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From: The Secretary

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Board Action: Executive Directors' **consideration** (Formal)

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The analytical chapters will be made available to the public on the IMF website in advance of the publication of the full document.

Questions: Mr. Bluedorn, RES (ext. 35392)
Mr. Wingender, RES (ext. 39831)

Additional Information: The paper will be revised for publication in light of the Executive Board discussion. If Executive Directors have additional comments, they should notify Mr. Bluedorn and Mr. Wingender by **5:30 p.m. on Friday, September 23, 2022.**

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WAGE DYNAMICS POST-COVID-19 AND WAGE-PRICE SPIRAL RISKS

Inflation rose markedly in many economies over 2021, reflecting a mix of supply- and demand-side drivers amid the recovery from the COVID-19 shock. Although nominal wage growth has so far generally stayed below inflation, some observers have warned that prices and wages could start feeding on each other, with wage and price inflation continually ratcheting up in a sustained wage-price spiral. This chapter unpacks the recent past and sheds light on future prospects using a mix of empirical and model-based analyses. Historical episodes in advanced economies exhibiting similar wage, price, and labor market dynamics to the conjuncture—in particular, those in which real wages (nominal wages deflated by consumer prices) have been flat or falling—did not tend to show a subsequent wage-price spiral. Model-based analysis suggests that different shocks underpinned wage and price developments through 2020–21: production capacity shocks predominantly drove wages while private saving and pent-up demand were important for prices. Empirical analysis suggests that while labor market conditions remain relevant drivers for wage growth, the importance of inflation expectations has recently increased. A forward-looking analysis points to the critical role of the expectations process in shaping prospects. It demonstrates how frontloaded monetary policy tightening, including through its clear communication, can lower the risk that inflation becomes de-anchored from its target. Given that inflationary shocks are originating outside the labor market, falling real wages are helping slow inflation, and monetary policy is tightening more aggressively, the chances of persistent wage-price spirals emerging appear limited.

Introduction

With the recovery picking up steam after the acute COVID-19 shock, inflation in 2021 started hitting levels that had not been seen in almost 40 years in many economies.¹ A wide array of factors has underpinned the sharp rises in prices, including pandemic-related supply chain disruptions, commodity price shocks, expansive monetary policy and fiscal support, a surge of pent-up consumer demand, and changes in consumer preferences for goods versus services (Figure 2.1, panels 1 and 3).

At the same time, economic recovery brought a resurgence in demand for labor in many sectors. Labor supply was slow to respond, with some workers hesitant to reengage because of ongoing health concerns and difficulties finding child and family care, among other factors.² This demand-supply imbalance led to tighter labor markets and increased wage pressures, with average nominal wages (per worker) rising and the unemployment rate falling from the second half of 2020 across economy groups (Figure 2.1, panels 2 and 5 for advanced economies and panels 4 and 7 for emerging market and developing economies).³

The authors of this chapter are Silvia Albrizio, Jorge Alvarez, Alexandre Balduino Sollaci, John Bluedom (lead), Allan Dizioli, Niels-Jakob Hansen, and Philippe Wingender, with support from Youyou Huang and Evgenia Pugacheva. The chapter benefited from comments by Jason Furman and internal seminar participants and reviewers.

¹ Price inflation is defined with respect to the consumer price index throughout, unless otherwise indicated.

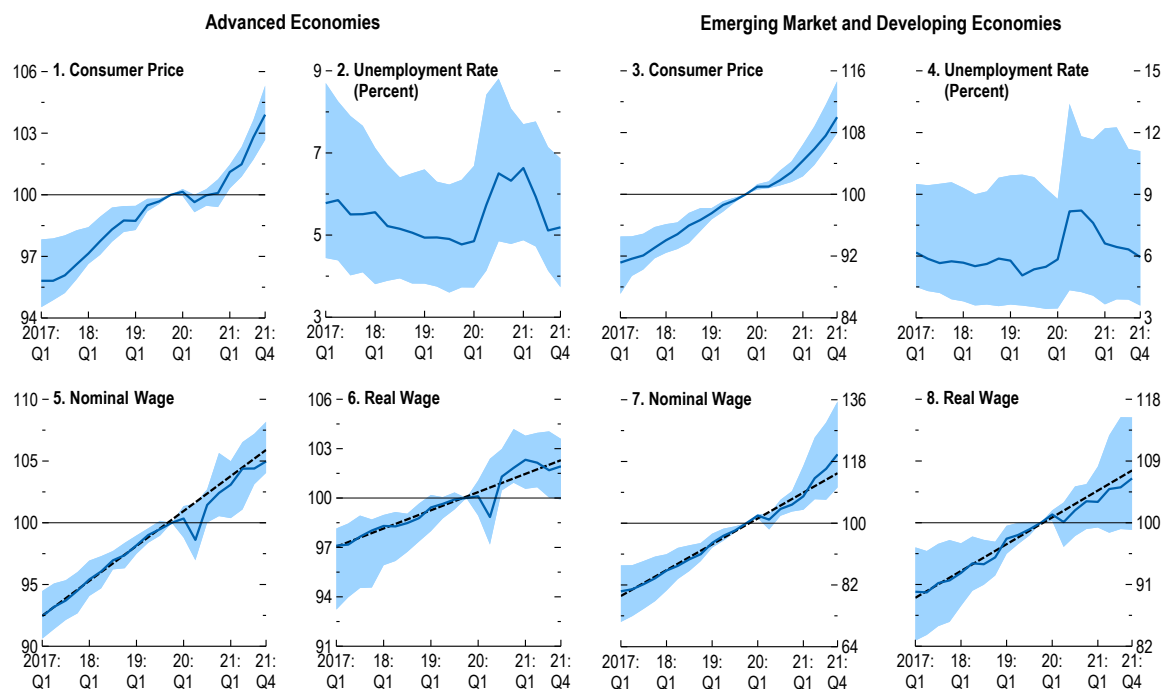
² See Bluedom and others (2021) for discussion of how the COVID-19 shock generated a “she-cession,” reflecting in part the disproportionate impact of these factors on women’s employment. See also ILO (2022) for a more recent assessment of the shock’s effects on employment and participation and the differential between men’s and women’s outcomes.

³ To achieve the broadest sample coverage possible in the empirical analysis, wages (nominal or real) are defined on a per employed worker basis throughout, unless otherwise indicated. For a smaller sample, the chapter includes some discussion highlighting how wages per hour contrast.

WORLD ECONOMIC OUTLOOK

Figure 2.1. Recent Wage, Price, and Unemployment Dynamics
(Index, 2019:Q4 = 100, unless noted otherwise)

Consumer price inflation has markedly accelerated since the 2020:Q2. While the nominal wage largely returned to its pre-pandemic trend, real wages have dipped below their pre-pandemic trend. Unemployment rates have continued to decrease as the economy recovers from the COVID-19 shock.



Sources: Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: Blue lines represent the median across economies; dashed lines indicate the pre-COVID-19 trend; shaded areas represent the interquartile range across economies. Wages (nominal and real) are calculated on a per-worker basis. See Online Annex 2.1 for details on the sample coverage.

Growth in nominal wages mostly brought the average level in 2021 back to the pre-pandemic trend, although there were differences across economies. Importantly, nominal wage growth in 2021 did not fully keep up with price inflation.⁴ This means that the path of real wages (nominal wages deflated by consumer prices) was fairly flat or even declined (Figure 2.1, panels 6 and 8). Against a backdrop of high or even rising price inflation, these nominal and real wage patterns have continued into the first quarters of 2022 for economies for which data are available.

At a sectoral level, nominal wages in both industry and services have tended to converge to their common pre-pandemic trends across economy groups (see Online Annex 2.2 for details on the sectoral perspective). In advanced economies, real wages across sectors largely matched their pre-pandemic trend, before deteriorating in the latter half of 2021 as inflation rose, while in emerging market and developing economies they have stayed mostly flat on average. Consistent with the picture of wages by sector, sectoral employment shifts so far have appeared to contribute little to overall wage changes for the average economy—common changes in wages across sectors themselves account for the lion’s share of the average overall wage change.

Some observers argue that recent wage and price dynamics could change, so that rising inflation expectations and tighter labor markets push workers to persistently demand wage increases to

⁴ The distinction between wages per worker and wages per hour became relevant during the pandemic’s acute phase, as hours worked were sharply adjusted for many workers (particularly in advanced economies). Annex Figure 2.1.1 shows the dynamics of wages per hour: spiking up in the second quarter of 2020 on average across economy groups, but quickly returning to trend. Similar to the patterns for wages per worker, wages per hour fell short of price inflation by the end of 2021.

catch-up to or exceed recent inflation. Such a “wage-price spiral” is defined here as an episode of several quarters characterized by accelerating wages and prices (that is, in which both wage and price inflation rates rise simultaneously).⁵

The chapter aims to better understand the current circumstances and prospects for wage and price inflation. To this end, crucial questions addressed include the following:

- **How do wage, employment, and price dynamics in the recovery from the COVID-19 shock compare with pre-pandemic dynamics?** Did historical episodes mirroring 2021 patterns in wages, employment, and prices in advanced economies subsequently evolve into wage-price spirals?
- **How well do inflation expectations and labor market conditions explain recent nominal wage growth in advanced and emerging market and developing economies?** What were the deeper, underlying drivers of wages, prices, and employment over 2020-21?
- **Could wage and price pressures post-COVID-19 lead to high and persistent wage and price inflation?** Have wage and price pressures from past inflationary shocks due to increasing global supply pressures lasted long? Historically, has monetary tightening been effective in reducing wage and price pressures? Looking ahead, how could changes in the formation of wage and price expectations affect prospects and how should policymakers take them into account?

Drawing both on empirical and model-based analyses, the chapter’s main findings are as follows:

- *Both wage and price inflation picked up in a broad-based manner through 2021, while real wages have tended to be flat or falling across economies on average.* At a sectoral level, nominal wages in both industry and services tended to converge to their common pre-pandemic trends across economy groups. Consequently, sectoral employment shifts appear to explain little of overall wage changes through the end of 2021.
- *On average, wage-price spirals did not follow historical episodes that were similar to the circumstances currently seen in advanced economies.* Although the COVID-19 shock is unusual and the current conjuncture unlike much recent experience, similar historical episodes of inflation in advanced economies—in which real wages were flat or falling—did not tend to entail a wage-price spiral. In fact, inflation tended to fall in the aftermath while nominal wages gradually caught up.
- *Changes in inflation expectations and labor market slack explain wage dynamics in the second half of 2021 relatively well.* In the immediate aftermath of the COVID-19 shock, wage growth across economies was poorly explained by its earlier empirical relationship with expectations and unemployment. However, by the end of 2021, wage growth was broadly in line with the increases in inflation expectations and labor market tightening observed across economy groups on average.
- *Reflecting the pandemic shock’s unusual nature, a complex mix of supply and demand shocks underpinned the behavior of wages and prices over 2020–21.* Analysis using a rich, multi-sector,

⁵ See Boissay and others (2022) for a similar definition and discussion on the debate about the possible emergence of wage-price spirals in advanced economies. Further discussion of the concept is in section 3 of this chapter.

multi-economy structural model points to differences in the shocks underlying historical changes in wages and prices. Over the two years from the pandemic's onset, wages were predominantly driven by production capacity and labor supply shocks (from social distancing and lockdowns), while prices were more affected by private savings and the release of pent-up demand. How and when (or if) these deeper shocks unwind will matter for how wage and price inflation develop.

- *When wage and price expectations are more backward-looking, monetary policy actions need to be more frontloaded to minimize the risks of inflation de-anchoring.* Using a newly developed model of expectations and wage and price setting, scenario analysis suggests that the decline in real wages observed has acted as a drag so far, reducing price pressures and thereby helping inhibit development of a wage-price spiral dynamic. However, the more backward-looking (adaptive) expectations are, the greater the chances are that inflation could de-anchor to a higher-than-target level. The monetary policy response in this inflationary environment should depend on the nature of wage and price expectations: the more backward-looking they are, the quicker and stronger the tightening needed to avert inflation de-anchoring and prevent large falls in the real wage.

Some important caveats to the analysis presented here should be stated upfront. First, the empirical analysis is constrained by the availability of data, both across economies and over time. Hence, the exact sample coverage differs across exercises. Second, although the empirical methods used are standard, their findings should be interpreted as associational rather than causal. Third, the empirical analysis and study of historical episodes essentially summarizes past patterns in the data, which may not be fully representative of the current circumstances. Moreover, if the COVID-19 shock caused a large structural break in the economy's behavior (such as a sharp shift in expectations formation or wage-setting processes), historical analyses may not be as informative about future prospects. The model-based analysis of expectations provides some insurance against structural breaks, since it allows for the possibility of a limited form of regime shifts in its examination of adaptive learning.

The chapter begins by identifying and examining historical episodes exhibiting wage, price, and employment patterns similar to those in the current circumstances, highlighting how the episodes subsequently developed. The chapter continues by studying how well recent wage dynamics can be explained by changes in inflation expectations and labor market slack and what the composition of shocks driving these developments are. In the penultimate section, the chapter highlights how inflationary shocks and monetary tightening affect wage (both nominal and real) dynamics. The final section considers how the processes for forming expectations regarding wages and prices may interact with the shock and monetary policy's responses to affect the economy's future path.

Historical Episodes Similar to Today

As explained in the introduction, rising inflation, positive nominal wage growth, declining real wages, and declining unemployment characterized the macroeconomic situation in 2021 in many economies. Although unusual, such conditions are not unprecedented. A sample of advanced economies covering the past 40 years (and for a few the past 60) reveals 22 other episodes

exhibiting similar conditions.⁶ The current coincidence of rising inflation and nominal wage growth has led to concerns that a wage-price spiral—in which both wages and prices accelerate for a prolonged period—could emerge.⁷ This section examines whether wage-price spirals have occurred in past, similar episodes.

Similar Past Episodes Do Not Show a Wage-Price Spiral Taking Hold

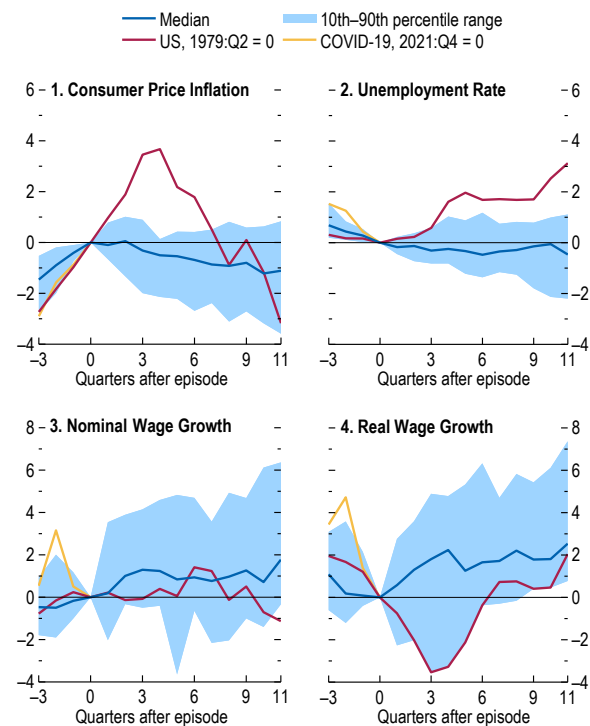
Similar past episodes were not followed by a wage-price spiral, in which both inflation and nominal wage growth keep rising over a prolonged period (Figure 2.2, panels 1 and 3). Nominal wage growth did tend to increase somewhat after these episodes, but inflation edged down on average. In combination, this led to an increase in real wages (Figure 2.2, panel 4). The unemployment rate generally stabilized after the episodes (Figure 2.2, panel 2).

Although the average subsequent path suggests little cause for alarm, there is heterogeneity across historical episodes. A notable example is the United States in the second quarter of 1979, where inflation was on a sharp upward path in the immediate sequel of the episode, rising rapidly for four quarters before starting to decline. The unemployment rate also rose more than during the other identified episodes. Underlying these changes was an aggressive monetary tightening that began around the time of the inflation peak: the so-called Volcker disinflation. Nominal wage growth—which had not shown signs of continuing its upward path—was relatively flat during this period, leading to a decline in real wages early on. But as inflation came down, the deterioration in real wages decreased.

A similar policy response is observed in many of the other episodes as well. In fact, monetary

Figure 2.2. Changes in Wages, Prices, and Unemployment after Similar Past Episodes
(Percentage point differences relative to first quarter in which criteria are fulfilled)

After past episodes with similar macroeconomic conditions to today's, consumer price inflation typically declined, while nominal and real wage growth increased.



Sources: International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF Staff Calculations.

Note: The figure shows the developments following episodes in which at least three of the preceding four quarters have: (1) accelerating prices/rising price inflation, (2) positive nominal wage growth, (3) falling or constant real wages, and (4) declining or flat unemployment rate. Twenty-two such episodes are identified within a sample of 30 advanced economies going back to at the earliest 1960. The COVID-19 episode represents an average of countries in the sample for the period starting in 2021:Q4. See Online Annex 2.3 for details.

⁶ The 22 episodes are identified within a sample of 30 advanced economies for which data on inflation, wages, prices, and unemployment are available at a quarterly frequency going back to 1960 at the earliest. For most economies in the sample, the quarterly data begins on a regular basis only in the 1980s. The selection criteria are that three out of the previous four quarters had: (1) rising inflation, (2) positive nominal wage growth, (3) declining real wages, and (4) declining unemployment. If the criteria hold for several quarters within three years, only the first episode in which the criteria held is selected. See Alvarez and others (forthcoming) for further details and discussion about these episodes.

⁷ The earlier literature on wage-price spirals has considered a wide array of definitions, ranging from a simple feedback between wages (as a cost of production) and prices, to a coincident acceleration of wages and prices, to a situation in which wage inflation persistently exceeds price inflation. As noted in the introduction, this chapter defines a wage-price spiral as an episode of several quarters characterized by accelerating wages and prices (that is, in which both wage and price inflation are rising simultaneously).

policy tightening followed most of the past episodes, which helped to keep inflation contained.⁸ Thus, the evidence from similar historical episodes suggests that an appropriate monetary policy response can contain the risks of a subsequent wage-price spiral at the current conjuncture to very low levels.

Wage-Price Spiral Episodes Did Not Typically Last Long

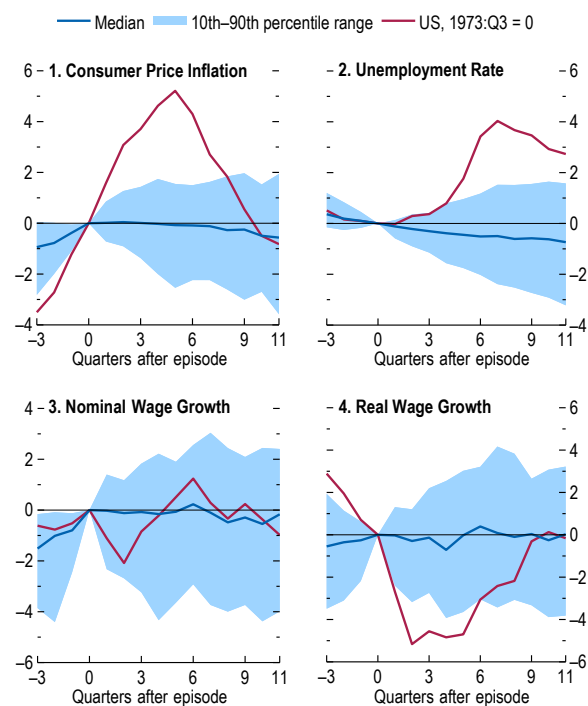
Turning to past episodes of wage-price spirals (regardless of the behavior of real wages or unemployment), further, sustained wage-price acceleration did not typically follow the initial dynamics.⁹ Following such episodes, inflation and nominal wage growth on average tended to stabilize in the subsequent quarters, leaving real wage growth broadly unchanged (Figure 2.3, blue lines). At the same time, the unemployment rate tended to edge down slightly.

However, in some rare examples, more extreme outcomes followed such episodes. For example, the United States’ episode starting in the third quarter of 1973 saw price inflation surging for five additional quarters—spurred by the first Organization of the Petroleum Exporting Countries oil embargo of the 1970s—before starting to come down in 1975 (Figure 2.3, red lines). On the other hand, nominal wage growth did not increase, leading real wage growth to decline. Another relevant example is that from Belgium during 1973, in which both nominal wage growth and price inflation surged markedly before coming down (see Online Annex 2.3). In that case, wage growth was high and exceeded price inflation for a while, partly owing to the wide prevalence of wage indexation.¹⁰

Farther back in time, another notable example occurred in 1946–48 in the United States, just after World War II concluded. Over those two years, price controls due to the war were lifted and pent-up demand was released. As the economy shifted from wartime, price inflation

Figure 2.3. Changes in Wages, Prices, and Unemployment after Past Episodes with Accelerating Prices and Wages
(Percentage point differences relative to first quarter in which criteria are fulfilled)

A period of stable wage growth and inflation typically followed past episodes with accelerating wages and prices.



Sources: International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: The figure shows the developments following episodes in which at least three of the preceding four quarters have: (1) accelerating prices/rising price inflation and (2) accelerating nominal wages/rising nominal wage growth. Seventy-nine such episodes are identified within a sample of 30 advanced economies going back to at the earliest 1960. The bands indicate the 10th–90th percentile of the outcomes in the identified episodes. See Online Annex 2.3 for details.

⁸ Out of the 22 episodes illustrated in Figure 2.2, 13 were followed by monetary policy tightening (Annex Table 2.3.2).

⁹ A wage-price spiral episode is identified if, for at least three of the past four quarters: (1) wages were accelerating (wage growth was rising); and (2) prices were accelerating (price inflation was rising). Note that these are less restrictive criteria than those used to identify historical episodes similar to today’s circumstances.

¹⁰ See also Battistini and others (2022) and Baba and Lee (forthcoming) for further discussion and analysis of the historical effects of oil price and energy shocks on price inflation and wages and the effects’ relationship to an economy’s structural characteristics.

and nominal wage growth picked up over 1946, both reaching about 20 percent year-over-year by the first quarter of 1947.¹¹ Thereafter though, inflation and wage growth started to come down gradually, while remaining at high levels for about a year. Toward the latter half of 1948 and into early 1949, inflation came down sharply, as supply chains had readjusted and pent-up demand became exhausted (with a mild recession in 1949).¹²

Overall, the historical evidence suggests that episodes characterized by about a year of accelerating prices and wages have not generally lasted, with nominal wage growth and price inflation tending to stabilize on average. It is important to remark that this means that inflation and wage growth remained elevated for several quarters on average after these past episodes.¹³

Wage Drivers during the COVID-19 Shock and Recovery

This section studies wage, price, and employment drivers in the context of the pandemic and subsequent recovery. It first examines recent wage dynamics empirically through the lens of the wage Phillips curve, which relates wage growth to inflation expectations and labor market slack. The section then attempts to further unpack wage and price changes over the past two years, using a rich structural model to identify the complex mix of underlying supply and demand shocks driving wages and prices.

An Empirical Decomposition of Recent Dynamics using the Wage Phillips Curve

Although the COVID-19 shock and recovery bear many unusual features, a recurring question is whether previous economic relationships can still explain recent dynamics. For wages, this means examining whether empirical estimates using the workhorse, wage Phillips curve—relating wage growth to measures of inflation expectations, labor market slack, and productivity growth—do well at capturing the variation in wage developments.¹⁴ The chapter first employs this framework to study the pre-COVID-19 wage-setting process. It then uses the framework to decompose wage growth changes since the pandemic across economy groups, to see how well it performs.

Wage Growth Tends to Rise with Inflation Expectations and Fall with Labor Market Slack

Consistent with earlier empirical and theoretical literature, the analysis suggests that rises in inflation expectations¹⁵ and productivity growth are associated with increases in nominal wage

¹¹ Wages are proxied by average hourly earnings in manufacturing, as an economy-wide wage measure is not available that far back in time.

¹² See Online Annex 2.3 for further details on this case. Rouse, Zhang, and Tedeschi (2021) also describe this and other past inflationary episodes in the United States with some features similar to today's recovery from the pandemic. Caplan (1956) provides a close-in-time and in-depth discussion of the situation in the late 1940s.

¹³ The relevance of this finding hinges critically on the sample coverage. As in Figure 2.2, quarterly time coverage for the critical variables starts only in the 1980s or later for most economies. For robustness, the exercise was thus repeated using a narrower wage concept (hourly earnings for the manufacturing sector only) allowing for time coverage back to the early 1970s for more countries. This did not overturn the broad results shown in Figure 2.3, although a few additional extreme outcomes were identified. See Online Annex 2.3 for additional information.

¹⁴ The specification used is based on Chapter 2 of the October 2017 *World Economic Outlook*, inspired by Galp's (2011) work micro-founding the wage Phillips curve as the outcome of a wage-setting process. The baseline specification using the unemployment rate and its change as measures of labor market slack permits a wider coverage of advanced and emerging market economies in the sample. Given recent inflation dynamics, the relationship between wage growth and inflation expectations is a key focus of this chapter's study. Online Annex 2.4 includes details on the baseline specification.

¹⁵ This section focuses on one-year-ahead inflation expectations. See Online Annex 2.1 for details on the measure used.

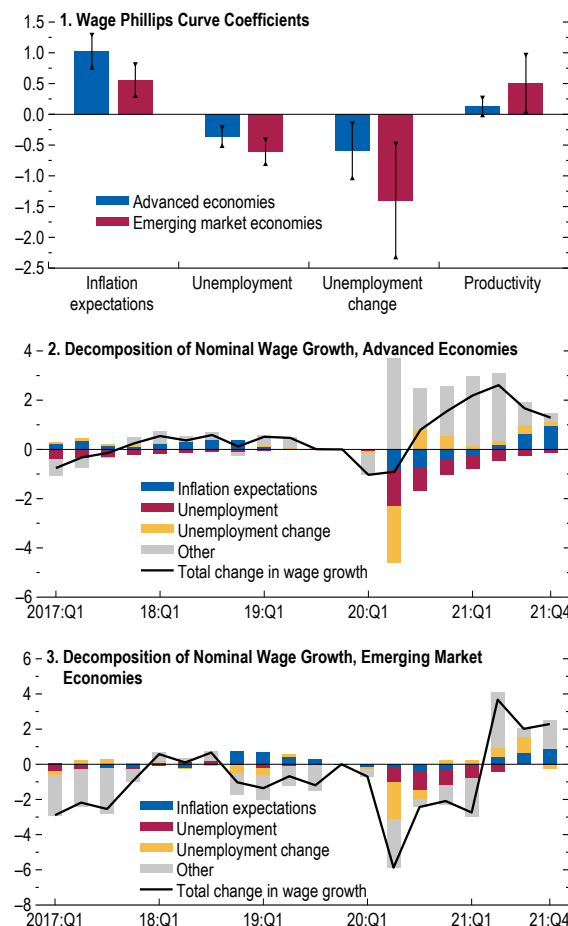
growth, while increases in labor market slack (captured by the unemployment rate and its change) are correlated with a slowdown in wage growth (Figure 2.4, panel 1). These relationships are statistically significant in both the advanced and emerging market economy groups.

The positive relationship with inflation expectations—a focus of the conjuncture—is consistent with a forward-looking wage setting process in which workers demand higher wages as prices are expected to rise.¹⁶ These nominal wage pressures add to those stemming from increases in the real returns on labor—as captured by productivity growth—and survive even if lagged inflation is controlled for. Wage growth appears to be highly sensitive to inflation expectations in advanced economies, with a one percentage point increase in inflation expectations being associated with a close to one percentage point increase in wage growth (compared to 0.6 percentage points in emerging markets). This relationship, however, weakened in the period after the global financial crisis when inflation was remarkably low and stable.¹⁷

The negative relationship with unemployment is consistent with high (or widening) slack in the labor market reducing wage pressures, as workers struggle to find jobs and accept lower wages. This last correlation is robust to using other measures of labor market slack, such as unemployment gaps, which allow for time-varying natural unemployment rates and unemployment-to-vacancy ratios.¹⁸ Point estimates suggest that emerging market wages

Figure 2.4. A Look at Nominal Wage Growth Through the Lens of the Wage Phillips Curve
(Percentage points)

Wage dynamics during COVID-19 did not follow the wage Phillips curve relationship closely, but more recent nominal wage growth is consistent with rising inflation expectations and labor market tightening.



Source: IMF staff calculations.
Note: Panel 1 reports the estimated effects (coefficients) from 1 percentage point rises in the indicated variables from a wage Phillips curve regression. The sample covering 2000:Q1–19:Q4 consists of 31 advanced and 15 emerging market economies. Whiskers indicate 90 percent confidence intervals. See Online Annex 2.1 for further details on the sample and estimation. For panels 2 and 3, bars show contributions of each component relative to the contributions observed in 2019:Q4. Contributions are calculated using pooled wage Phillips curve coefficients for the indicated economy group. Line depicts average overall nominal wage growth per worker observed relative to 2019:Q4. Only economies with continuously available data from 2017:Q1–21:Q4 are used for the contributions and aggregated using GDP purchasing-power-parity weights. “Other” category contains the contributions of productivity growth, the residual, and time fixed effects.

¹⁶ Additional robustness checks including lagged inflation as a regressor are shown in Online Annex 2.4.

¹⁷ See Online Annex 2.4 for how coefficients have lowered in advanced economies. Part of this observed flattening in the wage Phillips curve might be due to improvements in monetary policy credibility as discussed by Hazell and others (2022) for the price Phillips curve.

¹⁸ There has recently been much discussion about how alternative slack measures—such as unemployment rate gaps (unemployment rate minus the natural rate of unemployment) and the ratio of the number of unemployed to the number of job vacancies in an economy—could perform better. In robustness checks for the larger sample, using the unemployment gap does not make any marked differences in the relationships discussed. To study the unemployment-to-vacancy ratio, a further robustness check using the US (for which data are available on a sufficiently long basis) was also conducted with broadly similar results, although the unemployment-to-vacancy ratio performed better in explaining recent wage growth. This is similar to the evidence from Ball, Leigh, and Mishra (forthcoming), who find that the price Phillips curve using the unemployment-to-vacancy ratio explains inflation since the COVID-19 shock better in the US than alternative measures, without sacrificing its explanatory power before the pandemic. See Online Annex 2.4 for further details.

can be more sensitive than those in advanced economies to changes in labor market and productivity conditions, although variation in past experiences is substantial.

Part of the heterogeneity in experiences could be due to differences across economies and over time in structural factors that may affect wage-setting processes. In economies with more stringent employment protections, wage growth appears to be on average more sensitive to changes in labor market slack (unemployment) and inflation expectations (Figure 2.5, panel 1). This would be consistent with labor prices (wages) adjusting faster to changing conditions when restrictions on labor quantities (firing or hiring of workers) are present. In economies in which firms exhibit greater market power in product markets—as proxied by the average price markup—wages appear slightly more responsive to unemployment changes (Figure 2.5, panel 2). Such a finding is consistent with evidence from the literature showing that higher markup firms are more likely to use their margins to absorb cost changes and preserve their market shares.¹⁹

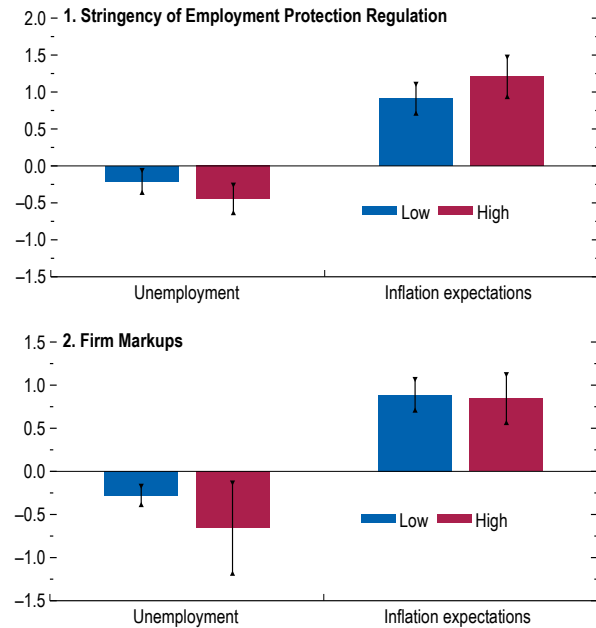
Relatedly, using long cross-sectional time series for Europe that helps with identifying the effects of within-economy structural changes, Baba and Lee (forthcoming) find that the pass-through of inflation shocks (captured by oil price changes) to wages can increase when union density and the degree of centralized bargaining are high.²⁰ Although disentangling specific structural factors as causal for differences in wage-setting is empirically challenging, these results and others from the literature suggest that regulatory, institutional, and structural features affect wages’ responsiveness to changes in inflation expectations and slack.

Wage Changes Were Highly Unusual in the Acute Pandemic Phase, but Recently Appear Broadly in Line with Developments in Inflation Expectations and Slack

How wages respond to changing conditions in labor markets and inflation are also dependent on the sources of shocks and their mechanics. The COVID-19 shock’s unprecedented nature and

Figure 2.5. The Role of Structural Characteristics in Wage Dynamics
(Percentage points)

Regulatory and structural features can shape how unemployment and inflation expectations affect nominal wages.



Source: IMF staff calculations.
Note: The figure shows average marginal effects of unemployment and inflation expectations on nominal wage growth, conditional on the level of the structural characteristic. High (low) refers to the average value of each structural indicator, given that it is above (below) the cross-economy median. “Stringency of employment protection regulation” refers to a composite indicator on the stringency of regulations related to individual dismissal of workers on regular contracts. The indicator of “firm markups” (a measure of firms’ market power in output markets) is the sales-weighted average of sectoral markups. See Online Annex for details.

¹⁹ See Box 2.1 for some discussion of this mechanism and also Box 1.2 for discussion of the relationship between market power and inflation.

²⁰ Battistini and others (2022) also analyze the effects of energy shocks, comparing the second-round effects in the 1970s versus today using model simulations calibrated to the relevant economic features. They find only limited second-round effects in the present circumstances, unlike what was observed in the 1970s. This difference likely reflects changes in economic structure, particularly in labor market bargaining and wage-setting processes. See also Boissay and others (2022) for additional discussion.

asymmetric sectoral effects meant that, overall, average wages did not move in line with the relationships predicted by the wage Phillips curve. A decomposition of average wage growth in advanced and emerging market economies using the wage Phillips curve unveils several notable features (Figure 2.4, panels 2 and 3).

First, both the acute shock and the recovery were unique, exhibiting abrupt swings that deviated from those explained by inflation expectations and unemployment changes according to the estimated wage Phillips curve.²¹ Only part of these deviations was due to movements in hours worked, as employers and employees adjusted along the intensive margin of employment.²² Importantly, the deviations were quantitatively and qualitatively different than those observed in the years preceding the pandemic and during the global financial crisis.²³ They also differed across economies. At the beginning of the pandemic, the drop in wage growth was less prominent than predicted by inflation and unemployment movements in advanced economies (particularly in the US), while the opposite was true in emerging markets.²⁴

Second, in both advanced and emerging market economies, the recovery of wage growth since the crisis peak has been largely in line with the observed drops in unemployment and increase in inflation expectations. In fact, by the end of 2021, wage growth in advanced economies did not seem to be abnormally above that predicted by falling unemployment and rising inflation expectations alone, with a shrinking contribution of the residual and other components in both advanced and emerging market economies. On average, the rise in inflation expectations appears to account for more of the very latest movements in wage growth.²⁵ Chapter 1 provides evidence on how the average and distribution of inflation expectations have evolved into 2022 for selected economies.

Relative Contributions of Supply and Demand Shocks to Wages and Prices

The large, unexplained movements in wage growth observed during the COVID-19 shock and recovery likely reflect the shock's unprecedented and complex nature, as well as the large policy responses. To help unpack the breakdown of the wage Phillips curve during the pandemic's acute phase, this subsection deploys a rich multi-economy, multi-sector general equilibrium model featuring nominal rigidities and credit constraints. Based on recent work by Baqaee and Farhi (2022a; 2022b) and Gourinchas and others (2021), the model facilitates the study of how different demand and supply shocks propagate and contribute to wage, price, and employment changes.

²¹ The large increase in temporary layoffs observed in some economies, which were particularly concentrated among lower-paid workers, could partly explain these wage growth swings (Duval and others 2022). This reason is also cited for some of the strange behavior of the price Phillips curve in the United States (Ball and others 2021).

²² See Online Annex 2.4 for a decomposition including hours worked using a more limited sample of countries.

²³ See Online Annex 2.4 for a similar decomposition over the period spanning the global financial crisis.

²⁴ Worker composition shifts during this period, particularly in the US where greater employment losses among low-wage workers pushed average wages upwards at the start of the pandemic, could partly explain the differences.

²⁵ The prominence of tighter labor markets for higher wage growth in the latest period appears greater when unemployment-to-vacancy indicators—particularly for the case of the United States—are considered, as these indicators point towards tighter labor markets than before the pandemic. Alternative labor market slack measures co-moved closely during the pandemic, but the degree of tightening relative to the fourth quarter of 2019 varies for some economies (including the US) depending on the measure used. See Online Annex 2.5 for details.

In total, seven types of shocks are considered, all of which have been cited as being important for understanding the COVID-19 shock and its effects. On the supply-side, the model includes three types of shocks:

- *Production capacity (or labor supply) shocks*, arising from lockdowns and social distancing which had a particularly large impact on labor supply. These shocks are calibrated based on changes in the number of hours worked by sector over time.
- *International trade cost shocks*, as measured by the shipping costs by product for US imports. Freight and insurance costs showed marked increases starting in 2020.
- *Commodity price changes for energy and food*. Energy and food prices went up by 85 and 20 percent year-over-year respectively in 2021.

The analysis also incorporates four types of demand shocks:

- *Changes in private saving behavior*. These shocks are calibrated by adjusting households' discount rate to track saving rates over time.
- *Consumption composition changes*. The pandemic led to a large reallocation of consumption away from services towards goods, driven by both availability and preferences. Consumer taste shocks are derived using changes in expenditure shares for different types of goods and services over time.
- *Fiscal policy support*, which was substantial in many advanced economies in 2020. This shock is derived from changes in government consumption and changes in spending on unemployment insurance.
- *Monetary policy support*, which was also extensive. This shock is obtained by calibrating the domestic interest rate to that observed for central bank policy rates.

A historical decomposition of key economic variables—including wages and prices—for the United States, euro area, and Mexico (an emerging market economy) are presented for 2020 and 2021 (Figure 2.6).²⁶

Wage Changes since 2019 Were More Related to Supply-Side Shocks from the Pandemic, While Demand-Side Shocks Contributed More to Price Changes.

Although all shocks contribute to the variation in an economy, two main contributors emerge from the results. First, reductions in production capacity (red bars in Figure 2.6) were the predominant contributors to nominal wage changes over 2020 and 2021. Second, changes in households' saving behavior (blue bars) were one of the most important drivers of price changes over the same years. These findings suggest that the future paths for these variables could depend heavily upon whether and how these shocks unwind, as well as whether new shocks arise.

In 2020, the main determinant of wages, prices, and employment across all three economies was the drop in production capacity that took place early in the pandemic (red bars). Lockdowns and the rise in social distancing due to the pandemic translated into decreases in production capacity

²⁶ The impacts of individual shocks do not necessarily add up to the total impact in combination because of interactions in general equilibrium. It is also important to note that the total model-based impacts by variable are broadly aligned, but not exactly equal to actual outcomes. The economies studied are selected based on a combination of their economic size, availability of data required for the model calibration (which is a constraint for many emerging market and developing economies), and diversity of policy support responses.

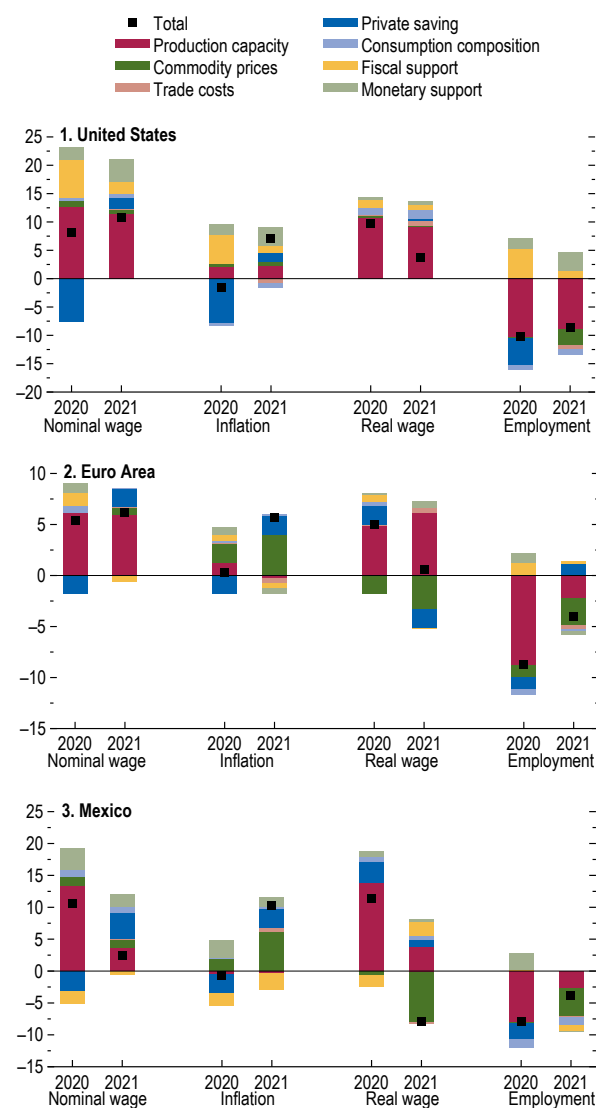
and falls in labor supply. These decreases led to a decline in employment and an increase in hourly wages.

The second key driver in 2020 was the rise in private saving (blue bars)—a contractionary force for aggregate demand—due to the myriad uncertainties surrounding the pandemic and its consequences. This negative demand shock had the usual disinflationary impact on nominal wages and consumer prices, particularly in the United States. Finally, the expansive fiscal and monetary policy responses in the United States and the euro area limited early damages to employment from the pandemic and helped support nominal wages.²⁷ In contrast, fiscal policy support in Mexico shrank in 2020, pulling wages and prices down to some extent (yellow bars). Monetary policy expansion in Mexico was effective at sustaining employment, along with pushing nominal wages and prices up (light green bars). For all three economies, the combination of a sharp increase in nominal wages and muted price responses led to strong increases in real wages.

In 2021, the main driver overall was the rebound in aggregate demand running ahead of production capacity—a supply-demand imbalance. The positive impact on consumer prices of private savings starting to be drawn down—a reversal of the negative impact of higher savings in 2020—shows this most clearly. Production capacity recovered somewhat last year, especially in the euro area and Mexico, but the recovery was not enough to fully boost employment. Continued monetary accommodation in the United States also pushed up wages and prices further. For the euro area and Mexico, the inflationary effects of monetary support were reduced. Fiscal policy support across economies decreased in 2021 compared with 2020,

Figure 2.6. Drivers of Changes in Wages, Prices, and Employment During the COVID-19 Pandemic and Recovery
(Cumulative percent change, relative to pre-COVID-19 trend)

Reductions in production capacity and changes in households' saving behavior were the predominant contributors to wage and price changes during the pandemic.



Source: IMF staff calculations.
Note: Estimated impacts are calculated using a multi-sector multi-economy general equilibrium model based on Baqaee and Farhi (2022b) model. See the Online Annex 2.5 for further details. The impacts of individual shocks do not necessarily add up to the total impact in combination as a result of interactions in general equilibrium. Total impacts are model based and broadly aligned with outcomes.

²⁷ Note that there are important aspects of the design and composition of fiscal support policies that the model abstracts away from. See chapter 3 of the April 2021 WEO and the October 2022 *Fiscal Monitor* for discussion on how the appropriate mix of job retention support and other measures may make fiscal policy support more effective.

relieving some of the earlier upward pressure on prices.²⁸ The mix of nominal wage and price changes led real wages to decline across the board last year, especially in Mexico.

The other major contributor to wages and prices in 2021 was the steep rise in commodity prices (green bars). The euro area and Mexico felt the impacts of those energy and food shocks on economy-wide prices were more strongly than the United States, but commodity price rises were drags on employment across the board. Commodity prices have risen even further in 2022 (particularly with the shock of the war in Ukraine) and are pushing inflation up even more. Wage and price prospects will depend in part on how long these and other shocks persist.

Inflation De-anchoring: Expectations and Policy Responses

Beyond the potential for more persistent and additional inflationary demand and supply shocks, the risks for inflation de-anchoring or the emergence of a wage-price spiral will also depend on how businesses and workers form their expectations for wages and prices. This section delves into this issue. It first studies empirically the dynamic responses of wages, prices, and expectations regarding them to an inflationary shock (driven by global supply pressures) and monetary policy tightening.

Building on the insights from the empirical exercise, the section then demonstrates how the dynamic effects of inflationary shocks and the effectiveness of monetary policy responses depend critically on how wage and price expectations are formed. Taking account of current monetary policy plans, it considers a couple of forward-looking scenarios under different assumptions about the formation of wage and price expectations. The findings suggest that more backward-looking expectations will require stronger monetary policy responses to reduce the risks of de-anchoring, but they also indicate that the risks of a wage price spiral are low.

Inflationary Shocks and Monetary Tightening

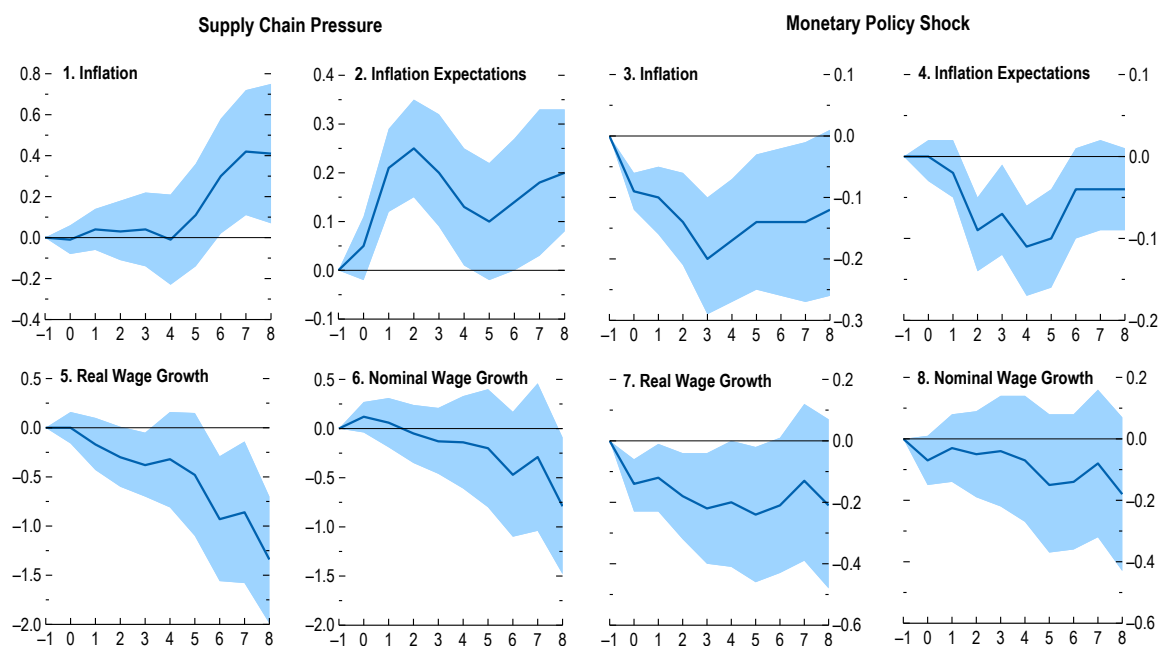
The empirical analysis estimates the dynamic effects of inflationary shocks and monetary tightening on wages and prices using local projections. Inflationary shocks are proxied by the Federal Reserve Bank of New York's Global Supply Chain Pressure Index, which captures the state of international supply chain pressures and disruptions (which are highly relevant to the conjuncture).²⁹ The index can be regarded as reflecting supply-side variation since the manufacturing data and transportation costs used in its construction have been previously purged

²⁸ Fiscal support likely had further, indirect inflationary effects through its effects on private saving and labor supply from income transfers, but these channels are difficult to quantify precisely in the Baqaee and Farhi (2022b) model used here. See Online Annex 2.5 for further details. See Ramey (2016) for a summary of the large empirical literature on the dynamic effects of fiscal support.

²⁹ The estimation sample excludes the United States and includes a set of small, open advanced economies in the euro area to help avoid the reverse causality and simultaneity concerns that would arise with the inclusion of large economies that could have sizeable, direct effects on the global economy (given the inflationary shock considered). Moreover, recent evidence suggests that changes in the index have had a meaningful impact on inflation in euro area producer prices and consumer goods prices (Akinci and others 2022). The sample includes 16 economies: Austria, Belgium, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, the Netherlands, Portugal, the Slovak Republic, Slovenia, and Spain. To avoid confounding with the large number of shocks occurring with the COVID pandemic, the estimation sample ends in the fourth quarter of 2019. See Benigno and others (2022a, 2022b) for details on the construction of the index.

Figure 2.7. Cumulative Effects of Supply Chain Pressures and Monetary Tightening on Wages and Prices
(Percentage points; dynamic response)

Increases in supply chain pressures tend to raise inflation and depress wage growth, with more persistent effects on inflation expectations. Monetary tightening is effective at bringing both inflation and inflation expectations down, but the actions required to offset inflationary shocks from supply chain pressures could be large.



Sources: Federal Reserve Bank of New York; Haver Analytics; Jarociński and Karadi (2020); Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Lines show the estimated impulse responses of the indicated variable to the indicated shock, with the shaded area representing the 90 percent confidence interval. The horizontal axes show time in quarters, where $t = 0$ is the initial impact quarter of the shock. The estimation sample includes euro area economies over 1999:Q4–2019:Q4. The left four panels (1, 2, 5, 6) are the responses to a supply chain pressure shock, defined as a one standard deviation increase in the Federal Reserve Bank of New York's Global Supply Chain Pressure Index. To account for economies' different degrees of exposure, the index is weighted by an economy's trade openness. The right four panels (3, 4, 7, 8) are the responses to a one standard deviation monetary policy shock, as identified as in Jarociński and Karadi (2020). "Inflation expectations" are 12-month ahead expected inflation. See Online Annex 2.1 for details on the sample and 2.6 for further details on the estimation.

of demand factors. Finally, to account for differences in economies' exposures to global supply chain developments, the index is interacted with trade openness by economy.³⁰

For a one standard deviation increase in global supply chain pressures, the inflation response outstrips that of nominal wage growth (Figure 2.7, panels 1 and 6). Both realized and short-term expected inflation increase persistently, taking three years (beyond the horizon shown) before reverting. In parallel, nominal wage growth increases slightly in the very near term and then deteriorates, as the shock's depressive effects on activity take hold. Together, these dynamics engender a fall in real wage growth (Figure 2.7, panel 5). Most important, there are no signs that such inflationary shocks kick off a wage-price spiral.³¹

In contrast, monetary tightening brings inflation down, with similar depressive effects on nominal wage growth. To estimate the effects of monetary policy tightening, the analysis uses the series of

³⁰ Trade openness is defined here as the sum of an economy's imports and exports, as a share of GDP. To address concerns about simultaneity, the estimation uses the lagged value of the supply chain pressure index. See Online Annex 2.6 for further details on the empirical specification and set of controls included.

³¹ Behind the scenes, the long-term interest rate on government bonds and the unemployment rate increase in response to such a shock. These increases could reflect the effects of endogenous monetary tightening in response to the adverse supply shock. See Online Annex 2.6 for further details on the dynamic responses of the long-term interest rate and the unemployment rate, along with a more detailed discussion of the specification and robustness.

identified European Central Bank monetary shocks from Jarociński and Karadi (2020).³² The impact of a one standard deviation monetary tightening on realized and expected inflation is shorter lived than the effect of an inflationary supply chain shock (Figure 2.7, panels 3 and 4). At the same time nominal and real wage growth declines, further helping to mitigate any inflationary pressures (Figure 2.7, panels 7 and 8). In the background, the unemployment rate rises alongside increases in the long-term rates on government debt.³³

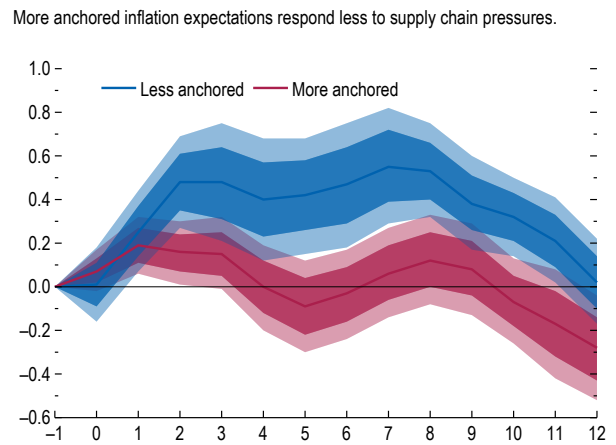
This empirical evidence suggests that supply chain-related inflationary shocks tend to have temporary effects on inflation and wage growth and do not give rise to a wage-price spiral. However, supply chain pressures do appear to have a more prolonged effect on expected inflation than a monetary tightening. The differences in dynamic effects could suggest that monetary policymakers should respond aggressively to such shocks, particularly in contexts like the conjuncture, in which inflation is high and rising, and wage growth is sensitive to inflation expectations (as shown earlier).

If inflation expectations become less anchored to the monetary policy target rate, the effects on wages and prices could change and increase the risks of a wage-price spiral emerging. When inflation expectations are more anchored, inflation expectations are comparatively less sensitive to an inflationary shock from an increase in global supply chain pressures, implicitly decreasing the risk of future de-anchoring (Figure 2.8, red line compared with blue line).³⁴

The Role of Expectations and Monetary Policy Responses in Wage and Price Inflation

Central banks often discuss the importance of monitoring price expectations to assess the proper stance of monetary policy, aiming to ensure that expectations do not drift away from central bank targets. With the world economy recovering from a global pandemic and inflation reaching levels not seen in decades in many countries, there are concerns that the current juncture could lead to

Figure 2.8. Cumulative Effects of Supply Chain Pressures on Inflation Expectations
(Percentage points; dynamic response)



Sources: Bems and others (2021); Federal Reserve Bank of New York; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Lines show the estimated impulse responses of inflation expectations (12-month ahead) to a one standard deviation rise in the Federal Reserve Bank of New York's Global Supply Chain Pressure Index (weighted by an economy's trade openness), conditional on the strength of inflation anchoring (defined by Bems and others 2021 over a five-year ahead horizon). The red (blue) is the response for economies with inflation anchoring above (below) the cross-economy median. Lighter-shaded areas represent the 90 percent confidence interval; darker-shaded areas are the 68 percent confidence intervals. The horizontal axis shows time in quarters, where $t = 0$ is the initial impact quarter of the shock. The estimation sample includes euro area economies over 1999:Q4–2019:Q4. See Online Annex 2.1 for details on the sample and 2.6 for further details on the estimation.

³² See Online Annex 2.6 for a detailed description of the analysis. Annex Figure 2.6.1 reports the monetary policy shocks aggregated at quarterly frequency. Note that the effect of monetary policy shocks could be seen as lower bound estimates since the effective lower bound might reduce the variation in some of the overnight indexed swap rates used in the construction of the shock.

³³ See Online Annex 2.6 for further details.

³⁴ The Global Supply Chain Pressure Index is interacted with a dummy equal to one if the lagged economy's strength of inflation anchoring, proxied by the Bems and others (2021) index, is above the cross-economy and cross-time median of the indicator. See Online Annex 2.6 for details on the construction of the indicator. This result is also in line with that of Carrière-Swallow and others (2022), who find that increases in the Baltic Dry Index lead to larger inflationary effects among economies with weaker monetary policy frameworks. To better anchor expectations, the recent literature has emphasized the role played by central banks' communication strategies and guidance, in addition to more traditional, policy actions, such as interest rate changes (Coibion, Gorodnichenko, and Weber 2022).

a break from recent, past trends, with expectations changing sharply. This subsection zooms in on how differences in the expectation formation processes can affect an economy's dynamics, with particular focus on the behavior of nominal wages and prices.

The analysis estimates a small, standard dynamic stochastic equilibrium model conditional on different expectation formation processes, thereby isolating their role in shaping the economy's response to shocks and policy actions. The model incorporates price and wage Phillips curves (which relate price and wage inflation, respectively, to expectations, the gap between real wages and productivity, and slack in the economy), an investment-savings curve (relating output to the nominal interest rate and inflation expectations), and a monetary policy reaction function.³⁵

With acknowledgment of the uncertainties surrounding expectations at the current juncture, three kinds of expectations formation processes are considered:

1. *Rational expectations.* With rational expectations, standard in much economic modeling due to its tractability, businesses and households understand the economy's complete structure, including the distribution of shocks that may hit the economy. This means that businesses and households make accurate forecasts on average about future outcomes, so that their expectations about the future are right in the absence of further shocks.
2. *Fully adaptive expectations.* At the other extreme, businesses and households have fully adaptive expectations, which means they look at the value of a variable only in the recent past and assume that it stays at that value in the future. Therefore, they project future variables to be exactly equal to their latest realization.
3. *Adaptive learning.* Partway between rational expectations and fully adaptive expectations, adaptive learning assumes that businesses and households form expectations using small statistical models for key variables such as wages and prices. They update these expectations regularly as new data become available, learning from their mistakes and adjusting their expectations process.³⁶

How Wage and Price Expectations Form Matters More the Farther Away Inflation and Inflation Expectations Are from Target

Estimating the model for the United States, a scenario in which there are no new shocks to inflation and interest rates are exogenously set according to the Federal Reserve's dot plot as of June 2022, a soft landing appears feasible if expectations for wages and prices are rational (Figure 2.9, dashed black lines).³⁷ In this case, the current inflationary shock is assumed to smoothly dissipate over the subsequent 12 quarters, allowing the output gap to smoothly converge to zero and inflation to come down to the Federal Reserve's target of 2 percent.

³⁵ See Online Annex 2.7 for more details about the model and its structure. See also Alvarez and Dizioli (forthcoming).

³⁶ See Online Annex 2.7 for further discussion of the alternative expectations formation processes, including the specific functional forms assumed for the adaptive learning process.

³⁷ The findings do not change in a meaningful way if monetary policy instead follows the estimated monetary policy reaction function, pointing to a high degree of consistency between the reaction function and announced policy. See Online Annex 2.7.

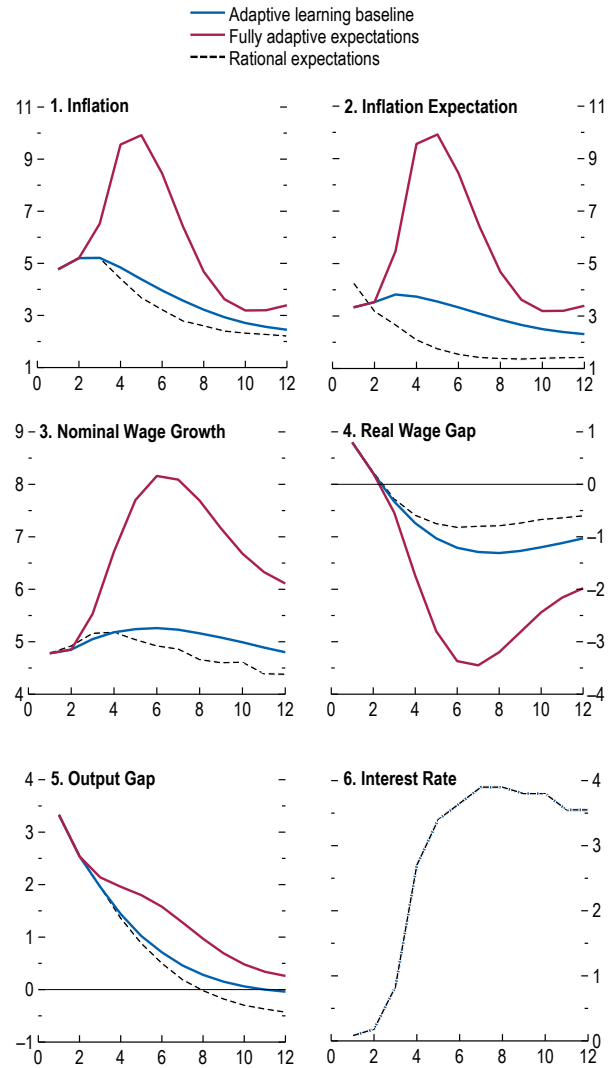
In contrast, if wage and price expectations are fully adaptive, there is a fast near-term acceleration in wage and price inflation because businesses and households expect them to be identical to their most recent realizations, which have been higher than usual (Figure 2.9, red lines). Moreover, the economy is still facing large cost-push shocks that exacerbate price pressures and mostly offset the near-term disinflationary effects of falling real wages (since wage growth does not keep up fully with price inflation). As shocks dissipate and the real wage gap becomes even more negative, price inflation quickly declines the after five quarters. However, although inflation comes down and there are no further future shocks assumed, price inflation remains 1.5 percentage points over target even 12 quarters later. To bring inflation down more quickly under this type of expectations formation, monetary policy would need to tighten much more sharply than is currently anticipated.

Under adaptive learning, which is the most realistic of the three expectations processes since the process is estimated to fit recent data on wage and price dynamics, the paths of inflation, wage growth, and the output gap lie between those for rational and fully adaptive expectations (Figure 2.9, blue lines). There is somewhat greater inertia than with rational expectations, but nowhere near the level seen in the fully adaptive case.³⁸ Even so, while the output gap mostly closes, inflation is still about a half-percentage point above target after eight quarters.

The results from simulations of the model estimated for the case of Brazil—an emerging market economy—exhibit broad patterns across the three expectations processes that are similar to those for the United States (see Online Annex 2.7). However, they show an even greater

Figure 2.9. Near-Term Scenarios with Set Interest Rate Path under Different Expectations (Percent)

With cost-push shocks originating outside the labor market, real wage dynamics help to stabilize inflation even when wage and price expectations are backward-looking (adaptive). If policy actions are not responsive enough, inflation and expectations can de-anchor from target the more adaptive expectations are.



Source: IMF staff calculations.
 Note: The responses illustrate scenarios calibrated to the United States, assuming that the inflationary shocks as of early 2022 decay as estimated based on previous experience. The horizontal axes show time in quarters since 2021:Q4. See Online Annex 2.7 for further details on the structure and estimation of the underlying small dynamic, stochastic general equilibrium model.

³⁸ The model is estimated over a period in which the monetary policy framework had high credibility, and hence the adaptive learning process begins centered on the inflation target, similar to the anchoring that occurs with rational expectations. Consequently, a very large shift in how expectations are formed would be needed to push the adaptive learning scenario to approximate the fully adaptive case. The greater economic inertia seen in the adaptive learning case is a function of the greater inertia in expectations.

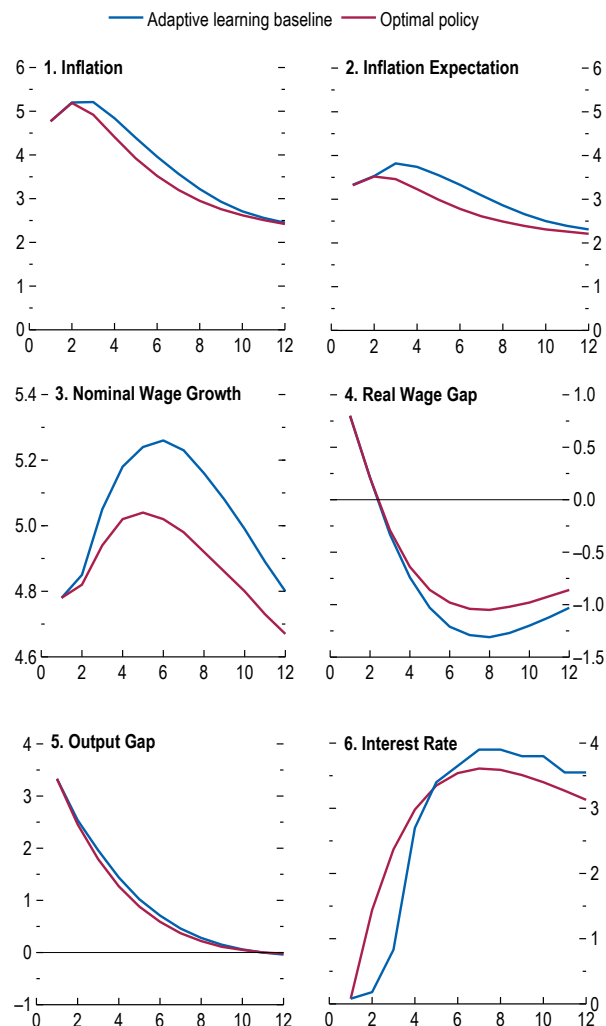
sensitivity to inflationary shocks and higher risks of de-anchoring in general. The greater sensitivity could entail a stronger reaction from the central bank to anchor expectations.

In all cases, the dynamics of real wages are critical to the evolution of wage and price inflation since they can affect price pressures. For simplicity, wages are the only determinant of marginal costs in the model employed here. Because of this, the model can also illustrate the likelihood of a wage-price spiral dynamic taking hold. This modeling choice not only allows the assessment of the likelihood of wage-price spirals in the simulated scenarios but also shows that wages can be an important anchor to inflation when cost-push shocks hit an economy. When inflationary, cost-push shocks occur, the negative real wage gap characterizing the current circumstances helps to anchor inflation, even in the case of fully adaptive expectations.³⁹ When the real costs of labor fall, they help to bring inflation down. Moreover, the larger the increase in inflation, the more negative the real wage gap becomes and the more powerful this anchoring mechanism is. Using a different methodology and focusing on the United States, Box 2.1 empirically examines the feedback from wages to prices by sector and finds that only limited pass-through from wage-cost shocks to prices.

As alluded to earlier, more backward-looking expectations will typically require a faster and stronger monetary tightening in response to an inflationary shock. But how much faster? For the case of the United States with a positive output gap and persistent cost-push shocks, if expectations are formed through adaptive learning, a central bank that minimizes a standard welfare function would choose to initially tighten policy by more and start easing earlier than the path implied by the Federal Reserve’s dot plot (Figure 2.10).⁴⁰ Even so, it would take several

Figure 2.10. Optimal Policy Scenario under Adaptive Learning Expectations (Percent)

Front-loading monetary policy tightening is optimal to lessen the buildup of inflation expectations, helping to achieve target more quickly and smoothly.



Source: IMF staff calculations.
 Note: The responses illustrate scenarios calibrated to the United States, assuming that the inflationary shocks as of early 2022 decay as estimated based on previous experience. The horizontal axes show time in quarters since 2021:Q4. Optimal policy is determined using an objective function that equally weights output and inflation deviations from potential and target respectively, with some weight given also to policy rate smoothing. See Online Annex 2.7 for further details on the structure and estimation of the underlying small dynamic, stochastic general equilibrium model.

³⁹ A negative real wage gap means that real wage (the ratio of the wage to the price level) has not kept up with labor productivity.

⁴⁰ The assumptions to determine an optimal monetary policy response include: (i) the central bank minimizes a welfare function that equally weighs output and inflation deviations (a quadratic loss function); and (ii) the central bank knows the expectation formation process and has full information on the cost-push shocks going forward. See Online Annex 2.7 for more details on the exercise.

quarters for inflation to come down, although the inflation gains would accumulate over time. Monetary policy affects inflation dynamics through three channels: (1) higher interest rates lower the output gap and real wages through the wage and price Phillips curves; (2) as expectations are partially adaptive, lower inflation realizations contributes to lower expected inflation; and (3) through recognizing mistakes in their forecasts, businesses and households learn over time and reduce the importance of past outcomes in affecting their expectations.

Conclusions

Many economies have seen sharp rises in price inflation since 2021, as adverse supply shocks buffet the global economy and labor markets appear tight in the wake of the acute COVID-19 shock. These inflation rises have raised concerns among some observers that prices and wages could start feeding on each other and accelerate, leading to a wage-price spiral dynamic. Using a mix of empirical and model-based analyses, this chapter has examined recent developments, trying to shed light on the prospects for wages and the chances that a wage-price spiral could emerge.

Although wage and price inflation picked up in a broad-based manner through 2021, real wages tended to be flat or falling across economies on average. This is an important aspect of the current conjuncture, since falling real wages can be disinflationary by lowering firms' real costs. An analysis of historical episodes with features similar to today's suggests that these episodes did not tend to show a subsequent wage-price spiral. In fact, inflation tended to fall gradually afterwards on average, while nominal wages gradually caught up over several quarters. However, in some cases, inflation remained elevated for a while afterwards.

Wage dynamics over 2020 and into early 2021 were poorly explained by inflation expectations and labor market slack, likely reflecting the highly unusual constellation of shocks arising with the COVID-19 pandemic. Model-based analysis of wages and prices over 2020–21 suggest they were underpinned by different shocks: wages were predominantly driven by production capacity and labor supply shocks while private saving was important for price changes. That said, in the second half of 2021, wage growth appears to be relatively well-explained by inflation expectations and labor market slack on average, potentially pointing to a gradual shift towards more normal economic dynamics. Of course, this shift is highly contingent on whether the earlier shocks continue unwinding and whether new shocks arise.

Finally, the analysis suggests a critical role for the expectations formation process in shaping wage and price prospects. When wage and price expectations are more backward-looking, monetary policy actions need to be more frontloaded to minimize the risks of inflation de-anchoring. With monetary policy tightening more aggressively and the decline in real wages acting to reduce price pressures, the scenario analysis suggests that the risk of a wage-price spiral emerging in the current episode is contained on average, assuming no more persistent inflationary shocks or structural changes in wage and price-setting processes (such as sharply higher pass-through from prices to wages or vice versa).

Box 2.1. Pass-Through from Wages to Prices: Estimates from the United States

The empirical literature offers limited evidence on the pass-through of wages to consumer prices. At the macro level, the link between labor cost and price inflation has weakened over the past three decades.¹ Meanwhile, analysis at a more disaggregated level has not reached much of a consensus on the pass-through of labor costs to retail prices.²

Using a novel estimation approach, this box finds that the recent pick-up in nominal wage growth has added only modestly to consumer price inflation, mostly through its effects on prices of certain services. The analysis studies the pass-through of labor costs to consumer prices (as measured by the personal consumption expenditure, or PCE, price index) by looking at disaggregated sectoral data. The main empirical challenge is that consumer prices, which reflect the final product of multiple production processes, cannot be readily matched to the costs of labor inputs, which are recorded at the industry level. To overcome this measurement problem, input-output matrices are used to construct the cumulative costs of labor inputs (traced through the supply chain of intermediate goods and services) for 73 subcomponents of the PCE index. Using the local projection method in Heise, Karahan, and Şahin (2021) with sectoral productivity growth and time and industry fixed effects controlled for, the impulse response of prices to wages changes shows a pass-through of about 10 percent to services after five quarters, but no measurable pass-through to goods prices (Figure 2.1.1). The lack of pass-through in goods compared with that in services could be due to firms absorbing more labor cost changes, on the back of higher market power and import penetration. The estimated pass-through appears materially unchanged from the mid-2000s up to the pandemic.

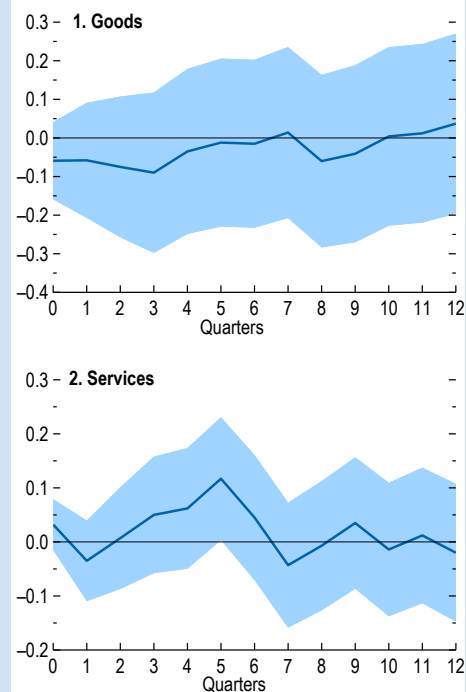
There is some tentative evidence that the pass-through from wages to service prices is stronger during periods or in sectors in which labor costs increased more quickly. Pre-2020 data suggest that contemporaneous pass-through in the services sector picks up to 20 percent (and is statistically significant at the 99 percent confidence level) when wage growth is at or above the 75th percentile (that is, 3.9 percent), while pass-through is about zero in periods with lower wage growth. In addition, the cross-section from the sectoral data suggests that the point estimate of the pass-through from wages to service prices has been increasing since the first quarter of 2021 but is not statistically significant.

The authors of this box are Moya Chin and Li Lin.

¹ See Bobeica, Ciccarelli, and Vansteenkiste (2021) for evidence on this.

² For further background on the debate, see Rissman (1995) and Heise, Karahan, and Şahin (2021), among others.

Figure 2.1.1. Pass-Through from Wages to Prices
(Percent)



Sources: US Bureau of Economic Analysis; US Bureau of Labor Statistics; and IMF staff calculations.

Note: Lines show the dynamic pass-through from a 1 percentage point change in current wage growth (at $t = 0$, measured by the four-quarter change in wages) to inflation (measured by the four-quarter change in the indicated sectoral prices). Shaded areas show the 90 percent confidence interval.

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Annex 2.1 Data Sources, Sample Coverage, and Variable Definitions

Data sources used in the chapter are listed in Table 2.1.1. The list of economies used for each exercise is provided in Table 2.1.2. The analysis primarily uses data in quarterly frequency.

The primary sources on wages, employment, unemployment, and inflation have been combined by taking one of the sources as the primary and extending backwards and forwards using growth rates from the other available sources. Where available, data from the Organisation for Economic Co-operation and Development (OECD) is taken first, followed by data from the International Labour Organization (ILO), and other sources listed in Table 2.1.1. For quarterly frequency, all original source data that was not seasonally adjusted by the source was seasonally adjusted by the authors using X-13ARIMA-SEATS procedure from the U.S. Census Bureau. For wage data, four series were constructed: 1) wage per hour in local currency, 2) wage per worker in local currency, 3) wage per hour index, 4) wage per worker index. For quarterly frequency, wage data in local currency was annualized. For employment data, four series were constructed: 1) number of people employed, 2) number of employees, 3) total number of hours worked, 4) number of hours worked per employee.

Inflation expectations are sourced from Consensus Forecasts (CF). Since monthly CF surveys provide with expected current- and next-year inflation (i.e., fixed-event forecasts), the twelve-month ahead (fixed-horizon) inflation expectations are constructed as the weighted sum of monthly vintages, following the standard approach in the literature (see Buono and Formai 2018, Methodological Appendix).

Sector Definitions

Sectors are defined based on the International Standard Industrial Classification of All Economic Activities (ISIC), revision 4. Because sectoral data granularity varies across economies, wages and employment are aggregated separately by economy into two broad sectors: industry and services. *Industry* includes manufacturing; construction; mining and quarrying; electricity, gas, and water supply. *Services* include market services (trade; transportation; accommodation and food; and business and administrative services); and non-market services (public administration; community, social, and other services and activities). Aggregate employment in industry and services is calculated as the sum of employment in each of their respective subsectors. Average wages in industry and services are the employment-weighted average of wages in each subsector.

WORLD ECONOMIC OUTLOOK

Annex Table 2.1.1. Data Sources

Indicator	Sources
Inflation	Haver Analytics; International Monetary Fund, World Economic Outlook database; Organisation for Economic Co-operation and Development
Wage (per worker, per hour; by sector)	Eurostat; Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Labor Statistics
Employment (number of people, hours worked; by sector)	Eurostat; Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Labor Statistics
Unemployment	Haver Analytics; International Labour Organization; International Monetary Fund, International Financial Statistics and World Economic Outlook databases; Organisation for Economic Co-operation and Development
Additional Sources for Wage Phillips Curve Analysis	
Unemployment-to-Vacancy Ratio	Duval and others (2022); Barnichon (2010); and national authorities (Australian Bureau of Statistics; Eurostat; Statistics Canada; UK Office for National Statistics; US Bureau of Labor Statistics, Job Openings and Labor Turnover Survey)
Output-Side Real GDP in Chained Purchasing-Power-Parity Dollars (mil. 2017US\$) per Worker	Penn World Table 10.0
GDP in Purchasing-Power-Parity Dollars	International Monetary Fund, World Economic Outlook database
Markups	Diez, Leigh, and Tambunlertchai (2018) based on the Industry Classification Benchmark by FTSE Russell
Stringency of Contract Regulation	Indicators of Employment Protection, Organisation for Economic Co-operation and Development
Additional Sources for Wages and Economic Dynamics: Inflation Shocks and Monetary Policy	
Inflation Expectations	Consensus Economics Inc.
Government Long-Term Rates	Organisation for Economic Co-operation and Development
Participation in GVCs	Organisation for Economic Co-operation and Development, Trade in Value Added (TiVA)
Global Supply Chain Pressure Index	Benigno and others (2022); Federal Reserve Bank of New York, Global Supply Chain Pressure Index (GSCPI)
Monetary Policy Shocks	Jarociński and Karadi (2020), updated version by Jarociński as of July 2022.
Index of Inflation Expectations Anchoring	Bems and others (2021)
Additional Sources for Decomposing Changes in Wages, Prices, and Employment	
Inter-Country Input-Output Tables	Organisation for Economic Co-operation and Development, Inter-Country Input-Output Database (ICIO); Organisation for Economic Co-operation and Development, Trade in Employment (TiM)
Household Consumption Composition	United States Census Bureau; USA Trade Online
Commodity Prices	International Monetary Fund, Primary Commodity Price System
International Trade Costs	United States Census Bureau; USA Trade Online
Fiscal Policy	Organisation for Economic Co-operation and Development, Quarterly and Annual National Accounts; United States Bureau of Economic Analysis
Monetary Policy	Haver Analytics; Wu-Xia Shadow Rates (Federal Funds Rate; European Central Bank Policy Rates)
Household Savings Rate	Organisation for Economic Co-operation and Development, Annual National Accounts
Additional Sources for Role of Wage and Price Expectations: Scenarios from a Small DSGE Model	
Real GDP per Capita	Haver Analytics; Brazilian Institute of Geography and Statistics (IBGE); Federal Reserve Economic Data (FRED)
IPCA-15 (Consumer Price Index)	Brazilian Institute of Geography and Statistics (IBGE)
Personal Consumption Expenditures	Federal Reserve Economic Data (FRED)
Federal Reserve Funds Rate	Federal Reserve Economic Data (FRED)
Selic Interest Rate	Central Bank of Brazil
Constant Composition Real Wages	Dizioli and Wang (2022); Howard, Rich, and Tracy (2022)

Source: IMF staff compilation.

Note: DSGE = dynamic stochastic general equilibrium; GVCs = global value chains.

Annex Table 2.1.2. Sample of Economies Included in Analytical Exercises

Figure 2.1

AEs (33): Australia; Austria; Belgium; Canada; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hong Kong SAR; Ireland; Israel; Italy; Japan; Korea; Latvia; Lithuania; Luxembourg; Netherlands; New Zealand; Norway; Portugal; Singapore; Slovak Republic; Slovenia; Spain; Sweden; Switzerland; Taiwan Province of China; United Kingdom; United States

EMDEs (22): Argentina; Belarus; Brazil; Bulgaria; Colombia; Croatia; Hungary; Kazakhstan; Mexico; Moldova; Peru; Philippines; Poland; Romania; Russia; Saudi Arabia; Serbia; South Africa; Thailand; Türkiye; Ukraine; Vietnam

Figure 2.2, Figure 2.3, Annex Figure 2.3.1

See Annex Table 2.3.1

Figure 2.4, Annex Table 2.4.1

AEs (31): Australia; Austria; Belgium; Canada; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hong Kong SAR; Ireland; Italy; Japan; Korea; Latvia; Lithuania; Netherlands; New Zealand; Norway; Portugal; Singapore; Slovak Republic; Slovenia; Spain; Sweden; Switzerland; Taiwan Province of China; United Kingdom; United States

EMDEs (15): Argentina; Brazil; Bulgaria; Colombia; Croatia; Hungary; Mexico; Peru; Philippines; Poland; Romania; Russia; Thailand; Türkiye; Ukraine

Figure 2.5

AEs (27): Australia; Austria; Belgium; Canada; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Japan; Korea; Lithuania; Netherlands; New Zealand; Norway; Portugal; Slovak Republic; Slovenia; Spain; Sweden; Switzerland; United Kingdom; United States

Figure 2.6

Albania; Argentina; Armenia; Australia; Azerbaijan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Cambodia; Canada; Chile; China; Colombia; Costa Rica; Croatia; Czech Republic; Denmark; Dominican Republic; Ecuador; Egypt; Euro Area (Austria; Belgium; Cyprus; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Portugal; Slovak Republic; Slovenia; Spain); Georgia; Guatemala; Guyana; Hong Kong SAR; Hungary; Iceland; India; Indonesia; Iran; Israel; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Korea; Kosovo; Kyrgyz Republic; Lao P.D.R.; Macao SAR; Malaysia; Mauritius; Mexico; Moldova; Mongolia; Montenegro, Rep. of; Morocco; Myanmar; New Zealand; North Macedonia; Norway; Paraguay; Peru; Philippines; Poland; Qatar; Romania; Russia; Saudi Arabia; Senegal; Serbia; Seychelles; Singapore; Slovak Republic; South Africa; Sri Lanka; St. Lucia; Sweden; Switzerland; Taiwan Province of China; Tajikistan; Thailand; Tunisia; Türkiye; Ukraine; United Kingdom; United States; Uruguay; Uzbekistan; Vietnam. (For model calibration)

Figure 2.7, Annex Figure 2.6.1

AEs (16): Austria; Belgium; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Latvia; Lithuania; the Netherlands; Portugal; Slovakia; Slovenia; Spain

Figure 2.8

AEs (10): Estonia; France; Germany; Italy; Lithuania; Latvia; the Netherlands; Slovakia; Slovenia; Spain

Figure 2.9, Figure 2.10

United States

Annex Figure 2.1.1

AEs (28): Australia; Austria; Belgium; Canada; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Japan; Latvia; Lithuania; Luxembourg; Malta; Netherlands; New Zealand; Portugal; Slovak Republic; Slovenia; Spain; Sweden; United Kingdom; United States

EMDEs (7): Bulgaria; Chile; Croatia; Hungary; Poland; Romania; Türkiye

Annex Figure 2.1.2

AEs (22): Austria; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Latvia; Lithuania; Luxembourg; Netherlands; Norway; Portugal; Slovak Republic; Slovenia; Spain; Sweden; United Kingdom; United States

EMDEs (4): Bulgaria; Hungary; Poland; Romania

Annex Figure 2.2.1

AEs (23): Austria; Belgium; Canada; Czech Republic; Denmark; Estonia; Finland; Germany; Greece; Ireland; Italy; Latvia; Lithuania; Luxembourg; Netherlands; Norway; Portugal; Slovak Republic; Slovenia; Spain; Sweden; United Kingdom; United States

EMDEs (14): Argentina; Brazil; Bulgaria; Colombia; Ecuador; Hungary; India; Indonesia; Jordan; Peru; Philippines; Poland; Serbia; Vietnam

Annex Figure 2.2.2

AEs (22): Austria; Belgium; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Latvia; Lithuania; Luxembourg; Netherlands; Norway; Portugal; Slovak Republic; Slovenia; Spain; Sweden; United States

Annex Figure 2.4.1, Annex Figure 2.4.2

AEs (29): Australia; Austria; Belgium; Canada; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Ireland; Italy; Japan; Latvia; Lithuania; Netherlands; New Zealand; Norway; Portugal; Singapore; Slovak Republic; Slovenia; Spain; Sweden; Switzerland; Taiwan Province of China; United Kingdom; United States

Annex Figure 2.4.3

AEs (14): Australia; Austria; Belgium; Canada; Finland; Germany; Ireland; Japan; Netherlands; Norway; Portugal; Sweden; United Kingdom; United States

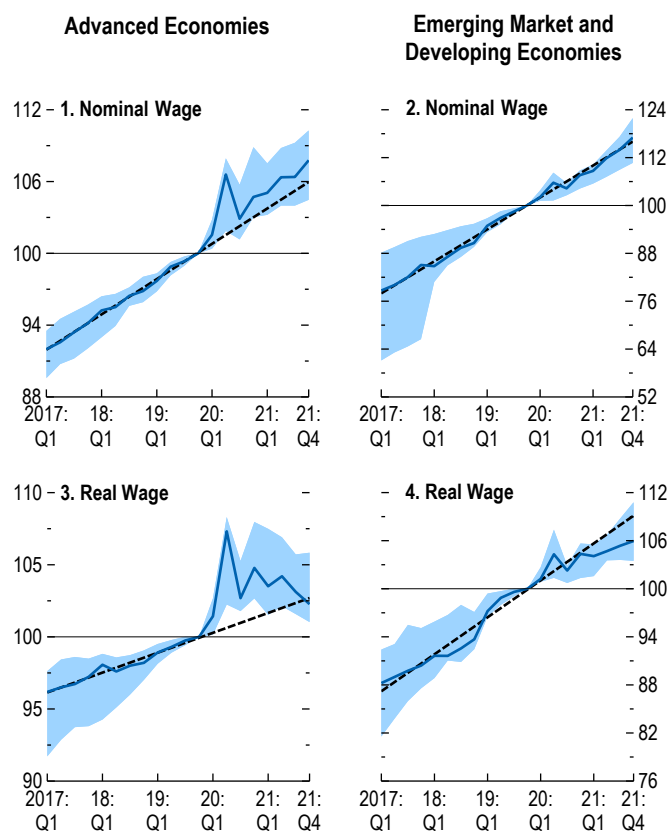
Source: IMF staff compilation.

Note: AEs = advanced economies; EMDEs = emerging market and developing economies.

Additional Figures

Wages per hour. The chapter focused on average wages per worker when describing the dynamics of nominal and real wages. Figures 2.1.1 and 2.1.2 show those dynamics for average wages *per hour worked* in both advanced economies and emerging markets, and across sectors. The distinction between wages per hour and wages per worker was particularly relevant during the pandemic, as hours worked were adjusted for a large portion of workers. As shown in Figure 2.1 and Annex Figure 2.2.1 (below), when the COVID-19 shock hit the economy, wages per worker spiked down, reflecting the negative impact of the pandemic on nominal wages. In contrast, wages per hour spiked *up*, as the adjustment in hours was more severe than the adjustment on wages. Nevertheless, we again find that wages per hour quickly returned to their previous trend and there are no clear signs of severe, above average wage inflation by the end of 2021.

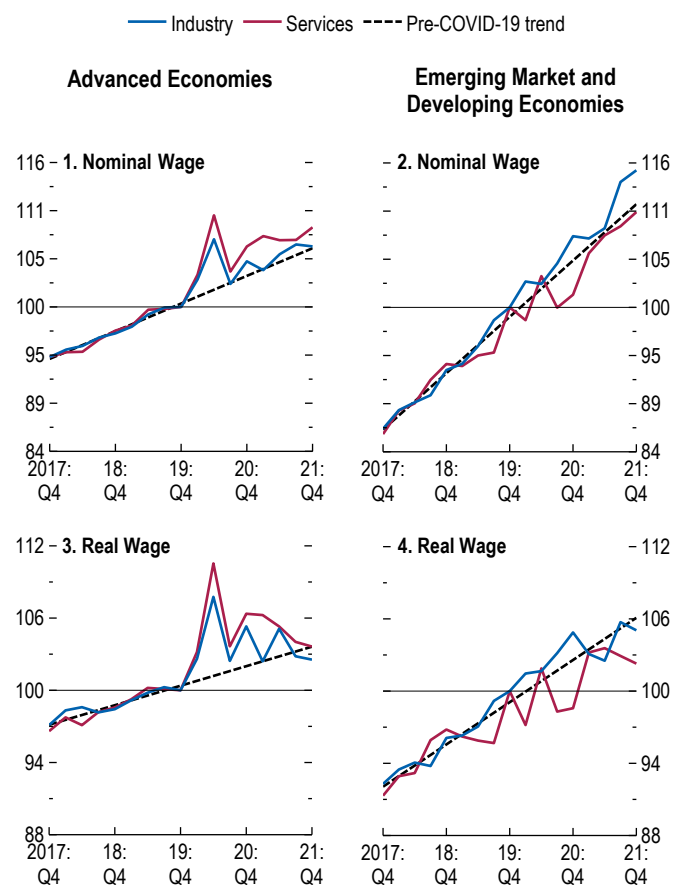
Annex Figure 2.1.1. Recent Hourly Wage Dynamics
(Index, 2019:Q4 = 100, unless noted otherwise)



Sources: Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: Blue lines represent the median across economies; dashed lines indicate the pre-COVID-19 trend; shaded areas represent the interquartile range across economies. Wages (nominal and real) are calculated on a per-hour-worked basis. See Online Annex 2.1 for details on the sample coverage.

Annex Figure 2.1.2. Sectoral Perspective on Recent Wage Dynamics
(Index, 2019:Q4 = 100)



Sources: Eurostat; Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: The figure shows the median value of the distribution of wage indices across economies, where wages (nominal and real) are calculated on a per-hour-worked basis. Industry includes manufacturing; construction; mining and quarrying; and electricity, gas, and water supply. Services include wholesale and retail trade; transport; hotels and restaurants; information and communication; financial intermediation; real estate activities; professional and scientific activities; administrative services; public administration; education; health; arts and entertainment; and other service activities. See Online Annex 2.1 for details on the sample coverage.

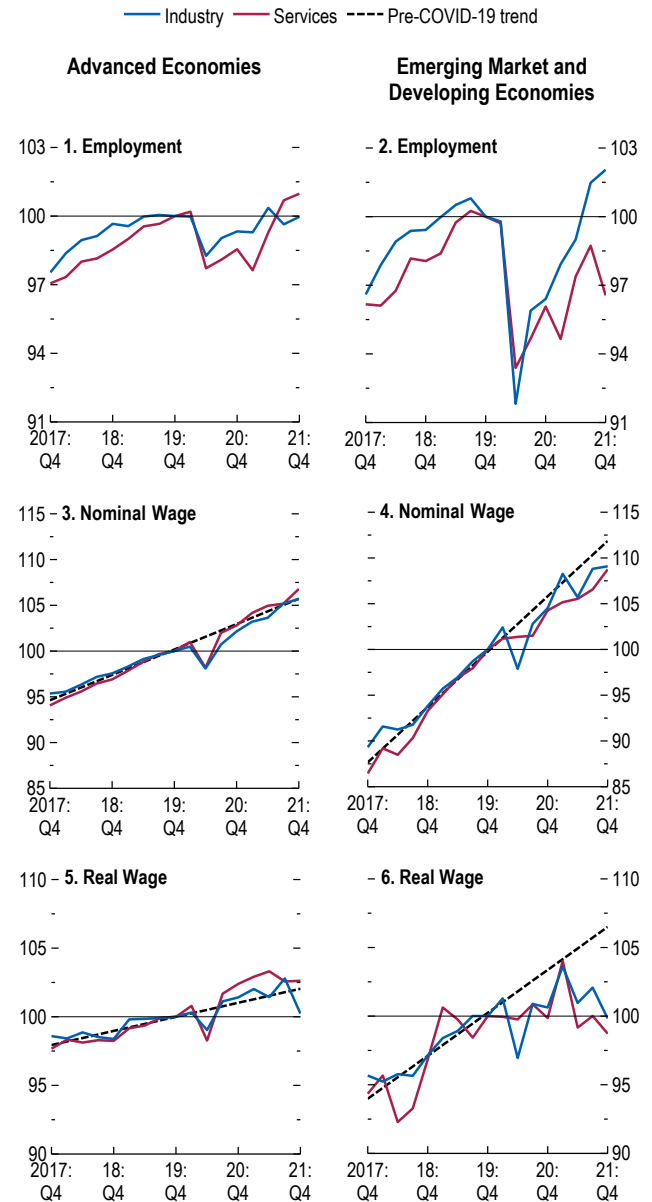
Annex 2.2. A Sectoral Perspective on Recent Wage Dynamics

With the acute COVID-19 shock impacting contact-intensive services more than goods-producing industries, a first question is whether these early sectoral differences are still evident in recent paths of wages and employment by sector or if there are signs that wage dynamics have converged as the economy recovers. Comparing economy groups, employment in advanced economies is back to its pre-pandemic level in both industry and service sectors on average, while the recovery in emerging market and developing economies has been skewed towards industry (Figure 2.2.1, panels 1 and 2).

In contrast to the lingering differences in employment across sectors, both nominal and real wages have displayed a consistent dynamic for both advanced and emerging market and developing economies—wages across sectors appear to return to (or, in one case, fall short of) the same common, aggregate trend (Figure 2.2.1, panels 3-6). This suggests that any wage pressures are currently broad-based, reflecting wider economic pressures rather than sectoral composition changes.¹

Despite the sectoral nature of the COVID-19 shock, it does seem that reallocation of labor across sectors has played a relatively minor role in explaining recent wage dynamics. Between 2019 and 2021, less than 5 percent of the change in the average nominal wages per worker can be accounted for by sectoral reallocation of workers within a sample of advanced economies (Figure 2.2.3, panel 1). The bulk of the decline is attributable to wage increases within each sector, reflecting the broad-based nature of recent wage increases. The exact contribution from sectoral reallocation varies across economies and depends

Annex Figure 2.2.1 Sectoral Perspective on Recent Wage and Employment Dynamics
(Index, 2019:Q4 = 100, unless noted otherwise)



Sources: Eurostat; Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: The figure shows the median value of the distribution of employment and wage indices across economies, where wages (nominal and real) are calculated on a per-worker basis. See Online Annex 2.1 for details on the sectoral composition and sample coverage.

¹ It's important to note that this does not mean that workers' nominal incomes by sectors are back to their previous path. First, to achieve the broadest sample coverage, the chapter focuses on wages per worker. For those economies where the data are available, hourly wages show slightly different dynamics—particularly during the acute pandemic phase—as both hours and employment were adjusted. See also the Online Annex 2.1 for further details. Second, since wage data are only available for the employed, the income loss for workers who became unemployed due to the COVID shock is missed. See Cajner and others (2020) for evidence from the United States on the more adverse impact of the COVID shock on low-income workers.

on how broadly the sectors are defined. For the United States, where more granular sectoral information is available, the contribution is somewhat larger at 10 percent on average during the period, with an even larger contribution during the acute phase of the pandemic (Figure 2.2.3, panel 2).²

Real wages across sectors also appear to reflect common patterns, although with few signs of a return to the pre-pandemic trend in emerging market and developing economies. Due to a pickup in nominal wage growth, the average real wage in advanced economies rose after the acute phase of the pandemic. However, the growth in inflation during the second half of 2021 undid a large portion of those gains. As a result, real wages in services are slightly above, while real wages in industry have mostly returned to their levels in the last quarter of 2019. In emerging market and developing economies, real wages across sectors have been generally flat through the whole period. The overall picture across sectoral labor markets aligns with the view that wage pressures are broad-based.

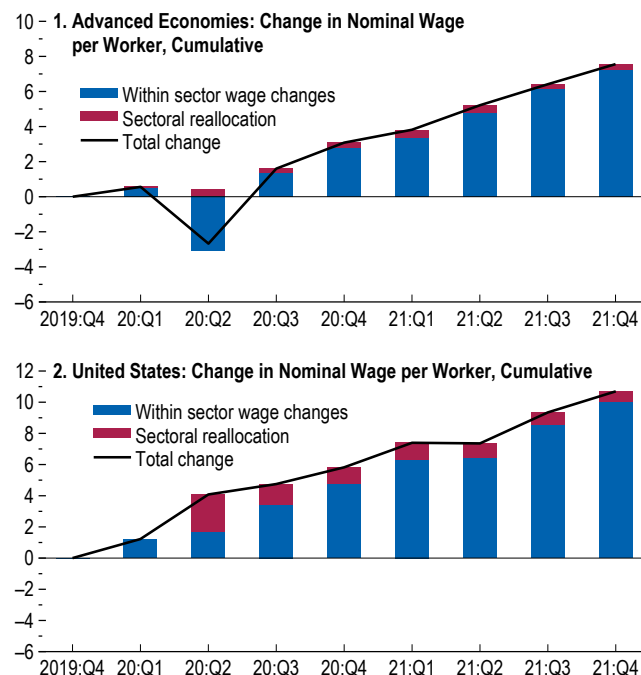
Sectoral Composition of Wage Growth Calculations

As seen in Figure 2.2.3, the change in wages per workers in economy c (w_{ct}), between time t and time $t+k$ can be written as

$$w_{ct+k} - w_{ct} = \sum_s \left(\frac{W_{cst+k}}{E_{cst+k}} - \frac{W_{cst}}{E_{cst}} \right) \frac{E_{cst+k}}{E_{ct+k}} + \sum_s \left(\frac{E_{cst+k}}{E_{ct+k}} - \frac{E_{cst}}{E_{ct}} \right) \frac{W_{cst}}{E_{cst}}$$

where W_{cst} are total wages in national currencies paid in economy c at sector s and time t , while E_{cst} is total number of employees in each sector. The first term captures the contribution from within sector wage change, and the second term captures the contribution from sectoral reallocation of labor to the overall change in wage levels. To get the contribution to relative wage growth (from period t), the equation is divided through by w_{ct} and simplified to

Annex Figure 2.2.2. Sectoral Contributions to Recent Wage Dynamics
(Percentage points; 2019:Q4 = 0)



Sources: International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: The figure shows the cumulative change in nominal wages per employee from 2019:Q4–21:Q4, decomposed into contributions from within sector wage changes and sectoral reallocation. See Online Annex 2.2 for details on the methodology. Sectoral definition is based on the International Standard Industrial Classification (ISIC) revision 4. Included sectors in panel 1 are B-E, F, G-I, J, K, L, M-N, and O-Q; in panel 2 are A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, and Q. In panel 1, the sample consists of 22 economies. See Online Annex 2.1 for details on the sample coverage.

² For the United States, data for 17 sectors are used while only 9 sectors are used for the broader set of advanced economies. However, using a restrictive sample of economies for which these 17 sectors are available does not overturn the conclusion that sectoral reallocation has played a relatively smaller role in explaining the recent nominal wage dynamics. See Online Annex 2.1 for additional details.

$$\frac{\Delta_k w_{ct}}{w_{ct}} = \frac{1}{w_{ct}} \left(\sum_s \Delta_k(w_{cst})s_{cst+k} + \sum_s \Delta_k(s_{est})w_{cst} \right)$$

In Figure 2.2.3 (panel 1), this algorithm is applied to data for eight aggregated sectors³ covering 22 advanced economies over the period 2019Q4-2021Q4 (see Table 2.1.2 for sample details). In Figure 2.2.3 (panel 2), the algorithm is applied to a more disaggregated set of 17 sectors for the United States covering the same time period.⁴

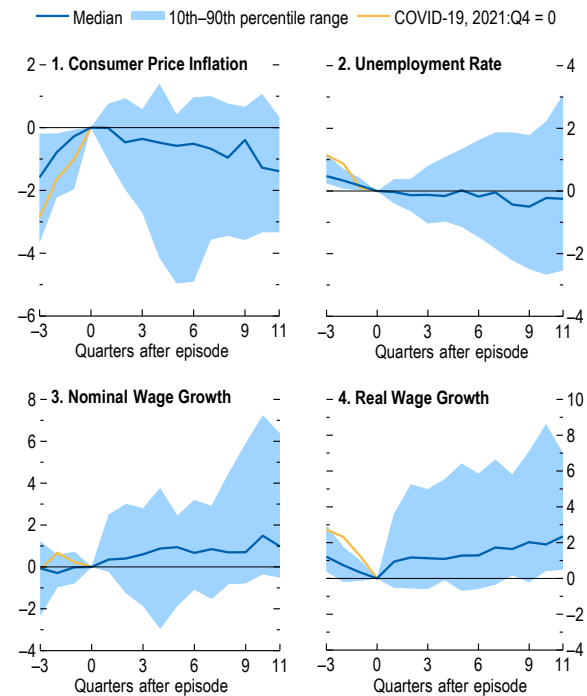
Annex 2.3. Case Studies

Episodes similar to the current macroeconomic conditions (Figure 2.1) are identified for economies and periods shown in Table 2.3.1. Episodes fulfill the following four criteria for at least three of the last four quarters: (i) year-on-year inflation is increasing; (ii) nominal wage growth is positive; (iii) real wage growth is negative; and (iv) unemployment is flat or falling.⁵ Outcomes following these episodes are presented in Figure 2.4. The list of episodes is shown in Table 2.3.2.

The data is also used to identify episodes with accelerating prices and wages. Episodes fulfill the following two criteria for at least three of the last four quarters: (i) year-on-year inflation is increasing; and (ii) nominal wage growth is also increasing. In this way, 79 episodes are identified. The distribution of outcomes following these episodes is presented in Figure 2.5.

To expand time-coverage, an alternative database is compiled using hourly nominal wages for the manufacturing sector (Table 2.3.1). In Figure 2.3.1-2.3.2, the analysis from Figure 2.5-2.6 is repeated using the longer sample. The

Annex Figure 2.3.1. Changes in Wages, Prices, and Unemployment after Similar Past Episodes
(Percentage point differences relative to first quarter in which criteria are fulfilled)



Sources: International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: The figure shows the developments following episodes in which at least three of the preceding four quarters have: (1) accelerating prices/rising price inflation, (2) positive nominal wage growth, (3) falling or constant real wages, and (4) declining or flat unemployment rate. Twenty-three such episodes are identified within a sample of 29 advanced economies going back to at the earliest 1960. The COVID-19 episode represents an average of countries in the sample for the period starting in 2021:Q4.

³ These are (i) Mining and quarrying, manufacturing, electricity, gas steam and air conditioning supply, and water supply (Sector B-E), (ii) Construction (sector F), (iii) Wholesale and retail trade, transportation and storage, accommodation and food service activities (sector G-I), (iv) Information and communication (sector J), (v) financial and insurance activities (sector K), (vi) real estate activities (sector L), (vii) professional, scientific and technical activities, administrative and support service activities (sector M-N), (viii) public administration and defense, education, human health and social work (sector O-Q).

⁴ These include Agriculture, forestry and fishing (sector A), Mining and quarrying (sector B), Manufacturing (sector C), Electricity, gas, steam and air conditioning supply (sector D), Water supply (sector E), Construction (F), Wholesale and retail trade (sector G), Transport and storage (sector H), Accommodation and food service activities (sector I), Information and communication (J), Financial and insurance activities (sector K), Real estate activities (sector L), Professional, scientific and technical activities (sector M), Administrative and support service activities (N).

⁵ If the four criteria hold repeatedly during a period of three years, only the first episode is selected.

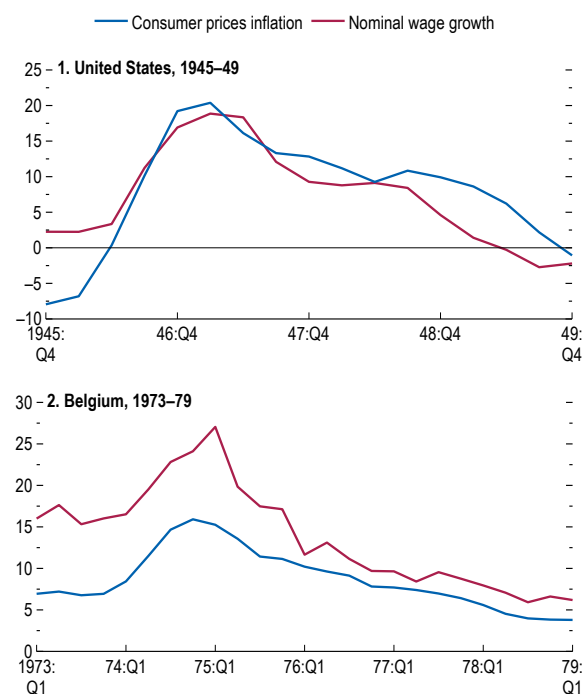
Annex Table 2.3.1. Data Sample for Event Studies

Economy	Aggregated Wages		Manufacturing Wages		Economy	Aggregated Wages		Manufacturing Wages	
	Start	End	Start	End		Start	End	Start	End
Australia	1976:Q3	2021:Q4	1983:Q4	2021:Q4	Korea	1989:Q1	2021:Q4	1992:Q1	2021:Q4
Austria	1995:Q1	2021:Q4	1967:Q1	2021:Q4	Latvia	2002:Q1	2021:Q4	2002:Q1	2021:Q4
Belgium	1995:Q1	2021:Q4	1960:Q1	2021:Q4	Lithuania	1995:Q1	2021:Q4	2000:Q1	2021:Q4
Canada	1981:Q1	2021:Q4	1978:Q4	2021:Q4	Luxembourg	1988:Q1	2021:Q4	1988:Q1	2021:Q4
Czech Republic	1995:Q1	2021:Q4	1993:Q1	2021:Q4	Netherlands	1995:Q1	2021:Q4	1970:Q1	2021:Q4
Denmark	1990:Q1	2021:Q4	1971:Q1	2021:Q4	New Zealand	1989:Q1	2021:Q4	1989:Q1	2021:Q4
Estonia	1995:Q1	2021:Q4	2000:Q1	2021:Q4	Norway	1995:Q1	2021:Q4	1972:Q1	2021:Q4
Finland	1975:Q1	2021:Q4	1973:Q1	2021:Q4	Portugal	1995:Q1	2021:Q4	2000:Q1	2021:Q4
France	1990:Q1	2021:Q4	1990:Q1	2021:Q4	Slovak Republic	1995:Q1	2020:Q3	1993:Q1	2021:Q4
Germany	1985:Q1	2021:Q4	1969:Q1	2021:Q4	Slovenia	1995:Q1	2021:Q4	1998:Q1	2021:Q4
Greece	1995:Q1	2021:Q4			Spain	1981:Q1	2021:Q4	1981:Q1	2021:Q4
Iceland			2005:Q1	2021:Q4	Sweden	1993:Q1	2021:Q4	1971:Q1	2021:Q4
Ireland	1995:Q1	2021:Q4	1983:Q1	2021:Q4	Switzerland	1995:Q1	2021:Q3		
Israel	1995:Q1	2021:Q2	1995:Q1	2021:Q4	United Kingdom	1992:Q2	2021:Q3	1971:Q1	2021:Q4
Italy	1980:Q1	2021:Q4	1960:Q1	2021:Q4	United States	1960:Q1	2021:Q4	1960:Q1	2021:Q4
Japan	1980:Q1	2021:Q4	1960:Q1	2021:Q4					

Sources: Eurostat; Haver Analytics; International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Labor Statistics; and IMF staff compilation.

results are broadly similar to those in Figure 2.5-2.6. In that sample, the United States following World War II and Belgium in the mid-1970s provide further illustrative examples of joint increase in wage and price inflation (Figure 2.3.2). In the post-war years, amid the elimination of price controls, supply shortages, and release of pent-up demand, price inflation and wage growth surged. In 1974 Belgium, consumer price inflation surged for several quarters following the first OPEC oil embargo. Nominal wage growth also picked up – in part owing to wage indexation mechanisms tying wage growth for negotiated wages to observed inflation. In both cases, price and wage inflation eventually subsided.

Annex Figure 2.3.2. Consumer Price Inflation and Nominal Wage Growth (Percent, year-on-year)



Sources: Organisation for Economic Co-operation and Development; St. Louis Federal Reserve Bank; US Bureau of Economic Analysis; and IMF staff calculations. Note: For the United States, nominal wages are measured by the average hourly earnings of production and nonsupervisory employees within the manufacturing sector; consumer prices are measured by the consumer price index for all urban consumers. For Belgium, nominal wages are measured using hourly nominal wages for the manufacturing sector.

Annex 2.4. Wage Phillips Curve Analysis

Empirical methodology

The baseline specification relates wage growth to inflation, labor market slack and trend productivity growth using a panel regression. This approach is motivated by the work of Galí (2011), who provide a structural micro-founded interpretation of these empirical relationships. Given both the prominence of inflation expectations in current policy discussions, inflation expectations are included as the main inflation variable, although specifications with lagged inflation are also presented. The following baseline wage Phillips curve is estimated at the quarterly level:

$$\pi_{c,t}^w = \alpha_c + \phi_t + \beta E_t(\pi_{c,t+4}^p) + \gamma_1 u_{c,t} + \gamma_2 \Delta u_{c,t} + \theta g_{c,t} + \varepsilon_{c,t}$$

where $\pi_{c,t}^w$ is the year-on-year change in nominal wages in local currency, $E_t(\pi_{c,t+4}^p)$ is a measure of one-year ahead inflation expectations⁶, $u_{c,t}$ is a measure of labor market slack (unemployment, in the baseline), $g_{c,t}$ is trend productivity growth over the preceding five-year window⁷, α_c are economy fixed effects, and ϕ_t are quarterly fixed effects. The coefficients on inflation expectations and labor market slack are identified using cross-economy variation in wage growth changes over time up to 2019:Q4. The post 2020:Q1 pandemic period is excluded for coefficient estimation. Decompositions of wage growth during the pandemic shown in Figure 2.6 in the chapter are obtained by taking the differences in observed wage Phillips curve components relative to 2019:Q4, aggregating across economies using purchasing-power-parity GDP weights.

To explore the role of structural drivers of cross-economy heterogeneity in wage growth responses to unemployment and inflation expectations, an interaction term

Annex Table 2.3.2. Similar Past Episodes

Economy	Time	Monetary Policy Stance	Source of Monetary Policy
Australia	1979:Q4	Tightening	OECD (1982)
Australia	1985:Q3	Tightening	OECD (1987)
Australia	1995:Q2	Tightening	OECD (1997)
Austria	2011:Q3	Loosening	OECD (2012)
Austria	2017:Q4	Loosening	OECD (2018b)
Belgium	2010:Q4	Loosening	OECD (2012)
Belgium	2016:Q2	Loosening	OECD (2018)
Canada	2003:Q1	Loosening	OECD (2004)
Denmark	1994:Q3	Tightening	OECD (1996)
Denmark	2011:Q2	Loosening	OECD (2012b)
Estonia	2011:Q1	Loosening	OECD (2012b)
France	2000:Q4	Tightening	OECD (2001)
Germany	1989:Q4	Tightening	OECD (1992)
Israel	2008:Q3	Loosening	OECD (2009b)
Luxembourg	2000:Q4	Tightening	OECD (2001c)
Netherlands	2006:Q3	Tightening	OECD (2009)
Slovenia	2000:Q4	Tightening	IMF (2001)
Spain	1989:Q2	Tightening	OECD (1991)
Spain	2000:Q1	Tightening	OECD (2001b)
Sweden	2011:Q2	Loosening	OECD (2012)
United States	1979:Q2	Tightening	OECD (1980b)
United States	2017:Q1	Tightening	OECD (2018)

Sources: International Labour Organization; Organisation for Economic Co-operation and Development; US Bureau of Economic Analysis; and IMF staff calculations.

Note: The table shows the identified episodes where at least three of the four last quarters had (1) accelerating prices, (2) positive nominal wage growth, (3) falling or constant real wages, and (4) declining or flat unemployment. The subsequent monetary policy stance (over the following 12-months) is characterized by the description in OECD Economic Surveys and IMF Country Reports. For euro area economies the monetary policy stance of the European Central Bank is used. For Australia 1995:Q2, the subsequent monetary policy stance is described as unchanged in OECD (1997) but as this was preceded by a tightening in 1994 the stance has been characterized as a "tightening."

⁶ Given that inflation expectations are based on the calendar year, we weight one-year ahead inflation expectations in the current and following year based on the quarter of observation.

⁷ Real GDP per worker is used as the productivity measure.

is added to the baseline specification as follows:

$$\pi_{c,t}^w = \beta_0 E_t(\pi_{c,t+1}^p) + \eta_0 u_{c,t} + \delta_0 \Delta u_{c,t} + High_c * (\beta_1 E_t(\pi_{c,t+1}^p) + \eta_1 u_{c,t} + \delta_1 \Delta u_{c,t}) + \theta g_{c,t} + \alpha_c + \phi_t + \varepsilon_{c,t}$$

where $High_c$ is an indicator variable for whether economy c is above the cross-economy median of a specific indicator. The two indicators presented in the chapter are stringency of employment protection regulations and economy-level average markups.⁸

Additional results

Table 2.4.1 shows regression results for different wage Phillips curve specifications. The first six columns show regressions only including inflation expectations and unemployment variables as the main variables of interest. Columns (6) and (7) report the baseline specification reported in Figure 2.6 in the chapter, while columns (8) and (9) report results adding lagged inflation as an additional dependent variable. Across specifications, there is a positive relationship between wage growth and inflation expectations—with a larger coefficient for advanced economies—and a negative relationship with unemployment variables. When adding lagged inflation as a dependent variable, the coefficient on inflation expectations remains positive, although significance is lost for emerging markets.⁹

Figure 2.4.1 shows additional results. Panel 1 shows a flattening of wage Phillip curve relationships in advanced economies. Panel 2 shows the same decompositions as in Figure 2.6 in the chapter, but focusing on the Great Financial Crisis. Although wage movements are less abrupt during this period in both advanced and emerging economies, two patterns are similar to

Annex Table 2.4.1. Wage Phillips Curve Estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations	1.191*** (0.227)	0.489*** (0.158)			1.012*** (0.162)	0.528*** (0.158)	1.026*** (0.158)	0.503*** (0.149)	1.648*** (0.240)	0.106 (0.315)
Unemployment			-0.476*** (0.140)	-0.578** (0.205)	-0.361*** (0.0900)	-0.601*** (0.123)	-0.364*** (0.0880)	-0.591*** (0.125)	-0.354*** (0.0839)	-0.611*** (0.124)
Unemployment Change			-0.142 (0.201)	-0.790* (0.398)	-0.614** (0.272)	-0.991 (0.592)	-0.595** (0.266)	-1.241** (0.541)	-0.553** (0.243)	-1.276** (0.526)
Productivity							0.127 (0.0828)	0.629** (0.248)	0.122 (0.0776)	0.604** (0.247)
Lagged Inflation									-0.477*** (0.145)	0.354** (0.163)
Number of Observations	2,263	930	2,391	985	2,263	930	2,263	930	2,263	930
Adjusted R^2	0.45	0.60	0.51	0.57	0.53	0.62	0.53	0.63	0.54	0.63
Sample	AEs	EMEs	AEs	EMEs	AEs	EMEs	AEs	EMEs	AEs	EMEs

Source: IMF staff calculations.

Note: Unbalanced sample of 31 advanced economies and 15 emerging markets covering 2000:Q1–19:Q4. See Online Annex 2.1 for details on the sample coverage. Clustered standard errors reported in parentheses. AEs = advanced economies; EMEs = emerging market economies.

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

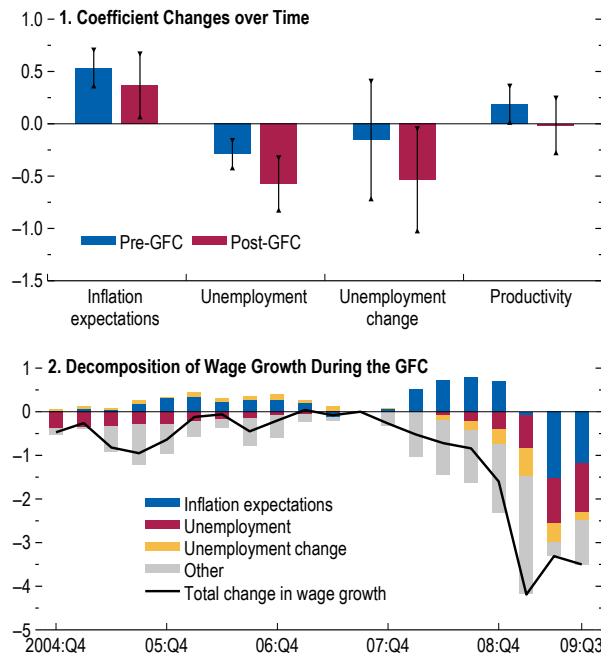
⁸ As noted in the text, coefficients on unemployment and inflation expectations are statistically significant for all groups. However, interaction coefficients are only statistically significant when comparing unemployment coefficients between low and high employment protection groups.

⁹ This would be consistent with a more forward-looking wage-setting process in advanced economies than emerging ones.

the most recent crisis. The first is the presence of large residuals at the time of the shock. The second is the reduction of those residuals over time.

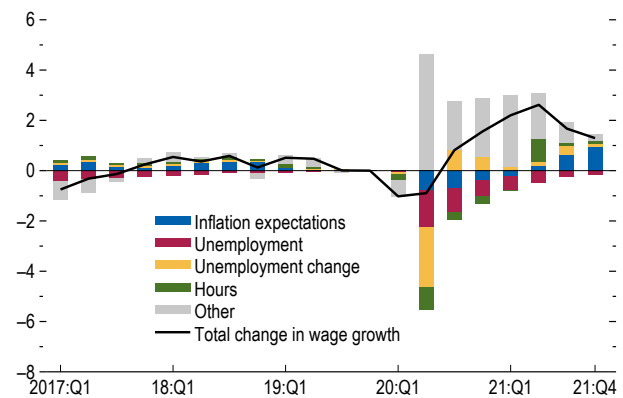
Figure 2.4.2 shows a decomposition adding hours worked as an independent variable. The conclusions with respect to the role of employment slack and inflation expectations seem to hold when controlling for changes in working hours observed. As an additional exercise, we estimated the baseline specification using alternative slack measures. Figure 2.4.3 panel 1 shows the evolution of alternative employment slack measures, including a standard unemployment gap¹⁰, a gap measure using an approach proposed by Michailat and Saez (2022)¹¹, and the unemployment-to-vacancy ratio. Figure 2.4.3 panel 2 presents the wage Phillips curve coefficients using the unemployment gap as an alternative measure for the full sample of economies. Figure 2.4.4 shows coefficients and a decomposition using unemployment-to-vacancy ratios as slack measures for the US—the only economy for which we have data for the

Annex Figure 2.4.1. Wage Phillips Curve over Time
(Percentage points)



Source: IMF staff calculations.
 Note: In panel 1, sample includes 29 advanced economies with available data pre- and post-2008. Coefficients estimated on unbalanced panel spanning 1990–2019. Whiskers indicate 90 percent confidence intervals. In panel 2, contributions calculated using pooled wage Phillips curve coefficients from 29 advanced economies, estimated on the sample covering 2000:Q1–19:Q4. Bars illustrate contributions of each component relative to contributions observed in 2007:Q3. Line depicts total per-worker wage growth observed relative to the reference point. Contributions illustrated only include economies with continuously available data throughout the period shown. These are aggregated using GDP purchasing-power-parity weights. Other category contains the productivity growth contribution, as well as time effects, economy effects and the residual. See Online Annex 2.1 for details on the sample coverage. GFC = global financial crisis.

Annex Figure 2.4.2. Wage Growth Decomposition with Hours
(Percentage points)



Source: IMF staff calculations.
 Note: Contributions calculated using pooled wage Phillips curve coefficients from 29 advanced economies, estimated on the sample covering 2000:Q1–19:Q4 and augmented with changes in hours-worked. Bars illustrate contributions of each component relative to contributions observed in 2019:Q4. Line depicts total per-worker wage growth observed relative to 2019:Q4. Contributions illustrated only include economies with continuously available data from 2017:Q1–21:Q4 and are aggregated using GDP purchasing-power-parity weights. Other category contains the productivity growth contribution, as well as time effects, economy effects and the residual. See Online Annex 2.1 for details on the sample coverage.

entire post-2000 sample period. Results are broadly consistent with the baseline, although greater tightness reflected in this measure implies greater explanatory power in describing the latest wage dynamics.¹²

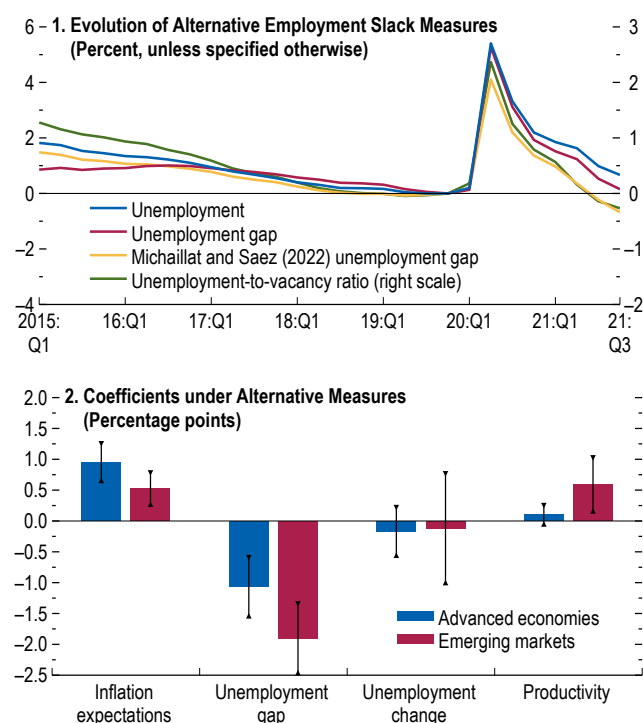
¹⁰ The unemployment gap is calculated as the difference between the unemployment rate and the neutral unemployment rate, where the latter is the result of an HP filter with a parameter of 1,600.

¹¹ This uses the square root of the product of the unemployed and vacancies as the measure of the efficient unemployment rate.

¹² Additional wage growth decomposition results similar to Figure 2.6 in the chapter are available under alternative measures upon request.

WORLD ECONOMIC OUTLOOK

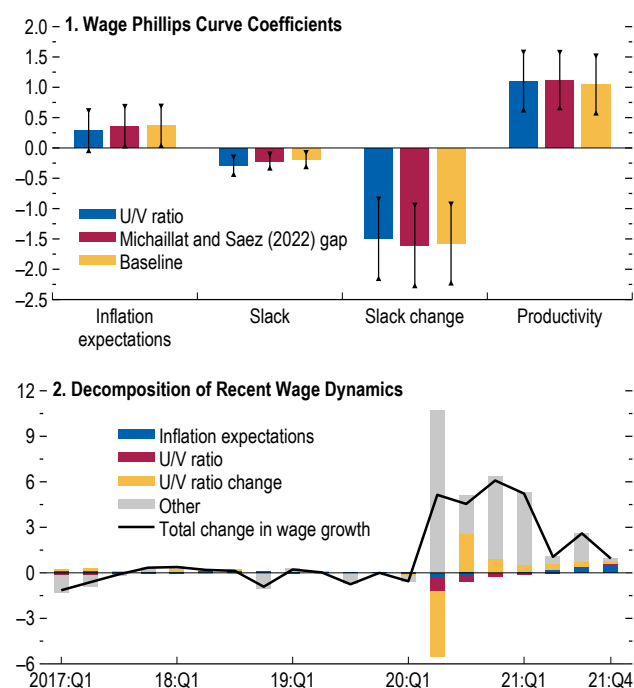
Annex Figure 2.4.3. Wage Phillips Curve under Alternative Slack Measures



Source: IMF staff calculations.

Note: In panel 1, averages weighted by purchasing-power-parity GDP across 14 advanced economies with available data. Differences relative to 2019:Q4 plotted. "Michaillat and Saez (2022) unemployment gap" refers to the difference between the unemployment rate and the square root of the unemployment-vacancy product divided by labor force participation. Panel 2 reports estimated coefficients from wage Phillips curve regression, using the unemployment gap as a measure of slack. The sample covering 2000:Q1–19:Q4 consists of 31 advanced economies and 15 emerging markets. Whiskers indicate 90 percent confidence intervals. See Online Annex 2.1 for details on the sample coverage.

Annex Figure 2.4.4. Wage Phillips Curve Using Unemployment-to-Vacancy Ratios: United States (Percentage points)



Source: IMF staff calculations.

Note: "U/V ratio" refers to estimation using the unemployment-to-vacancy ratio as a slack measure. "Michaillat and Saez (2022) gap" refers to the unemployment gap computed as the difference between the unemployment rate and the square root of the unemployment-vacancy product divided by labor force participation. "Baseline" refers to specification using unemployment rate. Sample covers the United States from 2000:Q1–19:Q4. Whiskers indicate 90 percent confidence intervals. In panel 2, bars illustrate contributions of each component relative to contributions observed in 2019:Q4. Line depicts total wage growth per worker relative to reference point. Other category contains the productivity growth contribution, as well as time effects, economy effects and the residual. U/V = unemployment-to-vacancy.

Annex 2.5. Contributions of supply and demand shocks to wages and prices

The chapter uses a multi-economy, multi-sector general equilibrium model to study the relative contributions of supply and demand shocks to wages and prices. The model is based on recent work by Baqaee and Farhi (2022a; 2022b) and Gourinchas and others (2021) and relies on a nested constant elasticity of substitution (CES) structure. This means that all decision points—whether they represent households maximizing utility over different consumption goods or firms deciding on a mix of intermediate inputs to minimize costs—can be described by CES aggregators. The economy includes multiple sectors, each modelled via a representative firm, that share input-output links. The model also includes international trade, with partner economies combined into a single rest of the world (ROW) aggregate for numerical tractability.

The model features 2 periods, where the second period can be thought of as

Annex Table 2.5.1. Armington Trade Elasticities

Agriculture and Food	6.3
Energy	22.8
Other Industry	6.8
Construction	1.5
Services	5.0

Sources: Baqaee and Farhi (2022b); Caliendo and Parro (2015).

a return to steady state after all shocks resorb as in Krugman (1998) and Eggertsson and Krugman (2012). Finally, the model includes nominal downward wage rigidities and credit constraints, which generate hand-to-mouth households and endogenous aggregate demand fluctuations. A full description of the model and the economic environment can be found in Baqaee and Farhi (2022a) as well as in Wingender (2022).

Calibration of structural parameters

The model's main building blocks are derived from inter-economy input-output (ICIO) tables published by the OECD. The tables are used to quantify expenditure, input and factor shares as well as sectoral and trade linkages. Data from 2018 (the last year available) are used to describe both the pre- and post-COVID steady state equilibria. Intermediate and final uses are aggregated into two economies (domestic and foreign) and five categories (agriculture and food manufacturing; energy; other industry; construction and services). There are three types of final demand: household consumption, government consumption and other final demand—the sum of investment, changes in inventories, non-profits and direct purchases abroad by residents. The breakdown of sectoral value-added is not directly published as part of the ICIO tables, but labor and capital shares by economy and sector can be calculated from the Trade in Employment (TiM) database that relies on the same 44 ISIC category classification.

Households. Elasticity parameters are calibrated as in Baqaee and Farhi (2022a and 2022b) and Gourinchas and others (2021). Starting with households, a first elasticity of substitution is used to determine intertemporal consumption decisions. The chapter uses a CES coefficient of 0.95, which implies a marginal propensity to consume for Ricardian households of 5 percent (Gourinchas and others 2021). Households also decide on the composition of a consumption basket over the 5 types of goods with a CES parameter of 0.8. Each consumption good in turn consists of an Armington aggregate over domestic and foreign varieties, with trade elasticities given in Table 2.5.1.¹³

Firms. Sectoral production by price-taking firms consists of 3 nests. At the highest nest, production combines value-added and intermediate inputs using constant returns to scale technology with CES coefficient equal to 0.6. Value-added consists of labor and capital that are combined using a CES parameter of 0.5. The intermediate input bundle aggregates sectoral output using a CES function with parameter equal to 0.2. Finally, just as for final consumption goods, sectoral output from each economy is combined for domestic use using the trade elasticities in Table 2.5.1 and economy and sector-specific input shares from the ICIO.

Labor markets. The chapter assumes downward nominal wage rigidities, meaning that wages cannot decline from their steady value. When workers in a sector face a lower demand schedule for labor, the market cannot clear, leading to Keynesian unemployment in that sector. As in Baqaee and Farhi (2022a), unemployed households cannot borrow or consume without government transfers, which in turn reduces aggregate demand. Nominal wage rigidities therefore introduce a role for aggregate demand management, and for monetary policy in particular to impact real output and employment.

¹³ Elasticities from Table 2.5.1 are simple averages from the 35 categories used in Baqaee and Farhi (2022b).

Calibration of supply and demand shocks

As described in the chapter, 7 types of shocks are used to decompose wage and price dynamics in response to the COVID pandemic. Because of the model's simple 2-period structure, only one period of shocks can be considered at a time. Therefore, shocks are calibrated using cumulative changes between the last year of pre-pandemic data and observed values at end-2020 and end-2021. The model is then solved separately for the two years.

On the supply side:

- *Production capacity and labor supply shocks* are calibrated by matching changes in total hours worked by economy and sector between 2019 and 2020 and 2021. As in Baqaee and Farhi (2022a), the chapter assumes only labor supply was affected by lockdowns and social distancing. This means that the decline in hours resulting from the shocks had to be accompanied by increases in hourly wages. In the data, this was the case for all sectors except construction in the United States for 2020.
- *International trade cost shocks* are measured by taking the log difference between the CIF (cost, insurance, freight) and FOB (free on board) values of imports by detailed goods classification published by the United States Census Bureau. The analysis assumes these trade costs are exogenous and increase by the same amount for goods in all other economies. By the 4th quarter of 2021, trade costs had increased by 7 percent compared to 2019 for the manufacturing sector on average. Trade costs are assumed to be zero for services.
- *Commodity price shocks* are calibrated by adjusting total-factor productivity for the food and energy sectors so that the model-based sectoral price changes in general equilibrium match the changes in the Energy and Food Price Indexes published by the IMF Primary Commodity Prices database. The published indexes show that energy and food prices had increased by 85 and 20 percent year-on-year respectively in 2021. In the model, this is the result of the underlying TFP shocks and the endogenous responses of supply and demand.

On the demand side:

- *Consumption composition shocks* are modelled by changing the consumption weights in the household CES utility function to match changes in expenditure shares over time. These shares are calculated for every quarter by detailed consumption categories published by the Bureau of Economic Analysis (BEA) for the United States and then aggregated to the 5-goods aggregation used in the model. For OECD member and selected other economies, only household consumption by durability is widely available in the OECD Quarterly National Accounts or national sources. Food and energy are matched to non-durables, while other industries and construction are considered durables. The share of services is also tracked as a separate category.
- *Fiscal policy support* during the pandemic is calibrated by multiplying government consumption in the input-output tables by changes in the nominal value of government final consumption

in 2020 and 2021.¹⁴ Government spending on transfers to households is not part of the standard input-output presentation. To include this channel in the model, the ratio of transfers to government consumption over time is used. These transfers are then included directly in the budget constraint of hand-to-mouth households. Since the analysis assumes the government’s intertemporal budget constraint must hold, Ricardian households do not respond to the disbursement of transfers.

- *Monetary policy support* is calibrated by using changes in the central bank policy rates. Since the United States and the euro area were at their effective lower bound during the crisis, the shadow policy rates from Wu and Xia (2016 and 2017) are used instead.¹⁵
- *Changes in consumers’ saving behavior* is calibrated by adjusting the discount rate in the consumption Euler equation. The calibration ensures that households’ savings rate in general equilibrium in the model matches aggregate savings rates by economy over time as measured by the OECD’s Annual National Accounts database.

Annex 2.6. Wages and Economic Dynamics: Inflation Shocks and Monetary Policy

The following equation is estimated using a Local Projection (LP) framework on a quarterly panel of sixteen euro area economies, between 1999:Q4 and 2019:Q4¹⁶:

$$y_{t+h,i} = \alpha_i^h + \sum_{j=1}^4 \rho_j^h y_{t-j,i} + \sum_{j=0}^4 \beta_j^h s_{t-j} + \sum_{j=0}^4 \gamma_j^h x_{t-j,i} + \varepsilon_{t,i}^h$$

The outcome variable, $y_{i,t}$, is, in turn, the economy’s nominal and real wage growth, unemployment rate, realized inflation and 12-month ahead expected inflation.¹⁷ Each of these variables is considered at different horizon, with $h=0, \dots, 8$ quarters. The main explanatory variable, s_t , is the inflationary shock in the first exercise, and the monetary shocks in the second exercise. Furthermore, the specification controls for other factors relevant for each exercise. In the former, the VIX proxies for global financial market uncertainty, and monetary policy shocks control for the policy reaction. In the latter, central bank communication shocks are included to take into account outlook surprises (Jarociński and Karadi 2020). Standard errors are clustered at economy-level, and they are corrected for heteroscedasticity and autocorrelation until the eighth lag.

The Fed Global Supply Chain Pressure Index (GSCPI) (Benigno and others 2022) is used as proxy for inflationary shocks since changes in the index have had a meaningful impact on euro area PPI and goods CPI inflation for the 1997-2021 period (Akinci and others 2022). The index encapsulates information on global factors that pose disruption pressure on supply chains. Two sets of factors are considered: (i) manufacturing data, such as backlogs and delays; and (ii) shipping

¹⁴ For the United States, changes in subsidies on production and imports are also included. This line item saw a large increase in 2020.

¹⁵ <https://sites.google.com/view/jingcynthiawu/shadow-rates> [downloaded on July 6, 2022].

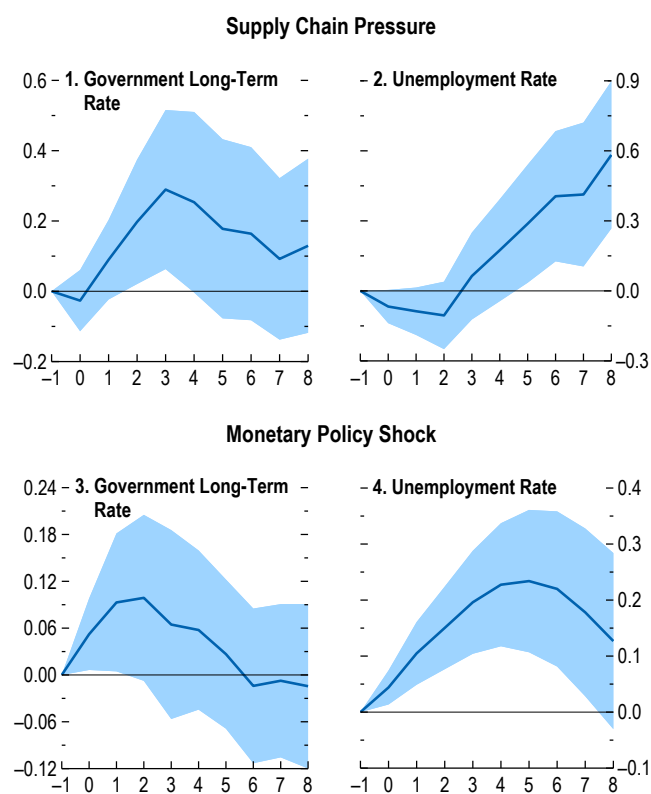
¹⁶ The pandemic period is excluded due to the temporarily structural breakdown induced by lockdowns and discretionary policies. The list of economies included in the analysis is reported in Table 2.1.2.

¹⁷ Sources are reported in Table 2.1.1.

costs and airfreight price indices. The index is the principal components of twenty-seven variables previously purged for demand factors, thus it can be considered a supply-side shock.¹⁸ To address endogeneity concerns, the index enters the equation in a lagged form, and, to account for exposure heterogeneity, the index is multiplied by economy-level openness, defined as the sum of exports and imports as share of GDP, lagged.

In the second exercise, monetary policy shocks are sourced from Jarociński and Karadi (2020).¹⁹ Shocks are identified based on a Bayesian structural VAR with high-frequency data and sign restrictions. Figure 2.6.1 panel 2 shows the time series of the monetary policy surprises aggregated at quarterly frequency to match the wage variables. The aggregation is based on the weighting scheme by Ottonello and Winberry (2020).²⁰ Figure 2.9 in the main text shows the cumulative effect at different horizons on the real and nominal wage growth, as well as expected and realized inflation to a one standard deviation of each shock. Figure 2.6.2 reports the cumulative effect on the government long-term rate and unemployment. Results are robust to different samples (dropping one economy at time and considering only economies in the euro area since 1999), as well as to alternative (i) orders of autocorrelation in the residuals, and (ii) measures of economy's exposure (using the OECD participation in GVCs).²¹

Annex Figure 2.6.1. Cumulative Effects of Supply Chain Pressure and Monetary Tightening on Unemployment and Government Long-Term Rate
(Percentage points; dynamic response)



Sources: Federal Reserve Bank of New York; Haver Analytics; Jarociński and Karadi (2020); Organisation for Economic Co-operation and Development; and IMF staff calculations.

Note: Lines show the estimated impulse responses of the indicated variable to the indicated shock, with the shaded area representing the 90 percent confidence interval. The horizontal axes show time in quarters, where $t = 0$ is the initial impact quarter of the shock. The estimation sample includes euro area economies over 1999:Q4–2019:Q4. Panel 1 and 2 are the responses to a supply chain pressure shock, defined as a one standard deviation increase in the Federal Reserve Bank of New York's Global Supply Chain Pressure Index. To account for economies' different degrees of exposure, the index is weighted by an economy's trade openness. Panel 3 and 4 are the responses to a one standard deviation monetary policy shock, as identified as in Jarociński and Karadi (2020). See Online Annex 2.1 for details on the sample coverage.

¹⁸ Refer to Benigno and others 2022 for a more extended description of the GSCPI methodology and data.

¹⁹ We use the updated version of the shocks that considers the first principal component of the unexpected changes in the overnight index swaps (OIS) with one-, three-, six-months and one-year maturities (Jarociński and Karadi 2020, time series downloaded from <https://marekjarocinski.github.io/> on June 2022). We are grateful to the authors to maintain updated the time series.

²⁰ The authors apply a triangular weighting scheme over the previous and current quarter to incorporate the time that agents take to react. The aggregation considers the fact that shocks occurring at the beginning of the quarter weight more on agents' decisions.

²¹ Participation in GVCs is proxied using the sum of an economy's backward and forward participation. These are defined as the foreign and domestic value-added share of gross exports, by the value added of the origin economy.

Finally, to test whether inflation expectations are less sensitive to shocks in economies where inflation expectations are more anchored to start with, the following state-dependent equation is estimated:

$$y_{t+h,i} = D_{t-1,i} * [\alpha_{i,A}^h + \sum_{j=1}^4 \rho_{j,A}^h y_{t-j,i} + \sum_{j=0}^4 \beta_{j,A}^h s_{t-j} + \sum_{j=0}^4 \gamma_A^h x_{t-j,i}] + (1 - D_{t-1,i}) * [\alpha_{i,B}^h + \sum_{j=1}^4 \rho_{j,B}^h y_{t-j,i} + \sum_{j=0}^4 \beta_{j,B}^h s_{t-j} + \sum_{j=0}^4 \gamma_B^h x_{t-j,i}] + \varepsilon_{t,i}^h$$

where $D_{t-1,i}$ is a time varying dummy indicated that inflation expectations are well-anchored. To identify these cases, we use the Bems and others (2021) index of the strength of inflation anchoring.²² The indicator is the simple average of three metrics: (i) deviation of long-term mean inflation forecasts from target, (ii) variability of mean long-term inflation forecasts, (iii) dispersion of long-term inflation forecasts. The reference horizon used is 5-year ahead. The dummy $D_{t-1,i}$ equals one if the index in economy i at time $t-1$ is above the cross-economy and cross-time median. Figure 2.10 in the main text, plots the coefficients $\beta_{j,A}^h$ and $\beta_{j,B}^h$, which capture the dynamic effect of the inflationary shocks at each horizon in economies with well- versus less-anchored inflation expectations, respectively. It shows that the impact of inflationary shocks on 12-month ahead inflation expectations is less persistent in economies with better-anchored inflations expectations.

Annex 2.7 Role of Wage and Price Expectations: Scenarios from a Small DSGE Model

Motivated by the need to better model the expectations formation and to match the inertia of macroeconomic variables, a growing literature has proposed deviations from the standard rational expectations (RE) assumption. The model presented here assumes that economic agents form their expectations based on a simple statistical model informed by a limited set of observed variables. Those agents update their beliefs about the underlying economic relations when new data becomes available. These expectations are called adaptive learning (AL).

Our workhorse model is based on Galí, Smets, and Wouters (2012) and Berg and others (2006), which is a standard New Keynesian model that includes wage and price Phillips curves (PC). The equilibrium equations of the linearized system are given by:

$$\begin{aligned} y_t &= \alpha_{yL} y_{t-1} + \alpha_{yF} y_{t+1} + \gamma(\pi_{t+1} - r_t) + s_{yt} && \text{(IS Curve)} \\ s_{yt} &= \rho_\varepsilon s_{yt-1} + \varepsilon_{yt} && \text{(Shock process)} \\ \pi_t &= \alpha_{\pi L} \pi_{t-1} + \alpha_{\pi F} \pi_{t+1} + k_\pi w_t + \varepsilon_{\pi t} && \text{(Price PC)} \\ \pi_{wt} &= w_t - w_{t-1} + \pi_t && \text{(Nominal wage definition)} \\ \pi_{wt} &= -\alpha_{wL} w_{t-1} + \alpha_{wF} \pi_{wt+1} + K_w y_t + \varepsilon_{wt} && \text{(Wage PC)} \\ r_t &= \rho r_{t-1} + (1 - \rho)(\rho_\pi \pi_{t+1} + \rho_y y_t) + \varepsilon_{rt} && \text{(Policy reaction function),} \end{aligned}$$

²² Due to limited data availability of the Bems and others (2021) index, the sample is reduced to ten euro area economies (see Annex Table 2.1.2).

where y is the output gap (measure of slack), π is quarter-on-quarter, annualized core inflation rate, r is the nominal monetary policy interest rate, w is the real wage gap (real wage deviations from labor productivity growth) and π_w is real wage inflation.

In an RE model, in the absence of further shocks, the expectation is the same as the future value: $E_t[x_{t+1}] = x_{t+1}$ given $\varepsilon_{t+1} = 0$. Economic agents use information on all the variables in the model and the expected value is a complicated function on the parameters. For the AL model, we use a version of the updating model developed in (Slobodyan and Wouters 2012). In particular, the AL model of economic agents' expectations follows an AR(2) process:

$$E_t[x_{t+1}] = \alpha_t + \beta_t^1 x_t + \beta_t^2 x_{t-1} \quad (\text{forecasting equation})$$

Note that the coefficients in this equation vary over time. They depend on how accurate the forecast is at each period. Since the models is in deviations, we would expect that these coefficients be close to zero in the inflation expectations equation if inflation is well-anchored. That is, expected inflation doesn't change much given current inflation. The fully adaptive expectations case is a particular case of this specification when $\alpha_t = 0$, $\beta_t^1 = 1$ and $\beta_t^2 = 0$

At each period, agents update these coefficients using a Kalman filter mechanism, and the learning update vector evolves according to:

$$B_{t|t} = B_{t|t-1} + P_{t|t-1} X_{t-1} [\Sigma_t + X'_{t-1} P_{t|t-1} X_{t-1}]^{-1} * (\text{forecast errors}),$$

where the $B_{t|t}$ is a vector that stacks all the coefficients of the AR(2) processes, $P_{t|t-1}$ is the covariance matrix and Σ_t is the variance-covariance matrix of the AR(2) equation residuals.

The model described above is estimated with Bayesian methods and quarterly macroeconomic data from 2000:Q1 to 2019:Q4 for Brazil and the USA. The set of variables included in the estimation are the output gap, the real wage gap, annualized quarterly price inflation deviation from target, and the policy rate. Since our model does not have enough structure to explain workforce composition change, we use the composition-constant real wage calculated by Howard, Rich, and Tracy (2022) for the USA and the one used in (Dizioli and Wang 2022) for Brazil.

The output and real wage gaps were calculated with both HP and linear filters. The results in the next section use the linear filter, which was chosen because the model has better in-sample (Table 2.7. 1) and out-of-sample forecast performance for wages and prices (Table 2.7.2). The modelling strategy contributes to the current debate about adaptive expectations. A price Phillip's curve that only includes the output gap and not marginal cost (real wage gap) directly would predict that, under adaptive expectations, the only way to lower inflation is with a negative output gap. This model shows that a negative real wage gap could enable an anchoring to inflation even with fully adaptive expectations.

Annex Table 2.7.1. In-Sample Forecast Performance for RE and AL Models

Log Marginal Likelihood	RE	AL
Linear Filter	-391.1	-341.4
HP Filter	-342.9	-338.5

Source: IMF staff estimates.

Note: AL = adaptive learning; HP filter = Hodrick-Prescott filter; RE = rational expectations.

Annex Table 2.7.2. Out-of-Sample Forecast Performance for RE and AL Models

	Real Wage Gap		Output Gap		Policy Rate		Inflation	
	RE	AL	RE	AL	RE	AL	RE	AL
Linear Filter								
1-Quarter Ahead RMSE	0.15	0.22	0.05	0.11	0.06	0.01	1.41	0.47
4-Quarters Ahead RMSE	0.95	1.44	0.63	1.11	0.56	0.27	0.66	0.31
8-Quarters Ahead RMSE	1.39	1.13	1.52	1.52	0.64	0.48	0.31	0.19
HP Filter								
1-Quarter Ahead RMSE	0.09	0.53	0.02	0.11	0.05	0.03	0.2	0.28
4-Quarters Ahead RMSE	1.43	1.27	0.5	0.88	0.73	0.44	0.8	0.64
8-Quarters Ahead RMSE	1.18	1.62	1.02	1.05	1.52	0.25	0.49	0.41

Source: IMF staff estimates.

Note: Numbers in bold indicate models that performed the best at that horizon. AL = adaptive learning; HP filter = Hodrick-Prescott filter; RE = rational expectations; RMSE = root-mean-square error.

Comparison of the estimation results for Brazil and the USA

If inflation expectations are well anchored, we would expect the lag inflation coefficients in the household’s forecasting equation above to be small and the mean inflation to be zero. The first striking result in Figure 2.7.1 is that expectations in Brazil depend a lot more on past outcomes than in the US. This can be seen when adding the coefficients on the first two lags of both inflation and wages. The case of real wages expectations are even more striking as they seem substantially more persistent in Brazil. The second result to highlight from this figure is the coefficient stability over the last ten years before the pandemic. The coefficient reflecting the mean expected inflation was zero as households expected inflation to be at the central bank target. The pandemic challenged this stability in both economies, as both started seeing inflation outcomes above target. As inflation expectations respond more to past inflation outcomes in Brazil, there is feedback from inflation to inflation expectations that keep inflation higher for longer for all the shocks in the model, despite stronger monetary policy response in Brazil. Monetary policy has to do more to lower inflation in an EM economy like Brazil, even if they are hit with the same shocks.

Optimal monetary policy decisions

Instead of using the estimated monetary policy reaction function, this chapter defines the optimal monetary policy path as the interest rate path, $\{i_t\}$ for $t=1$ to ∞ , that minimizes the welfare function below:

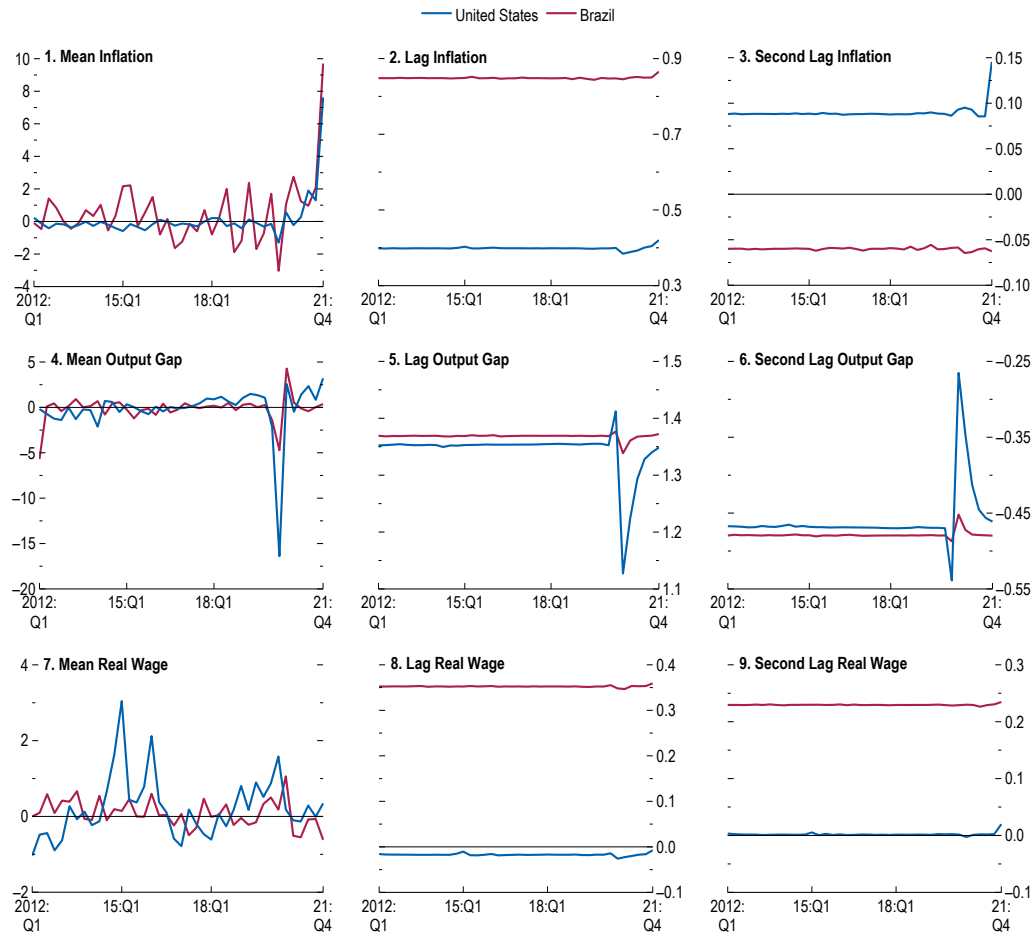
$$\sum_{t=j}^{\infty} \beta^t (0.75(i_t - i_{t-1}) + (y_t - 0)^2 + (\hat{\pi}_t - 0)^2),$$

note that it is assumed an equal weights for output gap (y_t) and inflation deviations from target ($\hat{\pi}_t$). It is also assumed a role for interest rate smoothing. Other implicit assumptions are that the central bank has full knowledge of the current shocks hitting the economy, know all the future shocks that will hit the economy and have full knowledge of how their actions impact expectations.

In the estimated AL model, the central bank has three channels to influence inflation. The standard direct channel in which a tighter policy cools-off demand, lowering the output gap and hence

inflation. The other two channels operate through inflation expectations. By tightening policy, the central bank lowers current inflation that enters into the forecasting equation, lowering next period expectations. Finally, the central bank can also affect the coefficients in the forecasting equation. By seeing less inflation this period than they have expected, households update their model of how past inflation matters for future inflation.

Annex Figure 2.7.1. Dynamic Beliefs on the Adaptive Learning Expectation Process
(Unit)



Source: IMF staff calculations.
Note: Mean inflation is measured as deviation from the inflation target.

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