pay), hourly basis, seasonally adjusted, Bundesbank	Wages approximated by remuneration per employee, National Accounts and Ministry of Labor and Social Economy	Rate of growth of nominal wages, quarterly and annualized, measured by the rate of change in private sector contractualized wages, Italian National Institute of Statistics (ISTAT)

		adjusted), Dares, Acemo survey			
cf1	Short-term inflation expectation	1-year-ahead inflation expectation, Consensus Forecast, backcast using 12 quarters moving average of HICP inflation	1-year-ahead expectation series as a weighted average of professional forecasters' predictions for the current and next calendar year, Consensus Economics	1-year quarterly inflation expectation (not seasonally adjusted), Business and Consumer Surveys of the European Commission	1-year inflation expectations, Consensus Economics
cf10	Long-term inflation expectation	Long-run annual inflation expectation (5–10 years ahead), Consensus Forecast	Inflation expectations of professional forecasters, 6–10 years ahead, Consensus Economics	Long-term quarterly inflation expectation (5 years) for the euro area, due to lack of a comparable variable for Spain (not seasonally adjusted), Survey of Professional Forecasters (SPF) of the European Central Bank	Long-term inflation expectations (10 years), annual series, interpolated by authors to obtain quarterly data, Consensus Economics
catch-up	Losses to workers' purchasing power due to inflation		Average headline inflation over the current and the previous 3 quarters minus the 1-year-ahead inflation expectations 1 year ago	Difference between the inflation rate accumulated in the last year and the 1-year inflation expectation recorded 4 quarters earlier	Losses to workers' purchasing power due to inflation, measured by the 4-quarter average of CPI inflation minus the 1-year inflation expectation 4 quarters earlier. Catch-up is a linear combination of past *gp* and *cf1*.

Exogenous variables

grpe	Rate of growth of the relative price of energy	Annualized quarterly change of HICP energy subcomponent relative to the wage index as defined above	HICP energy subcomponent, seasonally and calendar adjusted, relative to wage index, Destatis	HICP energy prices relative to wage series, National Accounts, National Statistics Institute	Rate of growth of the relative price of energy, quarterly and annualized, measured as the rate of change of the ratio of CPI energy prices to the private sector contractualized wages
grpf	Rate of growth of the relative price of food	Annualized quarterly change of HICP food subcomponent relative to the wage index as defined above	HICP food subcomponent, seasonally and calendar adjusted, relative to wage index, Destatis	HICP food prices relative to wage series, National Accounts, National Statistics Institute	Rate of growth of the relative price of food, quarterly and annualized, measured as the rate of change of the ratio of CPI food prices to the private sector contractualized wages
v/u	Labor Market Variable/ratio of job vacancies to unemployment	Ratio of job vacancies and unemployment, backcast using the 8-quarter moving-average growth rate of the Insee survey-based measure	Ratio of total number of unemployed persons, national definition (e.g., including refugees), seasonally adjusted, and total number of posted jobs, seasonally and calendar adjusted, Federal Employment Agency	Ratio of job vacancies to unemployment, Eurostat. Unemployment rate (adjusted estimated and calculated) from Labor Force Survey.	Ratio of job vacancies to unemployment, backcast by team's calculations, ISTAT

shortage	Index of shortages based on Google searches	Average value for Google searches for the words *pénurie(s)* and *approvisionnement*, corrected for peaks related to strikes at major oil refineries	Number of Google search requests for the term *Lieferengpässe*	Google trend data for the search term *escasez*	Global Supply Chain Pressure Index, first lag, Federal Reserve of New York
gpty	Trend productivity growth	Measure of trend labor hourly productivity in market branches using an 8-quarter moving average of productivity annualized quarterly growth rate, adjusted (through interpolation) for the steep fall observed during the COVID period	Real labor productivity per hour, seasonally adjusted, total economy, Destatis	Moving average of 8 quarters of the growth of gross value added per employee in the total economy, National Accounts and Ministry of Labor and Social Economy	Trend productivity growth measured by the change in the 8-quarter moving average of nonfarm business value added divided by nonfarm employee hours

		Netherlands	Belgium[a]	Canada
Endogenous Variables				
gp	Price inflation	CPI, annualized quarterly growth rate	Quarterly inflation rate of the National Index for Consumer Prices (NICP), which is the reference index for Belgian automatic wage indexation (seasonally adjusted), NBB.Stat	Inflation measured by quarterly annualized changes in the CPI, Statistics Canada
gw	Wage inflation	Compensation per hour, annualized quarterly growth rate	Quarterly growth rate of the nominal hourly wage cost of the private sector, computed as total compensation of employees	Wage growth measured by annual average negotiated wage adjustment over the period of the

			divided by the total volume of hours worked; includes gross wages as well as employers' social security contributions (calendar and seasonally adjusted but not adjusted for job retention schemes), NBB.Stat	contract in collective bargaining agreements
cf1	Short-term inflation expectation	1-year-ahead inflation expectations, Consensus Economics	1-year-ahead consumption price inflation expectations, measured as the quarterly average from the monthly Consensus survey, Consensus Economics	Short-term inflation expectations, defined as expectation of up to 2 years ahead, Bank of Canada staff calculation (not public)
cf10	Long-term inflation expectation	6–10-year-ahead inflation expectations, Consensus Economics	6–10-year-ahead consumption price inflation expectations, Consensus Economics. Backcast using long-term inflation expectations for the euro area as a whole (5-year-ahead annual HICP inflation forecast), ECB SPF.	Long-term inflation expectations, defined as expectations from 3 to 10 years ahead, Bank of Canada staff calculation (not public)
catch-up	Losses to workers' purchasing power due to inflation			4-quarter average of CPI inflation minus short-term inflation expectation 4 quarters earlier
Exogenous variables				
grpe	Rate of growth of the relative price of energy	HICP energy, relative to nominal wages, annualized quarterly growth rate	Energy price inflation as the quarterly 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 compensation per hour	Annualized log-difference of CPI energy prices relative to the wage measure, Statistics Canada and team's calculation

grpf	Rate of growth of the relative price of food	HICP food relative to nominal wages, annualized quarterly growth rate	Quarterly growth rate of the relative price of food, measured as the rate of change of the ratio of NICP food components (not seasonally adjusted) to compensation per hour	Annualized log-difference of CPI food prices relative to our aggregate wage measure, Statistics Canada and Canadian authors' calculation
v/u	Labor market variable/ratio of job vacancies to unemployment	Ratio of job vacancies to unemployment	Average over two indicators: (1) 1 minus the harmonized unemployment rate for Belgium (seasonally adjusted), NBB.Stat; and (2) the percentage of manufacturing firms pointing to "labor shortage as a factor limiting production" in the European Commission business survey (not seasonally adjusted); both indicators are detrended before entering the average	Ratio of job vacancies to unemployment, Statistics Canada and Bank of Canada staff calculation
shortage	Index of shortages based on Google searches	Google searches of the term *shortage* in the Netherlands	The first component of a principal component analysis on several indicators: Google searches of the terms *pénurie(s)*, *krapte*, the Global Supply Chain Pressure index from the Federal Reserve of New York, and two seasonally adjusted purchasing managers' indices for European markets by S&P Global, tracking manufacturing suppliers' delivery times, and an index for input prices in both manufacturing and services	Indexed measure of Google searches of the word *shortage*
gpty	Trend productivity growth	Gross value added per hours worked, 8-quarter moving average of the	8-quarter moving average on the quarterly growth rate of productivity until 2019Q4, reduced to 4-quarter moving average	Trend productivity growth in the business sector, measured by the 8-quarter moving average of log change

	annualized quarterly growth rate	thereafter, measured as Belgian private value added per hours worked (seasonally adjusted)	in business sector productivity, Statistics Canada

a. Belgium uses a social contributions variable in addition to the other variables: 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 without significantly changing the coefficients of other variables.

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