EXECUTIVE BOARD MEETING

EBS/21/84

September 15, 2021

To: Members of the Executive Board

From: The Secretary

Subject: **October 2021 World Economic Outlook—Analytical Chapter 2 and Online Annex**

Board Action:	Executive Directors' **consideration** (Formal)
Tentative Board Date:	**Tuesday, September 28, 2021**
Publication:	Yes, it is intended that the full set of the World Economic Outlook documents will be released to the public at the time of the World Economic Outlook press conference, tentatively scheduled for **Tuesday, October 12, 2021.** Chapters 2 and 3 will be made available to the public on the IMF website slightly in advance of the publication of the full document,
Questions:	Ms. Caselli, RES (ext. 35792) Ms. Mishra, RES (ext. 36037)
Additional Information:	Please note that, as usual, the WEO forecast remains under review. Final projections will be featured in the WEMD presentation to the Board. The paper will be revised for publication in light of the Executive Board discussion. If Executive Directors have additional comments, they should notify Ms. Caselli and Ms. Mishra by **5:30 p.m. on Friday, September 24, 2021**.

CHAPTER 2

INFLATION SCARES

BOXES

FIGURES

CHAPTER 2

INFLATION SCARES

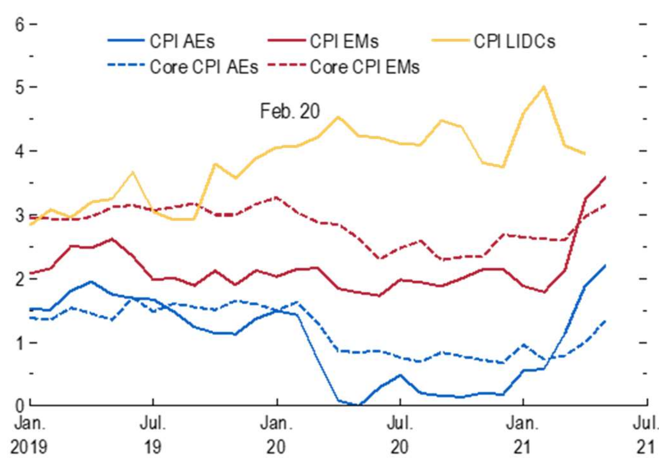
Since the beginning of 2021, headline consumer price index (CPI) inflation has increased in advanced and emerging market economies, driven by firming demand, input shortages, and rapidly rising commodity prices. Despite large uncertainty about the measurement of output gaps around the pandemic, a significant relationship remains between economic slack and inflation. Long-term inflation expectations have stayed relatively anchored so far, with little evidence that recent exceptional policy measures have de-anchored those expectations. Looking ahead, headline inflation is projected to peak in the fall of 2021, with inflation expected back to pre-pandemic levels by mid-2022 for both advanced economies and emerging markets, and with risks tilted to the upside. Long-term inflation expectations are projected to remain anchored in the baseline forecast. Given the recovery's uncharted nature, considerable uncertainty remains, particularly relating to the assessment of economic slack. Prolonged supply disruptions, commodity and housing price shocks, longer-term expenditure commitments, and a de-anchoring of inflation expectations could lead to significantly higher inflation than predicted in the baseline. Clear communication, combined with appropriate monetary and fiscal policies tailored to country-specific contexts, however, could prevent "inflation scares" from unhinging inflation expectations.[1]

Introduction

Headline inflation has risen rapidly in advanced economies and emerging market and developing economies since the beginning of 2021, though it has been relatively stable in low-income countries (Figure 2.1). While core inflation—the change in the prices of goods and services excluding food and energy—has risen less than headline rates, it has also ticked up in recent months. These developments have occurred amid still-substantial policy support as economies recover from the deep contraction of 2020. Moreover, as economies reopen, the release of excess savings accumulated during the pandemic could further fuel private spending. This combination of unprecedented factors has led to concern about the possibility of persistently high inflation.

Figure 2.1. Consumer Price Inflation by Country Group
(Median, year-over-year percent change)

Broad-based rise in headline inflation.



Sources: Haver Analytics; IMF, CPI database; and IMF staff calculations.
Note: The vertical line indicates February 2020. AEs = advanced economies; CPI = consumer price index; EMs = emerging market economies; LIDCs = low-income developing countries.

[1] The authors of this chapter are Francesca Caselli (co-lead), Sonali Das, Christoffer Koch, Prachi Mishra (co-lead), and Philippe Wingender, with contributions from Chunya Bu and support from Youyou Huang and Cynthia Nyakeri. Mattia Coppo and Swapnil Agarwal also provided data support. The chapter benefited from discussions with Rodrigo Valdés and from comments by internal seminar participants and reviewers. Olivier Coibion provided valuable guidance and suggestions.

From a macroeconomic perspective, a sustained rise in inflation in advanced economies leading to an unanticipated withdrawal of monetary accommodation could disrupt financial markets. Emerging market and developing economies would be especially affected from the resulting spillover effects through capital outflows and exchange rate depreciations, as seen during the taper tantrum episode in 2013. High inflation would also tend to hurt those who rely primarily on labor income (generally lower-income individuals) but could also benefit debtors while hurting lenders. Inflation can, therefore, have complex distributional consequences.

This chapter assesses the outlook for inflation and evaluates the risks around it. It first takes stock of inflation trends during the pandemic and then examines the drivers of inflation using the Phillips curve, which relates inflation to domestic slack—a key framework central banks use to form their views on inflation and, in turn, on monetary policy. It also examines whether there has been a change in the overall relationship between economic slack and inflation with inclusion of the pandemic period. This could have major implications for evaluating the effect of accelerating demand during the recovery and for the conduct of monetary policy (see, for example, Draghi 2017 and Powell 2018).

Inflation expectations and supply shocks are also crucial to understanding the inflation process. A key concern is identifying the conditions that could cause recent inflation spikes to persist, leading to unanchored expectations and self-fulfilling inflation spirals. Policymakers worry that the unprecedented policy support enacted in response to the COVID-19 crisis may have reduced the room for monetary policy to maneuver, thereby impacting the credibility of central banks and leading to possible de-anchoring of inflation expectations. This chapter examines how robust the anchor was during the pandemic and assesses the potential risk of de-anchoring during the recovery phase. Finally, the analysis zooms in on sectoral and commodity price movements, asking how supply shocks could contribute to the inflation outlook.

The key findings of the chapter suggest the following:

Inflation expected to revert to pre-pandemic levels by mid-2022: The analysis indicates that headline inflation and medium-term inflation expectations are projected to revert to pre-pandemic levels by mid-2022. Although much uncertainty remains, particularly regarding measurement of output gaps, recovering demand is expected to have only a small impact on future inflation. Our baseline forecasts suggest that, for advanced economies, headline inflation will peak in the fall of 2021 and will decline to around 2 percent by mid-2022. Risks remain tilted slightly to the upside over the medium term. The outlook for emerging market and developing economies similarly shows headline inflation declining to about 4 percent after a peak of 6.8 percent this fall, with risks tilted to the upside over the medium term. A key feature of the outlook is the significant cross-country heterogeneity across advanced and emerging market and developing economies—and even within advanced economies. While the United States drives the strong inflation dynamics in advanced economies in the short term, with near-term risks tilted to the upside, underlying inflation dynamics in the euro area and Japan remain weak.

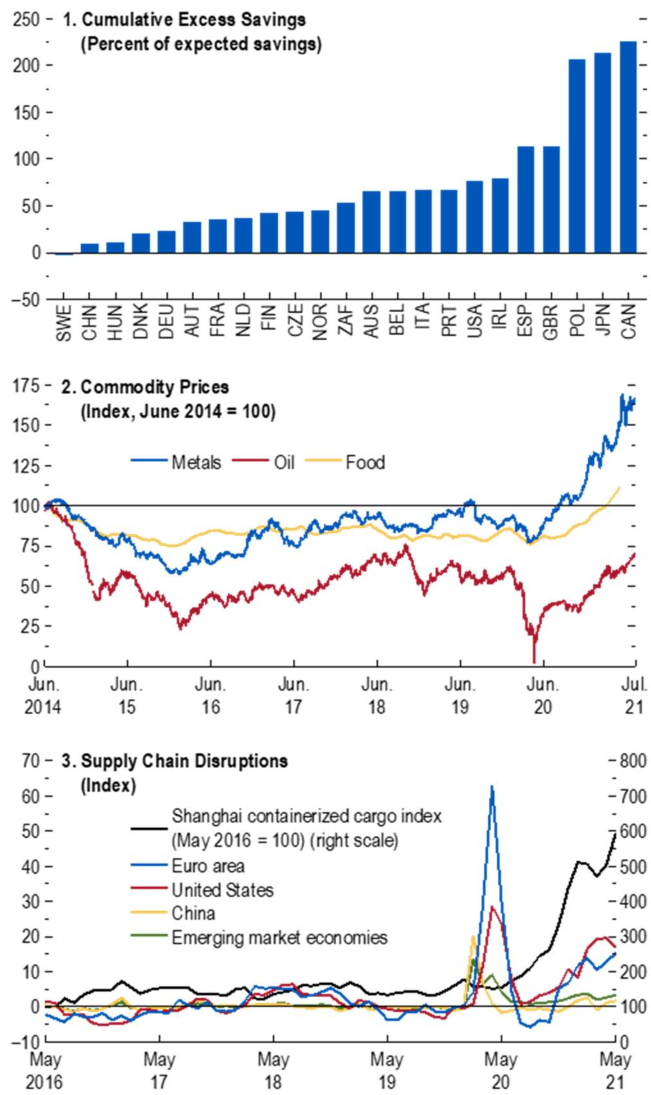
Risks: Inflation expectations have stayed relatively anchored so far, and risks of de-anchoring appear limited for advanced economies despite frequent monetary and fiscal policy announcements during the pandemic. The density forecast in the baseline also indicates anchored inflation expectations in emerging market and developing economies over the next two years. However, considerable uncertainty surrounds these forecasts, particularly related to the assessment of economic slack and reflected in the distribution around the baseline and in the counterfactual scenarios. Sharply rising housing prices and prolonged input supply shortages in advanced and developing economies and continued food price pressures and currency depreciations in emerging markets could keep inflation elevated for longer. Simulations of a tail risk scenario with continued sectoral disruptions and large swings in commodity prices show that headline inflation could rise significantly higher than the baseline. Simulations including a temporary de-anchoring of inflation expectations lead to even higher, more persistent, and volatile inflation.

Policy implications: Selected case studies complement the statistical analysis and confirm that persistent "inflation scares" could lead to higher inflation expectations. While strong, sustained policy action was often needed to bring down inflation and inflation expectations in the past, these actions were accompanied by—and helped reinforce the credibility of—sound and clear communication. Importantly, longer-term expenditure commitments could be associated with unhinged expectations and underscore the importance of credible medium-term fiscal frameworks in keeping expectations anchored (see Chapter 2 of the October 2021 *Fiscal Monitor*). It is important that policymakers be on the lookout and be prepared to act, especially if some of the risks we highlight in this chapter should materialize at the same time—prolonged supply disruptions, rising commodity and housing prices, permanent and unfunded fiscal commitments, a de-anchoring of expectations, combined with mismeasurement of output gaps.

The rest of the chapter starts with an overview of recent inflation developments before assessing the implications of

Figure 2.2. Excess Savings, Commodity Prices, and Supply Chain Disruptions

Rise in headline inflation amid pent-up demand, commodity price pressures, and supply chain disruptions.



Sources: Baltic Exchange; Haver Analytics; IMF, Primary Commodity Price System; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Cumulative excess savings are household savings from 2020:Q1–21:Q1 or the latest quarter available, exceeding expected savings based on a calculated linear trend from 2017:Q1–19:Q4 for each country. In panel 3, the composite emerging market economy data are from IHS Markit. Supply chain disruptions are calculated as the difference between the supply delivery times subindex in the purchasing managers' index (PMI) and a counterfactual, cyclical measure of suply delivery times based on the manufacturing output subindex in the PMI. Data labels use International Organization for Standardization (ISO) country codes.

recovering demand on the inflation outlook through the lens of a Phillips curve. It then explores the conditions under which inflation spikes have tended to persist and inflation expectations to become de-anchored in the past. Next, the chapter examines the implications of the recent sectoral price shocks for overall inflation and inflation expectations. The chapter concludes with a discussion of the analysis's main policy implications.

Inflation Dynamics: Recent Drivers

Our framework will shed light on three broad drivers of increases in headline inflation: (1) a pickup in economic activity or closing output gaps supported by accommodative fiscal and monetary policies, along with the release of pent-up demand and accumulated savings (Figure 2.2, panel 1); (2) rapidly rising commodity prices (Figure 2.2, panel 2); and (3) input shortages and supply chain disruptions (Figure 2.2, panel 3). Some have suggested that the fiscal expansion—unprecedented as it was, especially in advanced economies—may push unemployment low enough to cause overheating, possibly de-anchoring inflation expectations and resulting in a self-fulfilling inflation spiral (Blanchard 2021; Summers 2021). Others see a persistent surge in price pressures from a "one-time surge in spending" as unlikely (Powell 2021).

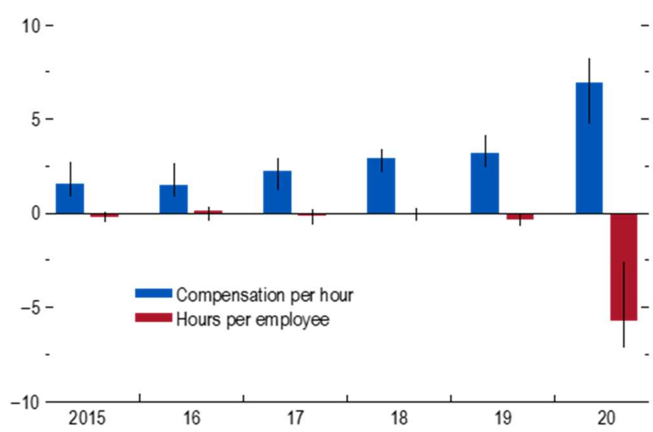
An Uncertain Outlook

The contrasting views on inflation prospects point to the high uncertainty surrounding the outlook for price movements. Several factors behind the uncertain inflation outlook—not necessarily covered explicitly in this chapter— include the evolution of housing (see Box 1.1 in Chapter 1), structural transformation in labor markets, and food prices. Global food prices are up by about 40 percent since the start of the pandemic. This has implications especially for low-income countries, where the share of food in consumption baskets is high (see Box 2.1).

Another source of uncertainty is wage processes coming out of the pandemic, with accelerating labor demand hitting up against likely temporary shortages, leading to worries about fueling a wage-price spiral. Consistent with a resumption of greater activity, signs of higher wage growth are apparent in sectors that were hurt the most by the COVID-19 shock early on—for instance, there have been notable upticks in wages for jobs in leisure and hospitality and retail, among other sectors in the United States. Evidence from a sample of 23 advanced economies also suggests that the average compensation per hour went up significantly in 2020. However, this wage growth happened at the same time as a decline in hours (Figure 2.3), and the

Figure 2.3. Labor Demand in Advanced Economies
(Year-over-year percent change)

While wages increased in 2020, this was concomitant with a decline in hours.



Sources: Eurostat; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: The bars represent medians and vertical lines represent the interquatile ranges of corresponding variables across 24 advanced economies. See Online Annex 2.1 for further details.

brunt of the reduction was disproportionately borne by low-skilled workers and youth, who tend to earn less. Despite sectoral wage pressures, and a slight uptick in economy-wide nominal wage inflation in the United States, few signs of acceleration in economies are visible where data are available through the middle of the year (Canada, Germany, Spain, United Kingdom). Even after adjusting for composition effects, overall wage growth has remained within normal ranges according to the Atlanta Federal Reserve's US Wage Growth Tracker. As health metrics improve and exceptional income support measures expire, hiring difficulties in certain sectors could abate. That said, substantial uncertainty remains—and depends on whether firms can hold off filling the vacancies, their views on how long current worker shortages will persist, and how workers' health-risk-adjusted reservation wages evolve (see the Chapter 1).

In order to take into account exceptionally large changes in prices of items other than food and energy—such as tourism and travel—during this crisis, alternative measures (such as trimmed means or medians that filter out these unusal movements) point to a more muted increase in underlying inflation (see Box 2.2). While some of the current price pressures could indeed be transitory (for example, because of droughts, export restrictions, and stockpiling of food stocks), much uncertainty remains regarding the evolution of different factors.

Economic Slack and the Inflation Outlook—Evidence from the Phillips Curve

A key element of central banks' policy frameworks is the Phillips curve relationship. This describes a trade-off between low slack (for instance, low cyclical unemployment) and high inflation.[2] In the Phillips curve, the inflation process is also related to cost-push shocks driven by supply disturbances and to long-term inflation expectations. As inflation-targeting regimes have become more prevalent, long-term inflation expectations have played a larger role in explaining inflation outcomes.[3]

This section focuses on evaluating the strength of the relationship between inflation and economic slack to assess to what extent expanding demand could contribute to inflation going forward. A Phillips curve that includes forward-looking inflation expectations, lagged inflation, foreign price pressures, and output gaps is estimated on a large sample of advanced economies and emerging markets for 2000–20. Figure 2.4 reports the estimates for the pooled sample and the group of advanced economies and emerging markets separately (see Online Annex 2.2 for details of the sample composition and estimation). A 1 percentage point widening of the unemployment gap—that is, unemployment higher than the natural rate of unemployment—is associated with a decline in core inflation of 0.22 percentage point on average. A similar point estimate is seen for advanced economies when splitting the sample by income groups. The coefficient for emerging markets is broadly similar, but not statistically distinguishable from zero.

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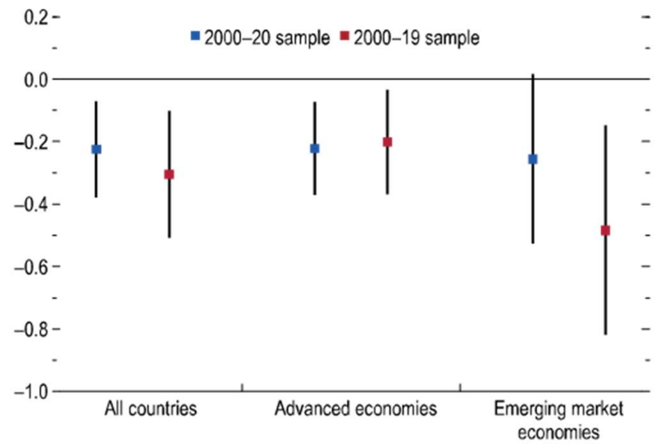
[2] Monetary policymakers typically use the "New Keynesian" framework comprising (1) an aggregate demand relationship, (2) optimal monetary policy, and (3) a Phillips curve relationship (see Clarida, Galí, and Gertler 1999). Alternative approaches to understanding the inflation process consider monetary aggregates as potential predictors of inflation (see, for instance, Pradhan and Goodhart 2021 for a review). In the context of the current crisis, Agur and others (2021) document that large increases in the money supply because of major fiscal and monetary stimulus have led to only modest short-term pass-through from money growth to inflation, especially in countries with credible central banks.

[3] Major central banks such as the European Central Bank and the Federal Reserve have recently adjusted their frameworks to guide long-term inflation expectations and mitigate deflationary risks, among other objectives. Thus far, the evolution of inflation expectations is consistent with the intended objectives of the frameworks' adjustment.

The COVID-19 period, however, poses many challenges to estimating this relationship. There is much uncertainty about unemployment and output gaps during the pandemic (see the Chapter 1). A massive, unprecedented fiscal and monetary policy response to the economic shock may also obscure the relationship between slack and inflation to a greater extent than would be seen over the course of a typical business cycle. Moreover, supply chain disruptions, sectoral dislocation associated with the pandemic, commodity price volatility, changing weights in consumer baskets (Cavallo 2020; Reinsdorf 2020), and extreme base effects also contribute to measurement challenges beyond those related to potential output.

Figure 2.4. Unemployment Gap–Inflation Phillips Correlation
(Percentage points)

Unemployment changes away from the natural rate are associated with softer inflation, more so in emerging market economies.



Sources: Haver Analytics; and IMF staff calculations.
Note: The squares represent the coefficient estimates of the unemployment gap-inflation Phillips correlation. The vertical bars represent the 90 percent confidence intervals. See Online Annex 2.1 for further details.

Comparison with the Phillips curve relationship prior to the pandemic can shed light on the extent to which the unusually sharp fall and rebound in effective potential output induced by lockdown and reopening in 2020 might have affected the estimates. Figure 2.4 reports the response of core inflation to the changes in the unemployment gap estimated up to the fourth quarter of 2019 for advanced economies. The unprecedented pandemic disturbances do not seem to have altered the Phillips curve relationship for advanced economies. Estimates for emerging markets instead seem to be more sensitive to the inclusion of the pandemic period.[4] The results also point to mixed evidence on nonlinear effects at different levels of slack (see Online Annex 2.2).

A Causal Phillips Curve Confirms the Relevance of the Inflation-Activity Trade-Off

Although these results are based on a model that includes country-specific indicators and several controls, they could still be confounded by omitted variables and reverse causality. A widening output gap and weakening of inflation, for example, could induce central banks to reduce interest rates to boost demand, and so blunt what might have otherwise shown up as pronounced movement in the data (for a detailed discussion of the endogeneity issues in this setting see McLeay and Tenreyro 2020). To address such concerns, an alternative estimation based on a treatment effect methodology is performed.[5] As proposed by Barnichon and Mesters

[4] The higher coefficient estimates for emerging markets in the pre-COVID sample could be driven by different policies and shocks and could point to measurement errors too, especially in measuring slack, attenuating the estimates in the 2000–20 sample toward zero.

[5] This involves estimating central banks' monetary policy reaction functions and using inverse probability weighting to identify the impact of unexpected changes in short-term rates. The methodology proposed by Angrist, Jordà, and Kuersteiner (2018) is extended here to a panel setting. Recent macroeconomic studies that use this methodology to achieve identification include Acemoglu and others (2019), Caselli and Wingender (2021), Jordà and Taylor (2016), and Serrato and Wingender (2016). Willems (2020) instead constructs a measure of monetary policy tightening based on large and unexpected interest rate hikes for 162 countries.

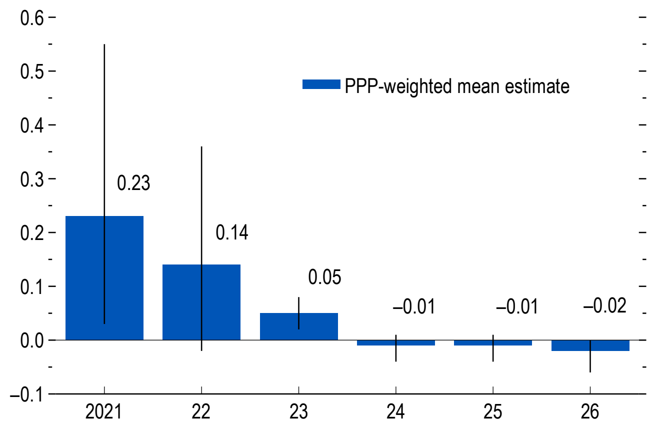
(2021), well-identified demand shocks can be used to instrument for changes in unemployment. In particular, monetary policy shocks are used to proxy for demand shocks, to recover a causal relationship between inflation and activity. Causal estimates of the Phillips coefficient can be recovered by taking the ratio of these impulse response functions of inflation to unemployment at the relevant horizon.[6] A negative and statistically significant slope coefficient of minus 0.22 is estimated for advanced economies, providing reassurance of the validity of the reduced form results. These findings provide further evidence of strength in the relationship between inflation and slack.[7]

The Impact of Recovering Demand on Inflation Dynamics

What role will the closing of output gaps play in the inflation outlook while the recovery is underway? The previous causal relationship is used to back out the contribution of the projected closing of the unemployment gap in advanced economies on inflation dynamics for the next six years.[8] This year and the next exhibit a moderately positive inflation impulse of about 0.23 and 0.14 percentage point respectively (Figure 2.5). This impact softens in 2023 and 2024 before turning into a negligible disinflation impulse in 2026. These aggregate figures mask a significant degree of heterogeneity, as shown by the interquartile ranges, with the United States and its extraordinary policy support driving short-term inflation dynamics. Results for emerging markets using reduced-form estimates show a stronger impulse toward inflation as a result of recovering labor markets equal to 0.5 percentage point in 2021, but moderate contributions through the forecast horizon (see

Figure 2.5. Slack-Induced Inflation Dynamics from Structural Phillips Curve in Advanced Economies
(Percentage Points)

Changes in advanced economies' unemployment gaps lead to a small inflation impulse from slack.



Sources: Haver Analytics; and IMF staff calculations.
Note: The bars represent the inflation impulse from changes in the unemployment gap based on the October 2021 *World Economic Outlook* vintage and the structural Phillips curve estimation described in the chapter. The vertical lines represent the interquartile ranges. PPP = purchasing power parity.

[6] Online Annex 2.2 presents the details of the impulse responses of inflation and unemployment to contractionary monetary policy surprises and discusses their dynamics. Annex Figure 2.2.2, panel 1, shows that the unemployment rate increases by 1 percentage point on average in response to a cumulative 40 basis point surprise tightening, compared with a neutral stance, and the full impact takes about 12 quarters to materialize. Figure 2.2.2, panel 2, shows that core inflation significantly decreases by about 0.2 percentage point after 15 quarters to the same sequence of monetary policy tightening. While the estimated impulse response function for the unemployment rate is on the higher end, it is consistent with the empirical literature that exploits narrative approaches to estimate the effects of monetary policy shocks on real activity (Ramey 2016). Moreover, it is important to stress the differences in terms of sample period and composition and estimation approach compared with the bulk of the literature, which focuses on linear models in the US. See the online annex for a more detailed discussion.

[7] Results are reported for advanced economies only. Data limitations and variability in policy reaction functions for emerging market central banks result in a weak first stage for these countries.

[8] The literature points to mixed evidence about the strength of the Phillips curve. Several explanations have been offered for a potential flattening of the Phillips curve: for instance, since the mid-1990s inflation expectations have become increasingly more important in explaining current inflation (April 2013 WEO, Chapter 3; Yellen 2015). Second, globalization forces have been mentioned as potential drivers of a weakening relationship between inflation and domestic slack (Auer, Borio, and Filardo 2017; Bems and others, forthcoming; Borio and Filardo 2007; October 2018 WEO, Chapter 3). Third, other long-term structural changes such as workers' declining bargaining power and automation, greater employer concentration, and higher wage rigidity reduced the sensitivity of inflation to the level of slack (Daly, Hobijn, and Pyle 2016; Hooper, Mishkin, and Sufi 2019; Yellen 2012).

Online Annex 2.2).[9] These calculations crucially rely on the projected unemployment paths and estimates of the potential scarring from the crisis (see Chapter 1). Given the recovery's uncharted nature, considerable uncertainty around these economic-slack-induced dynamics remains because of the difficulties in quantifying the extent of potential scarring and the effects of the crisis on potential output.

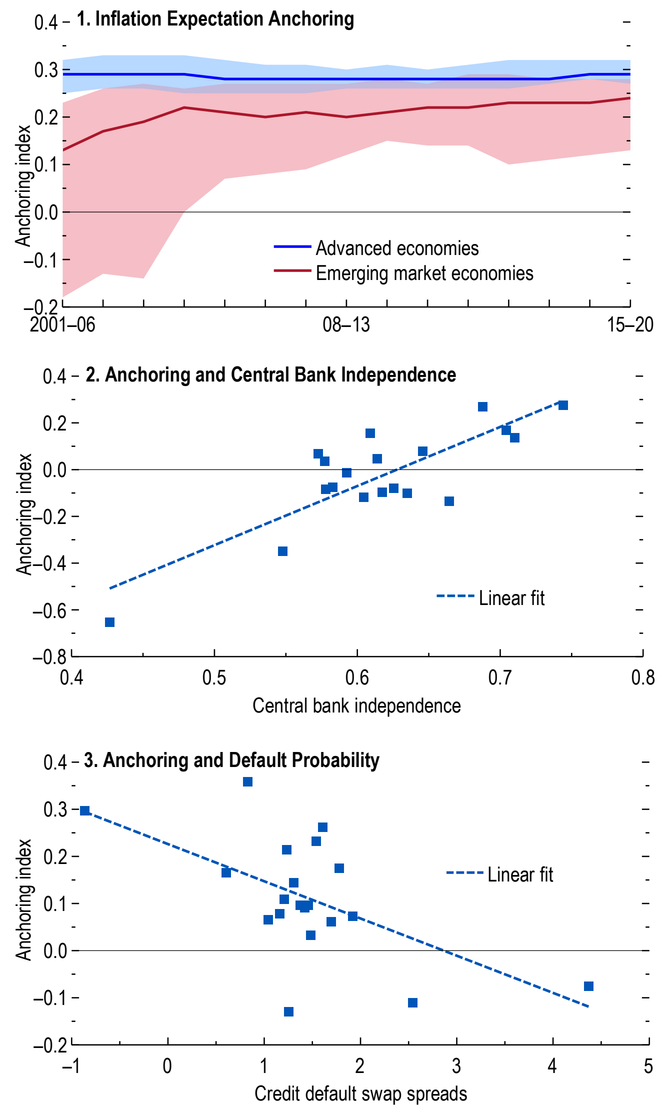
The Role of Inflation Expectations' Anchoring

The previous section presented evidence that expanding demand is likely to have a muted impact on future inflation. Nevertheless, other factors, such as the anchoring of inflation expectations and supply shocks, are also crucial to understanding the inflation process. A key question is the conditions under which recent inflation spikes could persist, including because expectations become unanchored and lead to self-fulfilling inflation spirals. This section explores the conditions under which expectations can become unanchored. It then examines what countries have done in the past to successfully keep expectations anchored or bring them down once they rose.

Anchoring: The literature proposes various indicators to measure the degree of anchoring. Chapter 3 of the October 2018 WEO and Bems and others (2021) construct a synthetic indicator that includes four subcomponents capturing either operational or practical characteristics associated with stable and anchored inflation expectations.[10] Inflation expectations are considered anchored if they are stable over time,

Figure 2.6. Inflation Anchoring
(Index)

Anchoring has improved, particularly in emerging market economies, but it still varies across countries. Sound and suitable monetary and fiscal policies are associated with more anchored expectations.



Sources: Berns and others (2021); Concensus Economics; Dincer and Eichengreen (2014); Garriga (2018); Haver Analytics; and IMF staff calculations.
Note: In panel 1, lines represent the median; shaded areas represent the interquatile range of anchoring index by country group. See Online Annex 2.1 for further details.

[9] The calculation for emerging markets is presented in Online Annex 2.2, Figure 2.2.3, and is based on ordinary least squares coefficients.
[10] These include (1) the variability of long-term inflation forecasts over time—if expectations are anchored, revisions to long-term forecasts should be small, and thus the average forecast relatively stable over time; (2) the dispersion of expectations across agents; (3) the sensitivity of long-term expectations to expectations about short-term inflation or macroeconomic surprises; and (4) the deviation of medium- or longer-term inflation expectation from the central bank's target. For details on the construction of the index see Bems and others (forthcoming-a). The index is constructed using professional forecasters' long-term (three-year and longer) inflation expectations.

exhibit little cross-sectional dispersion, are insensitive to macroeconomic news, and are close to the central bank target. As shown in Figure 2.6, panel 1, although advanced economies presented a relatively stable degree of anchoring during the past two decades, consistent with early adoption of inflation-targeting regimes, emerging markets have seen significant improvements since the beginning of the 2000s. These economies have achieved anchoring comparable to that of advanced economies in recent years. Nevertheless, among emerging market economies significant variability remains—as shown by the wider interquartile range in Figure 2.6, panel 1.

Institutional characteristics and anchoring of inflation expectations: The extent of anchoring is closely associated with institutional characteristics such as the credibility of monetary and fiscal policy, as well as the general macroeconomic situation and structural characteristics. In this regard, an independent and transparent central bank and sound and sustainable fiscal policy are key prerequisites for credible policies (Mishkin 2000; Mishkin and Savastano 2001). The cross-country variation in the degree of anchoring is positively correlated with the degree of independence of the central bank (Figure 2.6, panel 2) and negatively associated with the probability of default (Figure 2.6, panel 3).

Benefits of anchoring: What are the benefits of anchored inflation expectations? If long-term inflation expectations are not anchored, shocks that weaken economic activity could present the central bank with a policy dilemma. Although loose monetary policies might be appropriate to boost demand, they could accelerate price pressure and increase uncertainty, which would hold back private investment and employment growth. By contrast, if inflation expectations are anchored, the central bank has more scope to pursue the appropriate countercyclical policy response to stimulate demand (Chapter 3 of the October 2018 WEO; Bems and others 2020).

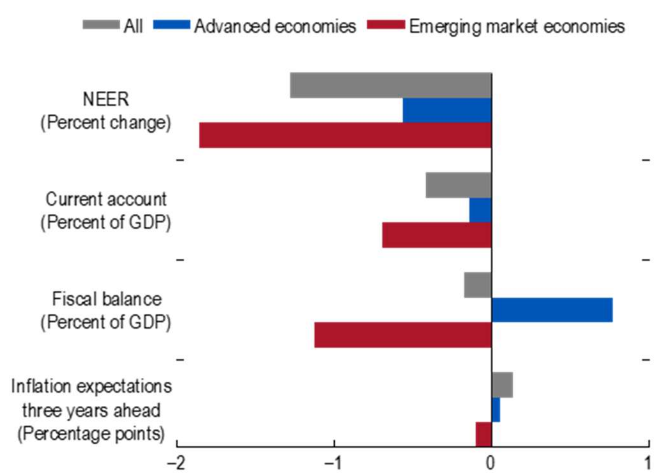
When Have Expectations Become Unanchored in the Past?

Analysis of past inflation episodes can help shed light on conditions that contribute to de-anchoring of inflation expectations. The exercise identifies turning points in inflation—"inflation accelerations or scares"—following the approach used in Hausmann, Pritchett, and Rodrik (2005) (for growth performance). Fifty-five episodes distributed equally across advanced economies and emerging markets are identified (Figure 2.7).

Inflation accelerations are associated with sharp exchange rate depreciations in emerging markets. On average, the nominal effective exchange rate

Figure 2.7. Inflation Episodes

Episodes of high inflation are associated with large exchange rate depreciations.



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: The chart presents the difference in the three-quarter averages just prior to the start of an acceleration (from $t-3$ to $t-1$) compared with the previous six-quarter averages ($t-9$ to $t-4$). NEER = nominal effective exchange rate.

depreciated by about 8 percent in the quarter the episode began.[11] Inflation acceleration was often preceded by an upsurge in fiscal and current account deficits. On average, both fiscal and current account deficits increased before the episode. The increases were even sharper for emerging markets. Short- and medium-term expectations rose sharply during inflation scares. More persistent episodes, defined as those during which inflation remained elevated for six quarters or more, were associated with a steeper rise in three-year-ahead inflation expectations (see Online Annex 2.3).

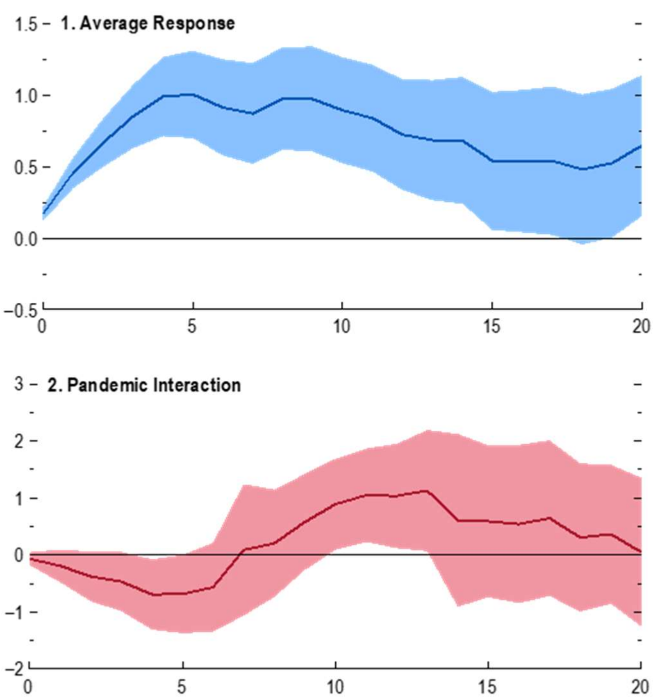
Given the difficulty of quantifying some important policy variables, such as communication from the central bank, this section also applies a narrative approach to selected case studies (Box 2.3). An analysis of macroeconomic outcomes in the case studies confirms many of the findings of the statistical analysis and offers additional insights. Longer-term-expenditure commitments (for example, financing the Vietnam War and Great Society programs in the 1960s in the United States and soaring subsidy bills and agricultural debt waivers in India in the late 2000s) could be associated with unhinged expectations.[12] External shocks combined with sharp exchange rate depreciations (for example Brazil in the early 2000s) could also trigger a de-anchoring of expectations, especially in countries starting from an environment of low monetary policy credibility. Moreover, even when expectations are well anchored, a prolonged deviation of inflation from target could cause expectations to move (such as in Chile before the global financial crisis).

Expectations Anchoring During the COVID-19 Pandemic

How robust has the inflation anchor been during the COVID-19 pandemic? If inflation expectations are well anchored, they should not respond to inflation surprises. To zoom in on the pandemic period, a daily market-based measure of long-term inflation expectations, the five-year, five-year forward breakeven inflation

Figure 2.8. Response of Five-Year, Five-Year Forward Breakeven Inflation to Oil Price Shocks
(Basis points)

Market-based inflation expectations respond to oil price surprises, but have not become more sensitive to surprises during the pandemic.



Sources: Bloomberg Finance L.P.; and IMF staff calculations.
Note: The solid lines represent the estimated response; shaded areas represent 95 percent confidence intervals. The *x*-axis indicates the number of days after the shock starts.

[11] The exchange rate depreciation is the only factor that appears as statistically significant.
[12] Coibion, Gorodnichenko, and Weber (2021) find that US households anticipate higher short-term and long-term inflation following news about future debt but do not in response to information about current debt, suggesting that households are able to distinguish between transitory fiscal changes and those that are more permanent.

rate, is analyzed for a sample of 14 countries.[13] Inflation surprises are proxied by oil price shocks, measured as the change in the price of one-year-ahead oil futures contracts. Consistent with the previous literature (Beechey, Johannsen, and Levin 2011; Celasun, Mihet, and Ratnovski 2012; Gürkaynak, Sack, and Wright 2010), the results indicate a small but significant effect of oil price shocks on expectations (Figure 2.8, panel 1). The introduction of an interaction term of oil futures prices with an indicator for the pandemic period (starting in March 2020) reveals that, on average, in the limited sample, there was no significant change in the relationship between oil surprises and the breakeven rate during the pandemic compared with normal times (Figure 2.8, panel 2). Breakeven inflation rates, in the United States, however, overshot their pre-pandemic levels in January 2021.[14] An analysis of daily monetary and fiscal policy announcements reveals no evidence of de-anchoring in response to the exceptionally large policy responses to the pandemic (see Online Annex Figure 2.3.2). Overall, these findings suggest that the anchor has remained relatively stable so far during the COVID-19 pandemic crisis.

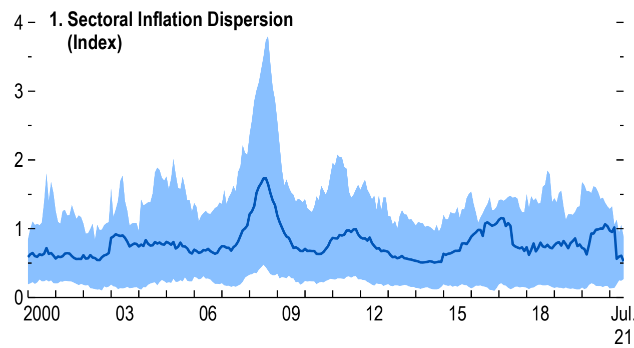
Sectoral Shocks and the Inflation Outlook

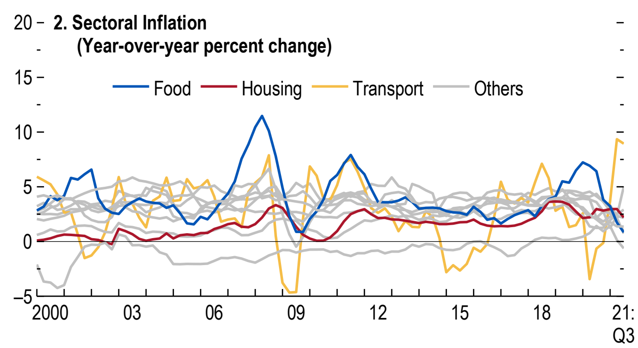
The COVID-19 crisis triggered large price movements in some sectors, notably transportation, food, clothing, and communications (see Online Annex 2.4). However, overall sectoral price dispersion so far has remained relatively subdued by recent historical standards, especially compared with the global financial crisis (Figure 2.9, panel 1). As illustrated in Figure 2.9, panel 2, this is driven by somewhat smaller and shorter-lived swings in fuel (transport), food, and housing prices, which are the three largest components of consumption baskets, on average.

In addition, a case study of the semiconductor industry in the United

Figure 2.9. Sectoral Inflation Dynamics

Sectoral inflation dispersion during the pandemic does not stand out by historical standards. This is largely due to smaller and shorter-lived swings in fuel, food, and housing prices.





Sources: Haver Analytics; IMF, CPI database; and IMF staff calculations.
Note: In panel 1, the solid line represents the cross-country mean of sectoral inflation dispersion; shaded area represents the 10th to 90th percentile range. The sectoral inflation dispersion index is calculated as the standard deviation of sectoral inflation weighted by consumption shares. Panel 2 presents averages weighted by country's purchasing-power-parity GDP.

[13] See Online Annex 2.3 for country coverage, variable definitions, and estimation details. In addition to reflecting expectations about future inflation, breakeven rates include both liquidity risk premiums and inflation risk premiums, reflecting uncertainty about future inflation, which could have important policy implications (October 2021 *Global Financial Stability Report* [GFSR], Chapter 1). Countries for which breakeven inflation rates are available are mostly advanced economies or major emerging markets with high central bank credibility and well-anchored inflation expectations. Robustness exercises with liquidity-adjusted measures are implemented following Gürkaynak, Sack, and Wright (2010). The time-varying effect of liquidity on inflation compensation is measured as the fitted values from a regression of the breakeven rate on liquidity proxies for both bonds.

[14] Consistent with the shift to the flexible average inflation-targeting framework, breakeven inflation rates in the United States rose, particularly at shorter horizons, primarily due to an increase in the risk-adjusted expected inflation component (October 2021 GFSR, Chapter 1).

States points to only a modest increase in overall inflation given a potential doubling of semiconductor input prices (see Online Annex Figure 2.4.2). This is because categories with the highest potential increase in inflation, as a result of the doubling input price of semiconductors, have a very small weight in personal consumption expenditures (such as personal computers and photographic equipment).[15]

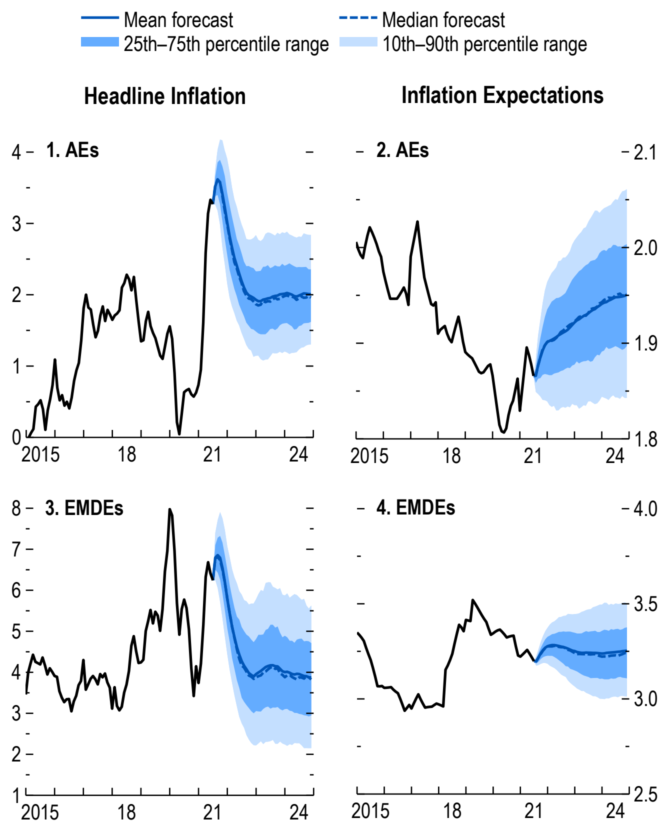
The Inflation Outlook

To assess how sectoral price dynamics could affect the inflation outlook, a structural quantile vector autoregression model is estimated for advanced economies and emerging market and developing economies to gauge the balance of risks by looking at broader moments of the density forecast (Boire, Duprey, and Ueberfeldt 2021; Chavleishvili and Manganelli 2020; Ghysels, Iania, and Striaukas 2018; Koenker and Xiao 2006; Montes-Rojas 2019).[16] Online Annex 2.4 provides details and definitions of the variables.

Density forecasts show a sharp rise in inflation in the near term. Headline inflation among advanced economies, is expected to peak at 3.6 percent in the fall of 2021 (Figure 2.10, panel 1). The forecast then drops to 3.2 percent by the end of the year and reaches around 2 percent by mid-2022. Risks are tilted slightly to the upside over the medium term for advanced economies. These findings also suggest a 10 percent probability of inflation remaining above 3.4 percent through the end of 2021. While the density forecasts suggest that inflation is likely to have peaked in the fall in advanced economies, uncertainty remains related to the factors mentioned earlier.

Figure 2.10. Headline Inflation and Inflation Expectation Baseline Outlook
(Percent)

In the baseline forecast, headline inflation exhibits a short-lived increase in both advanced economies and emerging market and developing economies, and Inflation expectations are projected to remain anchored over the medium term.



Sources: Consensus Economics; Haver Analytics; IMF, CPI database; and IMF staff estimates.
Note: The lines are averages weighted by countries' purchasing-power-parity GDP. Central tendencies for headline inflations are adjusted to ensure consistency with mean *World Economic Outlook* inflation forecasts. AEs = advanced economies; EMDEs = emerging market and developing economies. See Online Annex 2.1 for further details about the list of countries included in the samples.

[15] In contrast, consumption items with the highest weights in the consumption basket (for example, housing) exhibit negligible price increases from higher semiconductor input prices. The analysis makes use of US input-output tables.

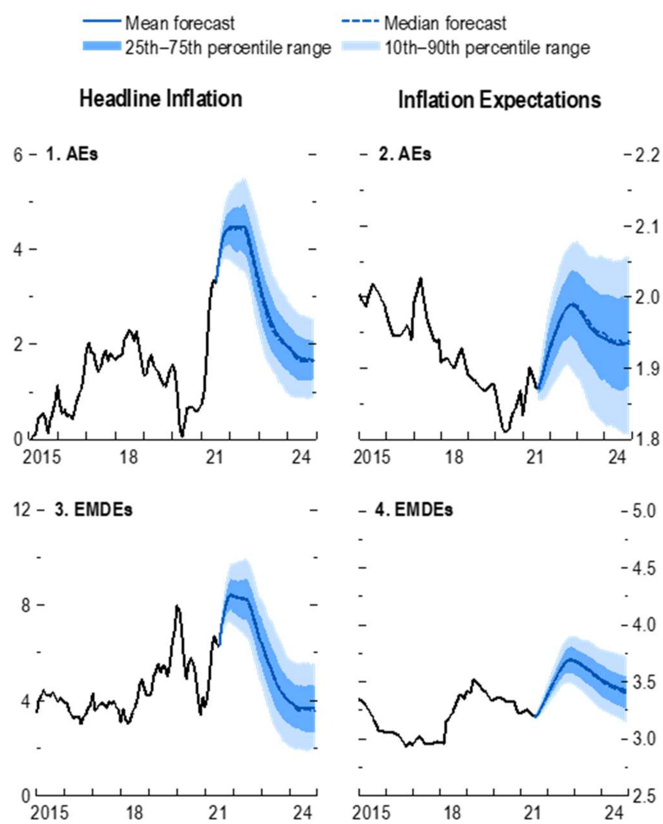
[16] Following Lenza and Primiceri (2020), the estimation of parameters of the model excludes the pandemic period.

The outlook for emerging market and developing economies indicates a return to trend of headline inflation of about 4 percent by mid-2022 (Figure 2.10, panel 3). Risks remain tilted the upside over the medium term for emerging markets as evidenced by the wider interquantile range at the top of density forecast than at the bottom.[17]

Inflation expectations: Long-term inflation expectations present a relatively strong degree of anchoring. They gradually trend back to around 2 percent on average in the baseline forecast for advanced economies, with little risk of de-anchoring (Figure 2.10, panel 2). For emerging market and developing economies, expectations are projected to remain anchored over the medium term, but with upside risks as shown by the mean forecast lying above the median forecast starting in mid-2023 (Figure 2.10, panel 4).

Figure 2.11. Headline Inflation and Inflation Expectation Outlook with Adverse Sectoral and Commodity Price Shock
(Percent)

A sharp rise in commodity prices and sectoral inflation dispersion over the next 12 months would have a strong but temporary impact on headline inflation. Inflation expectations could overshoot but revert to trend over the medium term.



Sources: Consensus Economics; Haver Analytics; IMF, CPI database; and IMF staff estimates.
Note: The lines are averages weighted by countries' purchasing-power-parity GDP. Sectoral dispersion and commodity price shocks are assumed to be drawn from the top 75 percent of the predictive distributions for 12 consecutive months from July 2021 to June 2022. AEs = advanced economies; EMDEs = emerging market and developing economies. See Online Annex 2.1 for further details about the list of countries included in the samples.

Assessing the Impact of Continued Strong Increases in Commodity Prices and Sectoral Price Dispersion

The previous results are based on the historical relationship between inflation dynamics and its determinants, including the reaction function of central banks to incoming data. Given the uniqueness of the current episode, any attempt to extrapolate lessons from experience into the future must be approached with caution. In particular, policymakers wonder about the effect of continued and sustained sectoral disruptions on the inflation outlook. Could sectoral price volatility, for example from housing or food prices, spill over into headline inflation and lead to higher, more persistent, and volatile inflation? Could this lead to an inflation spiral propelled by the de-anchoring of inflation expectations?

Tail-risk scenario: A forward-looking exercise is used to answer these questions. The exercise simulates inflation developments assuming a tail scenario which, according to our model, has less than 0.01 percent probability of materializing.

[17] Reversion to trend may be delayed if monetary policy does not respond as quickly to higher inflation as it has in the past.

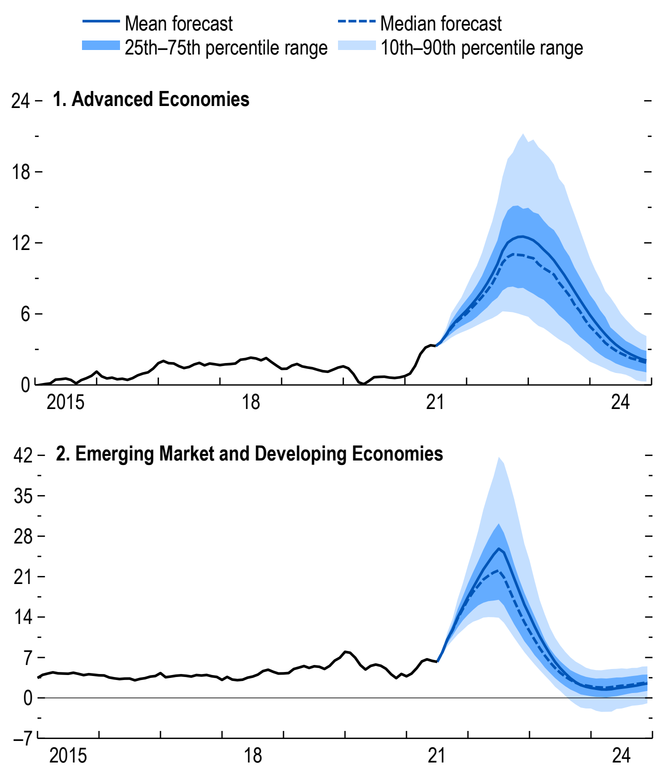
This scenario is marked by strong rises in commodity prices and sectoral inflation dispersion over the next 12 months and allows an assessment of the potential impacts of continued supply disruptions or mismatches as the recovery proceeds. In this scenario, headline inflation would increase significantly, peaking at 4.4 percent, on average, in advanced economies by mid-2022 and 8.4 percent in emerging markets by early 2022 (Figure 2.11, panels 1 and 3). The forecasts in this scenario show broadly balanced risks over the medium term. However, even in this extreme scenario, headline inflation goes back to trend by early 2024. A look at inflation expectations points to fairly strong anchoring around 2 percent in advanced economies with little risk of de-anchoring (Figure 2.11, panel 2). For emerging market and developing economies, there is overshooting of expectations in the short term (Figure 2.11, panel 4). However, inflation expectations are projected to remain anchored over the medium term.

In summary, sectoral disruptions and large swings in commodity prices could mean upside risks for headline inflation, with higher peaks and a delayed return to trend inflation. The medium-term outlook, nevertheless, would likely still be driven by fundamentals, including the speed of the recovery and the continued anchoring of inflation expectations.

Potential effects of an additional de-anchoring shock: Importantly, the preceding scenario assumes inflation expectations remain anchored. While plausible—sectoral inflation dispersion reached very high levels after the global financial crisis without having long-lasting effects on headline inflation—the possibility of expectations deviating from target and creating a self-fulfilling inflationary spiral is a serious concern for policymakers. To evaluate the potential effects of a de-anchoring shock on the outlook, the previous scenario is extended to allow for inflation expectations to become adaptive for a period of 12 months, meaning expectations are no longer forward-looking but rather react to incoming

Figure 2.12. Headline Inflation with Adverse Sectoral and Commodity Price Shocks and Adaptive Expectations Shock
(Percent)

Sectoral shocks with unanchored expectations would lead to higher, more persistent and volatile inflation.



Sources: Consensus Economics; Haver Analytics; IMF, CPI database; and IMF staff estimates.
Note: The lines are averages weighted by countries' purchasing-power-parity GDP. Adaptive expectations assume that inflation is driven by one-year-ahead inflation expectations instead of the conventional three-year-ahead horizon for 12 consecutive months from July 2021 to June 2022. See Online Annex 2.1 for further details about the list of countries included in the samples.

data.[18] In Figure 2.12, inflation increases substantially in this extreme scenario and becomes more persistent and volatile, as indicated by the much wider interquartile ranges—pointing to the serious implications of inflation expectations becoming de-anchored.

Conclusions

Rising commodity prices and supply chain bottlenecks are putting upward pressure on headline inflation rates. Moreover, the unprecedented nature of the current recovery has raised questions about how long supply will take to catch up with accelerating demand. These uncertainties are fueling worries that inflation could persistently overshoot central bank targets and de-anchor expectations, leading to a self-fulfilling inflation spiral.

The analysis in this chapter suggests that likely will not be the case. Although the overall findings imply an increase in headline inflation in both advanced and emerging markets, it is expected to subside to pre-pandemic ranges by mid-2022 in the baseline.

However, this assessment is subject to significant uncertainty given the uncharted nature of the recovery. Simulations of scenarios characterized by strong rises in commodity prices, continued sectoral shocks, and adaptive expectations suggest significant risks to the inflation outlook. More persistent supply disruptions and sharply rising housing prices in advanced economies, or currency depreciations and food price pressure in emerging market and developing economies, could all lead inflation to remain elevated for longer than currently expected.

In terms of policy implications, there are four key lessons.

First, the narrative account of selected case studies and scenario analyses suggest that when expectations become de-anchored, inflation can quickly take off and be costly to rein back in. Ultimately, policy credibility and setting of inflation expectations are an endogenous, and possibly nonlinear process, that is hard to pin down precisely; moreover, any assessment of inflation anchoring cannot be decided entirely on the basis of relationships observed in historical data. Policymakers therefore must be ready to act and, more importantly, ensure that sound monetary frameworks are in place, including triggers that could require action. Such triggers could comprise early signs of de-anchoring inflation expectations—from forward-looking surveys, unsustainable fiscal and current accounts, or sharp movements in the exchange rate. In particular, policymakers must be alert to triggers for a perfect storm of inflation risks that could be relatively benign when considered individually but that by materializing together could lead to significantly higher inflation than predicted in our baseline forecasts.

Second, case studies demonstrate that, while strong policy action was often successful in bringing down inflation and inflation expectations, sound and credible communication also played a crucial role in keeping expectations anchored. In this context, clear and state-contingent forward guidance and communication (with well-articulated triggers for action) from advanced economy central banks are key during periods of policy normalization to avoid taper-tantrum-like

[18] The simulations assume that the expectations relevant for price formation in advanced economies are the one-year-ahead inflation expectations instead of the conventional three-year horizon. For emerging market and developing economies, we assume expectations are equal to the previous month's inflation.

scenarios. Similarly, a well-communicated plan for a gradual exit from exceptional monetary policy and liquidity support as the recovery strengthens would foster orderly market transitions in emerging markets, too. The case studies also highlight the importance of maintaining strong fiscal credibility for inflation anchoring.

Third, policymakers need to walk a tightrope between acting patiently to support the recovery and at the same time preparing to act quickly if inflation expectations show signs of de-anchoring. Central banks could look beyond temporary inflationary pressures and avoid tightening policies prematurely until there is more clarity on underlying price dynamics (conditional on expectations remaining firmly anchored). At the same time, central banks should also prepare to act quickly if the need arises and chart contingent actions that reveal their true preferences. Fiscal policies should adhere to sustainable medium-term frameworks. However, uncertainty about medium-term output gaps is still high and could affect the optimal timing for removal of policy support while the recovery is still underway. Policies, therefore, should be mindful of the unusual short-term dynamics and uncertainties surrounding potential output.

Fourth, a key feature of the outlook is the significant degree of cross-country heterogeneity among advanced economies and emerging market and developing economies and even within advanced economies. While the United States is projected to drive much of the slack-induced inflation dynamics in the baseline for advanced economies, with near-term risks tilted to the upside, underlying inflation dynamics in the euro area and Japan remain weak. Policy recommendations should be tailored to economies' particular vulnerabilities and business cycle phases. Yet spillovers from asynchronous monetary and fiscal tightening must be at the core of multilateral policy discussions. For emerging markets, medium-term expectations rose sharply during inflation scare episodes, which were preceded by growing internal and external imbalances—all of which underscores the role of strong macroeconomic fundamentals and credible medium-term fiscal frameworks in keeping expectations anchored.

Box 2.1. Food Insecurity and Prices during COVID-19

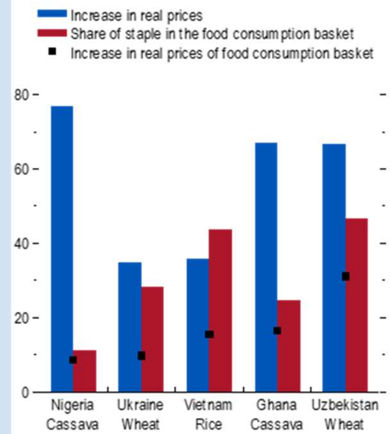
Nominal global food prices have risen more than 40 percent since the start of the pandemic.[i] The prices of goods sold in a local market—a more relevant indicator, especially if the good is produced domestically (for example, cassava in central and western Africa)—were influenced by numerous local factors, including supply and demand, government policies, exchange rates, transportation costs, and income levels. Data for monthly market food prices across locations for seven staples (wheat, rice, sugar, maize, milk, poultry, cassava), which contribute about 60 percent of average daily consumption, from 259 markets in 73 emerging markets are used. The real local price of staples in emerging markets has increased by 4.0 percent since the pandemic began.[ii] We observe significant price surges in staple foods in several countries. By contrast, a number of food-producing countries that experienced favorable weather conditions have avoided upward price pressure.

In the absence of frictions such as transportation costs, prices tend to equalize across markets. The pandemic, however, coincided with a sharp—20 percent on average—increase in within-country variation in food prices.[iii] This could indicate growing local supply shortages, likely because of pandemic-related declines in mobility, a greater concern for regions far from food production centers.

The dual shock of rising food prices and falling incomes will exacerbate inequality. In low-income countries, where food makes up about 40 percent of the consumption basket, staple food price growth raised consumer price index inflation 5 percentage points. Within countries, the poorest households spend proportionately more on food. (People in sub-Saharan Africa with consumption below $2.97 a day spend about 58 percent of their income on food.)

Figure 2.1.1. Selected Country-Commodity Price Surges

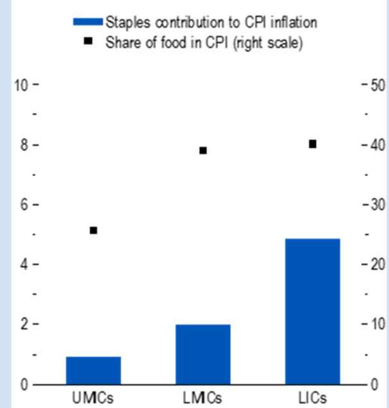
(Year-over-year percent change, unless noted otherwise)



Sources: FAOSTAT New Food Balances; GIEWS FPMA Tool; and IMF staff calculations.
Note: The real increase in consumption baskets includes all staples, not just the ones listed here. The data are from 2020:Q1–21:Q1.

Figure 2.1.2. Food Staples Contribution to CPI Inflation, Median by Income

(Percentage points; percent on right scale)



Sources: FAOSTAT New Food Balances; GIEWS FPMA Tool; IMF, *International Financial Statistics*; and IMF staff calculations.
Note: The staples included in the calculations are wheat, maize, rice, milk, poultry, sugar, and cassava. The countries included in the data set are those for which at least one staple price was available over the sample period. Missing prices are imputed from regional and income group averages. CPI = consumer price index; LICs = low-income countries; LMCs = lower-middle-income countries; UMCs = upper-middle-income countries. The data are from 2020:Q1–21:Q1.

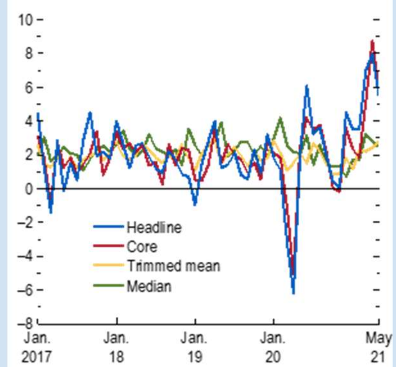
The authors of this box are Katrien Smuts, John Spray, and Filiz Unsal.

[i] IMF Primary Commodity Price System and authors' calculations; May 2020–May 2021 year-over-year change.
[ii] The values are calculated as the regional median of consumption share$_{ij}$ * change in real prices in local currency$_{ij}$, in which i = country and j = staple: 2020:Q1–2021:Q1 year-over-year change.
[iii] Variations in food prices are calculated as $\left(\max(price_{ijct})_{jct} - \min(price_{ijct})_{jct}\right)/\max(price_{ijct})_{jct}$ for commodity j, market i, in country c in quarter t. We then take an average across commodities and countries within each region. We exclude commodities that are not present in at least three markets: 2020:Q1–2021:Q1 year-over-year change.

Box 2.2. Core Inflation in the COVID-19 Crisis

US headline inflation has risen sharply since the start of the pandemic. To interpret such developments, economists distinguish between underlying or "core" inflation, which reflects macroeconomic conditions and is especially salient for monetary policy deliberations, and transitory fluctuations around the core arising from changes in relative prices caused by microeconomic factors. But making this distinction is challenging in the current environment because different measures of core inflation give different signals.

Figure 2.2.1. Headline and Underlying Inflation in the United States
(Percent)

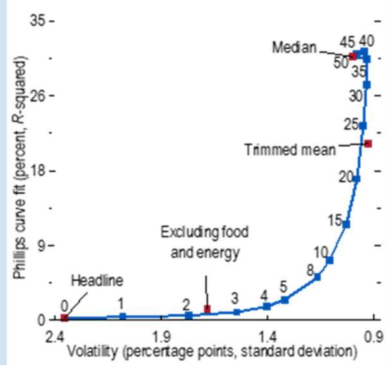


Sources: Haver Analytics; and IMF staff calculations.
Note: Inflation rates are based on the personal consumption expenditure chain-type price Index. Trimmed mean is produced by the Federal Reserve Bank of Dallas.

A common measure of core personal consumption expenditure inflation that excludes food and energy prices has recently spiked even higher than headline inflation. But simply removing food and energy prices is not the best way to measure core inflation: transitory movements can arise in different industries (Dolmas 2005). These concerns have led to core measurement based on median inflation (the price change at the 50th percentile of all prices each month) or on trimmed mean inflation (stripping out a fixed share of price changes).

Based on median or trimmed mean inflation, recent developments are less alarming. This difference reflects the large sectoral shocks to industries other than food and energy, which caused the traditional measure to rise sharply but are filtered out of median or trimmed mean inflation. For example, the April 2021 inflation spike reflected the prices of light trucks, hotel rooms, air transportation, spectator sports, and car rentals, which more than doubled at a monthly annualized rate, while median inflation was only 2.8 percent (Figure 2.2.1).

Figure 2.2.2. Inflation Rates by Industry in the United States, April 2021



Sources: Haver Analytics; and IMF staff calculations.
Note: Points along the line indicate different trimming percentages from monthly distribution of all price changes. Volatility is defined as standard deviation of change in monthly annualized inflation for each measure (Jan. 1990–May 2021). Phillips curve fit indicates *R*-squared of estimated relationship between quarterly annualized inflation for each measure in deviation from 10-year-ahead Survey of Professional Forecasters expectations and four-quarter average gap between unemployment and its Congressional Budget Office natural rate, estimated based on quarterly data for 1990:Q1–2019:Q4.

Which of these core measures is more relevant for understanding the current situation? Historical data suggest that it is median or trimmed mean inflation. Figure 2.2.2 compares the volatility of inflation and the strength of its relationship with unemployment using different measures. Trimming more extreme price movements increases the stability of the underlying inflation measure and strengthens its relationship with macroeconomic conditions. Inflation excluding food and energy has been 70 percent more volatile than median inflation and has had a much weaker relationship with unemployment. The COVID-19 crisis has strengthened the case for median or trimmed mean inflation.

The authors of this box are Laurence Ball, Daniel Leigh, Prachi Mishra, and Antonio Spilimbergo.

Box 2.3. Policy Responses and Expectations in Inflation Acceleration Episodes

United States 1965–83

Background: After two decades of low inflation following World War II, it started to increase gradually in the mid-1960s. Inflation continued to drift upward during the 1970s amid several external price shocks, high fiscal deficits due to military engagements and rising social spending, a likely overestimation of productivity growth and potential output, and dovish destabilizing monetary policy.

Policy response and results: The 1978 Humphrey-Hawkins Act amended the Federal Reserve's mandate and enabled then-Federal Reserve Board Chair Paul Volcker to aggressively raise interest rates. The federal funds rate averaged 11.2 percent in 1979, the first year of Volcker's tenure, and rose to 20 percent in June 1981. Inflation peaked in March 1980 at almost 15 percent and fell to 3 percent by 1983. The drop was induced by a sharp demand-led recession that raised the unemployment rate from 5.6 percent in May 1979 to 10.8 percent in November 1982.

Policy conclusions: Important policy lessons were learned from the US Great Inflation of the 1970s and its demise. Central bank independence as a potential mitigant to inflationary bias, as well as central bank transparency, prudent medium-term fiscal planning, and adherence to stabilizing monetary rules and inflation targeting became central.

Brazil 2002–05

Background: Currency depreciations coupled with domestic and external shocks in 2001 triggered a sudden stop in 2002. Brazil experienced a reversal in capital flows and cuts to trade credit lines, and the *real* depreciated by 53 percent in 2002. Inflation expectations rose along with the increase in inflation.

Policy response and results: Starting from low monetary policy credibility and concerns about fiscal dominance, policymakers decided against a gradual tightening. A cumulative increase of 550 basis points was implemented by February 2003, accompanied by an increase in banks' reserve requirements. Expectations began to lower only after the country's monetary policy committee kept the policy rate at 26.5 percent in April 2003 for a third month in a row, despite public outcry. Inflation expectations remained stable until mid-2004. In September 2004, the committee responded to rising inflation concerns by starting another tightening cycle and clearly laying out conditions under which they would act: (1) They committed to a forward-looking inflation objective for 2005. (2) They announced that policy would respond asymmetrically to inflation-increasing and -decreasing shocks. Expectations fell afterward, even as inflation continued to rise, and expectations indeed converged to the target by the end of 2005. The new government also made efforts to assert a fiscally prudent policy.

Policy conclusions: Considered a stress test of a new inflation-targeting (IT) framework, the experience showed (1) the need for larger monetary policy action to counter unanchored expectations and establish credibility, and (2) how clear and state-contingent guidance could complement the initial response.

The authors of this box are Christoffer Koch, Sonali Das, and Prachi Mishra.

Chile 2007–09

Background: The Banco Central de Chile (BCC) formally adopted a flexible IT framework in 1999. Inflation expectations were well anchored thereafter at about 3 percent. The new monetary policy regime was accompanied by a credible fiscal rule, sound financial sector regulation, and supervision. From mid-2007 to late 2008, however, Chile experienced upward inflation pressure from international factors—rising copper, food, and energy prices. Headline inflation exceeded the target range in August 2007. Inflation expectations began to increase and moved above the 3 percent target by late 2008.

Policy response and results: In the second half of 2007, the BCC tightened monetary policy, raising the policy rate by 25 basis points in July 2007. Despite a cumulative rate increase of 325 basis points by September 2008, two-year-ahead expectations increased to 3.9 percent. The BCC was somewhat slow to act on the rise in inflation for several reasons: (1) The degree of slack in the economy did not rise as high as was estimated. (2) The pass-through from the appreciating exchange rate was lower than expected. (3) The size and persistence of the increase in agricultural commodity prices was unanticipated. The global financial crisis then led to a recession and reversal of commodity prices, while inflation declined sharply and expectations came down to target through 2009.

Policy conclusions: Even when expectations are well anchored, risks to credibility could arise when inflation moves far from its target or when it remains beyond its band for an extended period.

India 2010–14

Background: Following a rebound after the global financial crisis, growth began to slow in 2011 because of domestic and external factors. The 2003 fiscal rule was abandoned, leading to internal and external imbalances. Inflation expectations were not anchored during this time. At the first hint of US monetary policy tapering on May 22, 2013, India's large current account deficit and excessive dependence on portfolio flows stood badly exposed. A plunging rupee heightened concerns of even higher inflation and risks of a ratings downgrade.

Policy response and results: A new central banker was appointed and laid out several priorities on the first day, September 2, 2013. Two things stood out: (1) a pledge to restore confidence, and (2) a commitment to make the central bank more transparent and predictable. A new IT framework began guiding policy and communications in January 2014. Foreign exchange interventions to address commodity price volatility accompanied this strategy. Confidence in the country's economy was achieved as rupee expectations became firmly anchored and inflation and inflation expectations were brought under control.

Policy conclusions: Monetary policy operations improvements and communication strategies, along with a transparent and credible commitment to reducing inflation, worked to disinflate from high levels. The central bank's success on this front opened up the space to pursue other objectives without disturbing inflation expectations.

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CHAPTER 2
ONLINE ANNEX

This appendix to Chapter 2 of the October 2021 World Economic Outlook provides documentation of data sources, country coverage, methodologies, and extensions of the analyses and narratives of the chapter. Section 2.1 compiles table summaries of the data sources and country coverage. Section 2.2 provides more details on the reduced form and structural Phillips Curve estimation. Section 2.3 elaborates on the analysis of inflation scares and market-based expectations. Section 2.4 illustrates a case study of the semiconductors sectors and its impact on inflation in the US, before moving on to the discuss of the quantile VAR analysis.

Annex 2.1 Countries and Data Sources

Annex Table 2.1.1 itemizes the data sources for the empirical exercises and Annex Table 2.1.2 lists the countries included in the different sections of the analyses.

Annex Table 2.1.1 Sample of Economies included in Analytical Exercises

Analysis	Indicator	Sources
Phillip's Curve	Bilateral Exchange Rate against the US dollar	IMF, Directions of Trade Statistics
	Bilateral Exports and Imports	IMF, Directions of Trade Statistics
	Core Consumer Price Index	Haver Analytics
	Domestic Output Gap	IMF, World Economic Outlook Database, IMF staff calculations
	Producer Price Index	Haver Analytics
	External Price Pressure	IMF staff calculations
	Foreign Output Gap	IMF staff calculations
	Nominal Effective Exchange Rate	IMF staff calculations
	Nominal Imports, Exports, and GDP	IMF, World Economic Outlook Database
	Unemployment	IMF, World Economic Outlook Database
Inflation Expectations Anchoring	5-year 5-year forward breakeven rate	Bloomberg
	Central Bank Transparency	Dincer and Eichengreen 2014
	Core Inflation	Haver Analytics
	Credit Default Swap Spreads	Datastream
	Current Account	Haver Analytics
	Debt-to-GDP	Haver Analytics; and IMF staff calculations
	Fiscal balance	Haver Analytics
	Inflation Expectations (1-,2-,3-,5-,10-years ahead)	Consensus Economics; Bureau for Economic Research
	Monetary Policy Rate	Haver Analytics
	Nominal Effective Exchange Rate	Bloomberg; and IMF staff calculations
	Real Effective Exchange Rate	Bloomberg; and IMF staff calculations
	USD/LC	Bloomberg; and IMF staff calculations
Sectoral Price Dispersion and Inflation	Commodity Prices (Food and Energy)	IMF, International Financial Statistics
	Consumer Price Index	IMF CPI database
	External Price Pressure	IMF staff calculations
	Industrial Production	Haver Analytics
	Inflation expectations	Consensus Forecast
	Unemployment Rate	Haver Analytics
Semiconductors Price	Input-Output Tables	U.S. Bureau of Economic Analysis
	Import Prices of Semiconductors	U.S. Bureau of Labor Statistics
	Personal Consumption Expenditure	U.S. Department of Commerce, U.S. Bureau of Economic Analysis

Annex Table 2.1.2 Sample of Economies included in Analytical Exercises

Figure	Countries
Inflation and Labor Demand (Figure 2.3)	Australia, Austria, Belgium, Canada, Czech Repubilc, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States
Unemployment Gap—Inflation Phillips Correlation (Figure 2.4)	Australia, Austria, Belgium, Brazil*, Bulgaria*, Canada, Chile*, China*, Colombia*, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Hungary*, India*, Indonesia*, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Malaysia*, Mexico*, Netherlands, New Zealand, Norway, Peru*, Philippines*, Poland*, Portugal, Romania*, Russia*, Singapore, Slovak Republic, Slovenia, South Africa*, Spain, Sweden, Switzerland, Thailand*, Turkey*, United Kingdom, United States
Slack Induced Inflation Dynamics from Structural Phillips Curve in Advanced Economies (Figure 2.5)	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, United Kingdom, United States
Inflation Anchoring (Figure 2.6, panel 1)	Argentina*, Australia, Brazil*, Bulgaria*, Canada, Chile*, China*, Colombia*, Croatia*, Czech Republic, Estonia, France, Germany, Hong Kong SAR, Hungary, India*, Indonesia*, Italy, Japan, Korea, Latvia, Lithuania, Malaysia*, Mexico*, Netherlands, New Zealand, Norway, Peru*, Philippines*, Poland*, Romania*, Russia*, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Thailand*, Turkey*, Ukraine*, United Kingdom, United States, Venezuela*
Inflation Anchoring (Figure 2.6, panel 2)	Argentina*, Australia, Brazil*, Bulgaria*, Canada, Chile*, China*, Colombia*, Croatia*, Czech Republic, Estonia, France, Germany, Hungary, India*, Indonesia*, Italy, Japan, Korea, Latvia, Lithuania, Malaysia*, Mexico*, Netherlands, New Zealand, Norway, Peru*, Philippines*, Poland*, Romania*, Russia*, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan Province of China*, Thailand*, Turkey*, Ukraine*, United Kingdom, United States, Venezuela*
Inflation Anchoring (Figure 2.6, Panel 3)	Argentina*, Australia, Brazil*, Chile*, China*, Colombia*, Estonia, France, Germany, Hong Kong SAR, Hungary, Indonesia*, Italy, Japan, Korea, Latvia, Lithuania, Malaysia*, Mexico*, Netherlands, New Zealand, Norway, Peru*, Philippines*, Poland*, Romania*, Russia*, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Thailand*, Turkey*, Ukraine*, United Kingdom, United States, Venezuela*
Inflation Episodes (Figure 2.7)	Argentina*, Australia, Brazil*, Bulgaria*, Canada, Chile*, China*, Colombia*, Croatia*, Czech Republic, Estonia, France, Germany, Hong Kong SAR, Hungary, India*, Indonesia*, Italy, Japan, Korea, Latvia, Lithuania, Malaysia*, Mexico*, Netherlands, New Zealand, Norway, Peru*, Philippines*, Poland*, Russia*, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan Province of China*, Thailand*, Turkey*, Ukraine*, United Kingdom, United States
Responses of Five-Year, Five-Year Forward Breakeven Inflation to Oil Price Shocks (Figure 2.8)	Australia, Brazil*, Canada, Chile*, France, Germany, Israel, Italy, Japan, Mexico*, South Africa*, Sweden, United Kingdom, United States
Headline Inflation and Inflation Expectations Outlooks—Three Scenarios (Figure 2.10, Figure 2.11, and Figure 2.12)	Advanced Economies: Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong SAR, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States Emerging Market Economies: Bangladesh*, Bulgaria*, Chile*, China*, Colombia*, Costa Rica*, Ecuador*, Egypt*, El Salvador*, Honduras*, Hungary*, Malaysia*, Mexico*, Moldova*, Pakistan*, Paraguay*, Philippines*, Poland*, Russia*, South Africa*, Thailand*, Turkey*, Ukraine*, Uruguay*, Vietnam*

Source: IMF staff compilation.

[1] Asterisk(*) denotes emerging market and developing economies as classified by the April 2021, World Economic Outlook.

Annex 2.2 Phillips Curve Estimation

This section describes the reduced and causal form estimations of the relationship between economic slack and inflation. The chapter's starting point for the empirical investigation is a reduced form hybrid variant of a standard New Keynesian Phillips curve. Drawing on IMF (2018), we augment the baseline hybrid Phillips Curve (Gali and Gertler, 1999; Gali, Gertler, and Lopez-Salido, 2001, 2003) with open economy variables that proxy for macroeconomic developments in the rest of the world (Borio and Filardo, 2007; Ihrig et al. 2010; Auer, Borio, and Filardo 2017; Bems, Caselli, Grigoli, and Gruss 2020). Specifically, the chapter starts with an estimate of the following model:

$$\pi_{i,t} = \beta_1 \pi^e_{i,t} + \beta_2 \pi_{i,t-1} + \beta_3 y^{dom}_{i,t} + \beta_4 y^{for}_{i,t} + \beta_5 \Delta \mathrm{P}^*_{i,t} + FE + \varepsilon_{i,t} \qquad (2.2.1)$$

where *i* indexes the country, *t* the quarterly time period. Annualized quarter-over-quarter core CPI inflation $\pi_{i,t}$ is regressed on the following covariates. $\pi^e_{i,t}$ is the three-year ahead inflation expectation from Consensus Forecast, $\pi_{i,t-1}$ is lagged inflation, $y^{dom}_{i,t}$ is, depending on the specification, the domestic output or unemployment gap, $y^{for}_{i,t}$ is the foreign output gap, FE captures both country and time fixed effects, $\Delta \mathrm{P}^*_{i,t}$ captures external price pressures (Eq. 2.2.2). It is defined as the percent change in the import-weighted producer price index (PPI) of countries from which country *i* imports, converted to local currency using the nominal effective exchange rate, and relative to the percent change in the GDP deflator

$$\Delta \mathrm{P}^*_{i,t} = \Delta mPPI_{i,t} + \Delta \mathrm{neer}_{\mathrm{i,t}} - \Delta \mathrm{P}_{i,t} \qquad (2.2.2)$$

in which $\mathrm{P}_{i,t}$ is the natural logarithm of country i's GDP deflator. The change in the import-weighted foreign PPI is given by

$$\Delta mPPI_{i,t} = \sum_{j=1}^{J} \omega_{ij,t} \Delta PPI_{j,t}\ , \qquad i \neq j\ ,$$

in which $\mathrm{PPI}_{j,t}$ is the natural logarithm of country i's producer price index; and $\omega_{ij,t}$ is the share of exports from country j in country i's total annual imports.

The change in the nominal effective exchange rate is constructed as the change in the bilateral exchange rate of each trading partner vis-à-vis the US dollar, weighted by their import shares (Gopinath 2015; Carrier-Swallow and other 2016).

$$\Delta \mathrm{neer}_{\mathrm{i,t}} = \sum_{j=1}^{J} \omega_{ij,t} (\Delta \mathrm{e}_{i,t} - \Delta \mathrm{e}_{\mathrm{j,t}})\ , \qquad i \neq j\ ,$$

in which, $\mathrm{e}_{i,t}$ is the natural logarithm of country *i*'s bilateral exchange rate (expressed in local currency per US dollar, so that an increase denotes a depreciation of the domestic currency); and Δ is the first difference operator.

The foreign output gap is defined as:

$$Y_{i,t}^{*Gap} = \sum_{j=1}^{J} \omega_{ij,t} Y_{\mathrm{j,t}}^{\mathrm{Gap}} \ , \qquad i \neq j \ ,$$

in which $Y_{i,t}^{Gap}$ is the Hodrick-Prescott filtered series of real GDP of country *j*.

The domestic output gap is the difference between the actual and potential output in percent of potential output where potential is estimated as a HP-filtered underlying trend of output. Similarly, the unemployment gap is the percentage point difference between HP-filtered unemployment and actual unemployment.

Annex Table 2.2.1 presents the results for the output gap and the unemployment gap for all economies, advanced economies, and emerging economies. The coefficients on the output gap and unemployment gap are the ones visualized in the Figure 2.4 in the main text. The remaining coefficients are intuitive. Inflation expectations matter, but more so in Advanced Economies (AEs), which presumably had more success with inflation targeting, than in Emerging Economies (EMs). Conversely, the backward-looking component is more important, indicating inflation of a more adaptive nature, in EMs compared to AEs. The impact of external price pressures is also more pronounced for EMs that are likely to display more small open economy features in their business cycles dynamics.

Annex Table 2.2.1 Hybrid Phillips Curve: Baseline Estimation Results

VARIABLES	(1) Core Unemployment gap All 2000-19 (OLS) cluster	(2) Core Output gap All 2000-19 (OLS) cluster	(3) Core Unemployment gap AEs 2000-19 (OLS) cluster	(4) Core Output gap AEs 2000-19 (OLS) cluster	(5) Core Unemployment gap EMs 2000-19 (OLS) cluster	(6) Core Output gap EMs 2000-19 (OLS) cluster
Inflation expectations 3 years ahead	0.681*** (0.207)	0.688*** (0.195)	0.935*** (0.215)	0.913*** (0.207)	0.307*** (0.085)	0.353*** (0.109)
Lag of core price inflation	0.311** (0.124)	0.297** (0.118)	0.096 (0.073)	0.096 (0.074)	0.551*** (0.038)	0.511*** (0.061)
Unemployment gap	-0.304** (0.121)		-0.201* (0.099)		-0.483** (0.193)	
Lag of external price pressure	0.026*** (0.007)	0.026*** (0.007)	0.009** (0.004)	0.009** (0.004)	0.032*** (0.009)	0.032*** (0.010)
Foreign output gap	0.296* (0.148)	0.251 (0.151)	0.553*** (0.174)	0.537*** (0.187)	0.225 (0.231)	0.216 (0.235)
Output gap		0.154*** (0.042)		0.117*** (0.042)		0.215** (0.079)
Observations	2,054	2,061	1,279	1,285	775	776
R-squared	0.713	0.705	0.391	0.395	0.795	0.768
Adjusted R-squared	0.697	0.689	0.348	0.351	0.774	0.745
Within R-square	0.445	0.424	0.179	0.182	0.604	0.562

Sources: Consensus Economics; Haver Analytics; IMF, Direction of Trade Statistics; and IMF staff calculations.

Note: Robust standard erros are in parentheses. AEs = advanced economies; EMs = emerging market economies; OLS = Ordinary Least Squares.

* p<0.1; ** p<0.05; *** p<0.01

Annex Table 2.2.2 presents results for median inflation in columns (1) and (2) for a set of emerging economies (Brazil, Chile, India, Malaysia, Mexico, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey) where such data could be constructed. The estimated coefficients are broadly in line with the baseline results. Estimation results in columns (3) to (8) present results that add a squared term in the output and unemployment gap to check for nonlinear effects at high levels of slack (for a discussion see for instance Kumar and Orrenius 2016, among others). The results present mixed evidence of nonlinear effects in this sample.

Annex Table 2.2.2 Hybrid Phillips Curve: Median Inflation Measures and Nonlinearities

VARIABLES	(1) Median (NSA) Unemployment gap EM 2000Q1–19Q4 (OLS)	(2) Median (NSA) Output gap EM 2000Q1–19Q4 (OLS)	(3) Core Unemployment gap All 2000Q1–19Q4 (OLS)	(4) Core Output gap All 2000Q1–19Q4	(5) Core Unemployment gap AE 2000Q1–19Q4 (OLS)	(6) Core Output gap AE 2000Q1–19Q4	(7) Core Unemployment gap EM 2000Q1–19Q4 (OLS)	(8) Core Output gap EM 2000Q1–19Q4
Inflation expectations 3	1.173***	1.180***	0.681***	0.685***	0.914***	0.907***	0.311***	0.348***
	(0.071)	(0.084)	(0.207)	(0.192)	(0.223)	(0.213)	(0.086)	(0.097)
Lag of core price inflation	0.147	0.166	0.310**	0.296**	0.094	0.095	0.551***	0.504***
	(0.097)	(0.097)	(0.124)	(0.118)	(0.072)	(0.073)	(0.037)	(0.061)
Unemployment gap	-0.641***		-0.309**		-0.231**		-0.503***	
	(0.200)		(0.123)		(0.107)		(0.172)	
Lag of external price pressure	0.035**	0.034**	0.026***	0.026***	0.009**	0.009**	0.032***	0.031***
	(0.014)	(0.015)	(0.007)	(0.007)	(0.004)	(0.004)	(0.009)	(0.009)
Foreign output gap	-0.329	-0.176	0.297**	0.247	0.553***	0.535***	0.253	0.193
	(0.625)	(0.502)	(0.148)	(0.150)	(0.173)	(0.185)	(0.209)	(0.222)
Squared unemployment gap			0.009		0.030		-0.081	
			(0.023)		(0.022)		(0.055)	
Output gap		0.236***		0.151***		0.117***		0.199**
		(0.067)		(0.042)		(0.042)		(0.081)
Squared output gap				0.008		0.002		0.027***
				(0.006)		(0.005)		(0.006)
Observations	418	428	2,054	2,061	1,279	1,285	775	776
R-squared	0.670	0.666	0.713	0.705	0.393	0.395	0.796	0.770
Adjusted R-squared	0.607	0.604	0.697	0.690	0.349	0.351	0.774	0.746

Sources: Consensus Economics; Haver Analytics; IMF, Direction of Trade Statistics; and IMF staff calculations.

Note: Robust standard erros are in parentheses. AE = advanced economies; EM = emerging market economies; NSA = non-seasonally adjusted; OLS = Ordinary Least Squares

* p<0.1; ** p<0.05; *** p<0.01

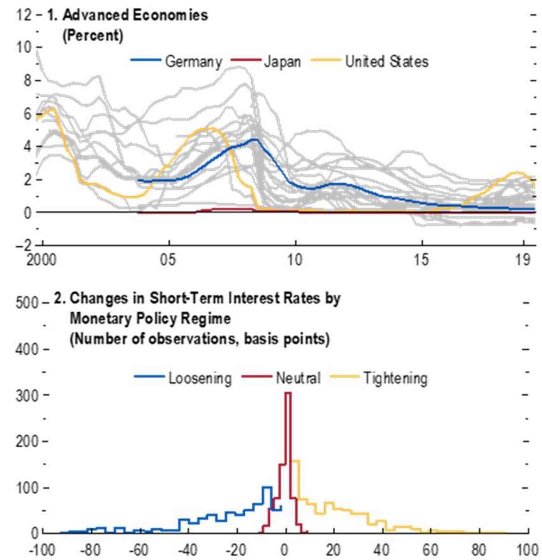
A causal Phillips curve estimation

To address endogeneity concerns due to omitted variables bias and simultaneity (see main text for a discussion), the chapter presents results where the unemployment rate is instrumented via monetary policy shocks. The results are presented for a sample of 31 advanced economies for the period from 2000 Q1 to 2019 Q4. The dependent variable is year-on-year changes in core inflation. The endogenous explanatory variable of interest is the unemployment rate. Regressions also include 3-year ahead inflation expectations from Consensus Forecasts, an index for imported foreign price pressures from Eq. (2.2.2), as well as changes in nominal short-term interest rates. All variables, including the dependent variable, enter the estimating equation with up to 3 quarterly lags.

To identify monetary policy shocks, the chapter relies on a treatment effects framework. This entails discretizing changes in nominal short-term interest rates and assigning them to one of three 'treatment' groups based on the direction and size of the change. Specifically, for every country we assign quarter-on-quarter changes in nominal short-term interest rates in equal proportion to either a Loosening, Neutral or Tightening stance based on the country's history. For example, the highest third of quarterly increases in short-term nominal interest rates based on the country's history will be assigned a Tightening stance. This approach reduces information on monetary policy changes that would be available in a standard linear model since monetary policy now only takes one of three distinct values based on the 'treatment' received, i.e. a Loosening, Neutral or Tightening stance. However, the advantage of the approach is that it allows for a more credible and transparent identification of monetary policy shocks. Annex Figure 2.2.1 presents the distribution of quarter-on-quarter short-term interest rate changes in the sample. Despite the zero-lower bound, short-term interest rates do vary in this sample of AEs providing variation for the instrumentation procedure.

Figure 2.2.1. Short-Term Interest Rates

Despite the zero-lower bound, changes in short-term interest rates are frequent in the sample considered for the structural Phillips curve estimation.



Sources: Haver Analytics; and IMF staff calculations.

To give some intuition for the approach, consider the case of a central bank that keeps its policy rate unchanged while inflation declines from weak demand. The treatment effects method used in the chapter would treat this as a 'surprise' outcome since it would diverge from an expected Taylor rule-type behavior. This observation in the sample would therefore be a good control that could be matched to similar periods of weak demand and inflation where the central bank did in fact lower its policy rate. The treatment effects approach provides a systematic and data-driven way of identifying these unexpected monetary policy actions. The chapter follows the semi-parametric identification approach outlined in Angrist, Jordà and Kuersteiner (2018) where the probability of a change in the monetary policy stance is modeled using an ordered logit with lags of the dependent and explanatory variables used as predictors $(z_{i,t})$. Inverse probability weighting (IPW) using the parametrically estimated propensity scores allows one to non-parametrically estimate counterfactual outcomes for inflation and unemployment had a monetary policy tightening *not* taken place in the quarter.

The impact of a surprise monetary policy tightening can be estimated by comparing the average outcomes across the group of observations depending on the monetary policy stance. Specifically, at horizon h, the causal impact can be estimated by taking the difference between the average predicted outcome $(\hat{\pi}_{i,t+h})$ for observation where the stance was unexpectedly tightened $(D_{i,t} = T)$ to the average of the reweighted observations (with inverse propensity weights $\frac{\hat{p}_T(z_t)}{\hat{p}_N(z_t)}$) where the stance was neutral $(D_{i,t} = N)$

$$\hat{\gamma}^h = \frac{1}{N}\sum_n \left[\hat{\pi}_{i,t+h}\left(1\{D_{i,t} = T\} - \frac{\hat{p}_T(z_t)}{\hat{p}_N(z_t)} 1\{D_{i,t} = N\}\right)\right]. \tag{2.2.3}$$

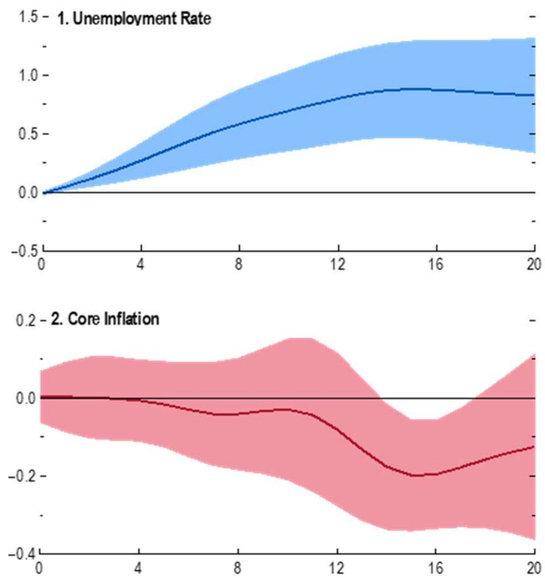
In addition to the IPW adjustment in Eq. (2.2.3), we rely on regression adjustment (RA), which entails replacing the outcome variable $\pi_{i,t+h}$ with its predicted value based on a group-specific linear model using the same instruments $z_{i,t}$ as for the ordered logit estimate

$$\hat{\pi}_{i,t+h} = \hat{\beta}^{RA} z_{i,t}.$$

Combining IPW and RA provides double-robustness to our identifying assumption (Imbens and Wooldridge 2009). Estimates of $\hat{\gamma}^h$ at various horizons show the impulse response functions of the unemployment rate and core inflation to an average cumulative tightening of monetary policy of 40 basis points.[1] Figure 2.2.2, panel 1 shows the unemployment rate increases by 1 percentage point on average in response to a cumulative 40 basis points surprise tightening, compared to a neutral stance, and the full impact takes about 12 quarters to materialize. Figure 2.2.2, panel 2 shows that core inflation significantly decreases by around 0.2 percentage point after 15 quarters to the same sequence of monetary policy tightening.[2]

Annex Figure 2.2.2. Response of Unemployment and Core Inflation to Monetary Policy Tightening
(Percentage points)

A monetary policy tightening gradually raises the unemployment rate and lowers inflation.



Source: IMF staff calculations.
Note: The solid lines represent the smooth local projection and shaded areas represent 90 percent confidence intervals. The x-axis indicates the number of quarters after the monetary tightening starts.

While the estimated impulse response function for the unemployment rate is on the higher end, it is consistent with the empirical literature that exploits narrative approaches to estimate the effects of monetary policy shocks on real activity (Ramey 2016, Table 2). Moreover, it is important to stress the differences in terms of sample period and composition and estimation approach compared with the bulk of the literature that focuses on linear models in the US. Notably, the sample used in the chapter includes several Euro area countries where, even through the lens of structural DSGE models with labor markets, monetary policy explains twice or thrice the variation in unemployment (Mihailov, Razzu, and Wang 2019, Table 5) compared to the standard US results (in Galì, Smets, Wouters 2012). In addition, the impulse responses of unemployment and inflation to a monetary loosening are smaller than those following a tightening, i.e. the "pushing on a string" metaphor (Angrist and others 2016). The treatment effects approach allows the estimation of these asymmetric effects, unlike standard linear VARs which implicitly assume the

[1] Impulse response functions are estimated using smooth local projections (Barnichon and Brownlees 2019). The average cumulative tightening of 40 basis points is the peak difference between nominal short-term interest rates in the Tightening and Neutral regimes following a surprise tightening. This peak is reached after 4 quarters.

[2] The timing of the effect of monetary policy contractions on unemployment and core inflation is consistent with Barnichon and Mesters (2020). Ramey (2016) reports the trough effects of 100 basis point funds peak as varying between 4 and 6 quarters.

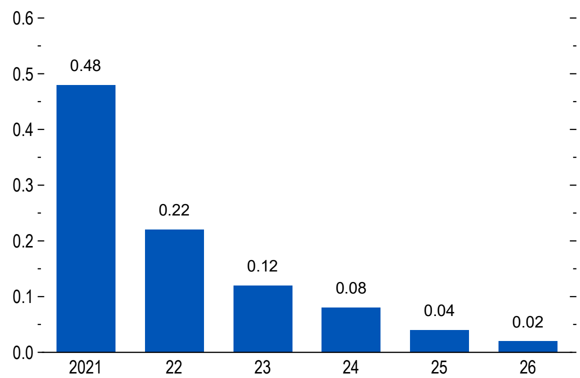
same marginal effects of loosening and tightening. This biases the VAR impulse responses of a tightening towards zero, a feature we also find when averaging the impulse responses of loosening and tightening using our approach.

As discussed in Barnichon and Mesters (2021), the ratio of the two impulse response functions yields an instrumental variable estimate of the Phillips curve coefficient. These estimates suggest a Phillips curve coefficient estimate of -0.22 (standard error of 0.09; p-value 0.02) which is derived by taking the ratio of the impulse response functions from lags 14 to 16 when the instrument has sufficient explanatory power (e.g. when the first stage passes standard significance tests).

For AEs, this estimate is combined with the forecasted changes in the unemployment gaps from the most recent vintage of the World Economic Outlook to summarize the expected contribution of slack to inflation in advanced economies (Figure 2.5 in the main text). Generating credible instruments for EMs is more challenging than for AEs and EMs also do not have available long-run unemployment gap projections.

Annex Figure 2.2.3. Slack-Induced Inflation Dynamics from Reduced Form Phillips Curve in Emerging Market Economies
(Percentage points)

Short-term inflation dynamics from slack as measured by the output gap are moderate for emerging market economies.



Sources: Haver Analytics; and IMF staff calculations.
Note: The bars represent the inflationary impulse from changes in the output gap based on the October 2021 *World Economic Outlook* vintage and the structural Phillips curve estimation described in the chapter.

Annex Figure 2.2.3 uses the reduced form coefficient on the output gap version of the Phillips Curve from Annex Table 2.2.1 (column 6) to determine the projected contribution of recovering demand to inflation. The slack-induced inflation dynamics in EMs are somewhat more pronounced than in the AEs adding about one half-percentage point in the year 2021.

Annex 2.3. Inflation Expectations Anchoring

Inflation acceleration episodes

To focus on how inflation expectations and policy responses evolve around turning points in inflation, the analysis identifies inflation accelerations using an approach similar to that of Hausmann, Pritchett, and Rodrik (2005) for growth performance. The sample consists of 43 countries on which both quarterly inflation data and professional forecasters' (consensus forecasts) data is available, from 1998Q1 onwards. AEs comprise 60 percent of the sample, and EMs the other 40 percent. The inflation rate is measured as the year-on-year change in the quarterly CPI.

Instances of rapid acceleration in inflation that are sustained for at least 2 quarters are identified as follows (and episodes that last at least 3, 4, 5, and 6 quarters are classified similarly):

(1) The episode starts with an acceleration: the *change in* the inflation rate is at least 0.75.

(2) The inflation rate is at least 3.5 percent in each period in AEs, and at least 10 percent in each period in EMs.[3]

(3) The episodes are at least 3 years apart. (Any episode that had one within three years before it is dropped.)

The procedure yields 55 episodes that last at least 2 quarters. Annex Table 2.3.1 shows the distribution of episodes across country group and length.

Annex Table 2.3.1 Inflation Episodes

Episode length:	At least 2 quarters	At least 3 quarters	At least 4 quarters	At least 5 quarters	At least 6 quarters
Panel A. Number of Episodes					
Advanced economies	28	20	18	9	7
Emerging markets	27	23	21	16	10
Total	55	43	39	25	17
Panel B. Frequency of Episodes *(Percent)*					
Advanced economies	1.3	0.9	0.8	0.4	0.3
Emerging markets	2.3	1.9	1.7	1.2	0.7
Total	1.6	1.2	1.1	0.7	0.4

Source: IMF staff calculations.
Note: Table shows the number and frequency of inflation acceleration episodes in the 43 country sample since 1995. Frequency is the number of inflation episodes divided by number of data points in that region.

As discussed in the main chapter, inflation acceleration episodes coincide with large currency deprecations in EMs. Before the start of an episode, the main noticeable difference is that larger exchange rate depreciations occur in the episodes that end up being longer.

Annex Table 2.3.2 Inflation Episodes Summary Statistics

Panel A. Before Episodes

	Previous Mean	Just Prior Mean	Difference Mean	Difference *p-values*
NEER (% change qoq)	-1.1	-2.4	-1.3	0.05
Current account (percent GDP)	-0.3	-0.7	-0.4	0.61
Fiscal balance	-1.1	-1.2	-0.2	0.78
Expectations 3-years ahead	5.1	5.3	0.1	0.79

Note: Table reports difference in average value of variable just prior to the start of an acceleration (from t-3 to t-1) compared to the previous 6 quarters (t-9 to t-4).

Analysis of market-based inflation expectations

This section analyses the drivers of market-based measures of inflation expectations. Central banks follow these measures closely as they (i) incorporate new information rapidly and (ii) reflect the views of investors with money at stake. The main measure analyzed is the 5-year-5-year forward breakeven inflation rate. For a given maturity bond, the breakeven inflation rate is calculated as the difference between the yield on conventional bonds and comparable inflation-indexed bonds. This is the level of expected inflation at which an investor would be indifferent between holding either bond. The 5-year (spot) breakeven rate, for example, is a measure of the

[3] In the country sample after 2004: the 90th percentile of changes in the inflation rate is 0.75 for AEs, and 1.5 for EMs; the 90th percentile of inflation rate is 3.35 percent in AEs and 10 percent in EMs.

average expected inflation rate over the next 5 years. The five-year-five-year forward breakeven rate is calculated as follows (using spot-forward parity condition to calculate the 5 and 10-year forward rates):

$$\pi_{i,t}^{e,LT} = BE5Y5Yforward_{it} = \left(\frac{(1+BE1\ \ _{it})^{10}}{(1+BE5_{it})^{5}}\right)^{1/(10-5)} - 1 \qquad (2.3.1)$$

The data on bond yields is daily, from Bloomberg, and the sample consists of 14 countries (11 AEs and 3 EMs) that issue inflation-indexed bonds at both 5- and 10-year maturities.

Building on the literature (Gürkaynak, Sack, and Wright 2010; Beechey, Johannsen, and Levin 2011, Celasun, Mihet, and Ratnovski 2012) the analysis uses local projections (Jordà 2005) to trace the response of the 5-year-5-year forward breakeven rate to oil price shocks. The analysis employs oil price surprises as a proxy for inflation surprises as in IMF (2016). Oil price surprises are measured as the daily percentage change in prices on one-year ahead futures contracts. The controls are: ten lags of the dependent variable $\Delta\pi_{i,t-p}^{e,LT}$, the daily percentage change in the nominal effective exchange rate $NEER_{i,t}$ and its ten lags, the daily change in the VIX $VIX_{i,t}$ and its ten lags, and month and country fixed effects, τ_{month}^{h} and α_i^h respectively.

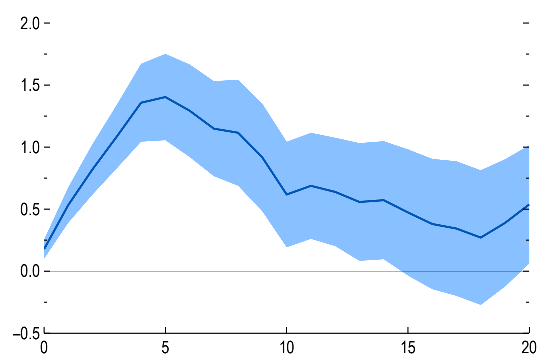
$$\Delta\pi_{i,t+h}^{e,LT} = \alpha_i^h + \tau_{month}^h + \sum_{p=0}^{P} \Delta\pi_{i,t-p}^{e,LT} + \sum_{p=0}^{P} \beta_p^h Oil_{t-p} + \sum_{p=0}^{P} \delta_p^h NEER_{i,t-p} + \sum_{p=1}^{P} \rho_p^h VIX_{i,t-p} + \varepsilon_{i,t+h} \qquad (2.3.2)$$

The baseline result (Figure 2.8 in main text) is that a one percentage point increase in the oil future price is associated with a one basis point change in the expectations measure five days after the shock, with the effect lasting about two weeks. The analysis also explores whether there are non-linearities in the relationship between oil price shocks and inflation expectations. No evidence of non-linearities is found, as the response to large oil price shocks is not statistically significantly different from the average response.

A robustness exercise is conducted, where the breakeven rate is cleaned of liquidity risk premia following Gürkaynak et al. (2010). In addition to reflecting inflation compensation, breakeven rates include liquidity risk and inflation risk premia. The inflation-risk premia, which reflects investors' uncertainty about future inflation and increases breakeven rates, is not extracted. This is similar to Beechey et al (2011) and Strohsal and Winkelmann (2015), since this uncertainty is a relevant component of anchoring that central banks seek to minimize.[4] The five-year-five-year forward breakeven rate is adjusted for the relative liquidity premia of the nominal and

Annex Figure 2.3.1. Response of Liquidity Adjusted Five-Year, Five-Year Forward Breakeven Inflation to Oil Price Shocks
(Basis points)

The response of the market-based inflation expectations measure cleaned of liquidity premia is similar to that of the simple (unadjusted) five-year, five-year forward breakeven rate.



Sources: Bloomberg Finance L.P.; and IMF staff calculations.
Note: The solid lines represent the estimated response and shaded areas represent 95 percent confidence intervals. The *x*-axis indicates the number of days after the shock starts.

[4] For the US, Goel and Malik (2021) find that recent increase in the five-year five-year forward breakeven is due mostly to an increase in the inflation risk premium, whereas for the shorter horizon 5 year breakeven the increase is about half from an increase in expected inflation and half from an increase in inflation risk premia.

inflation-indexed bond markets as follows: (1) For each country, the time-varying effect of liquidity on inflation compensation is measured as the (negative of) the fitted values from a regression of the 5-year-5-year forward breakeven rate on liquidity proxies for both the nominal and inflation-indexed bonds. The liquidity proxies used are the daily bid-ask spreads, which are available for a subset of 10 countries in the sample. Trading volumes, which are another indicator of liquidity and used in the literature on the US, are not available for a sufficiently long time period for other countries to employ in the estimation. This method captures the time variation but not the level of the liquidity premium. Thus, the level of the liquidity premium is normalized to have a minimum of zero, by country. (2) The normalized liquidity premium is then added to the 5-year-5-year forward breakeven rate, to obtain the rate cleaned of liquidity risk premia.

$$BE5Y5Yfoward_{it} = \pi_{it}^{adjusted} - LiquidityRisk_{it} \quad (2.3.3)$$

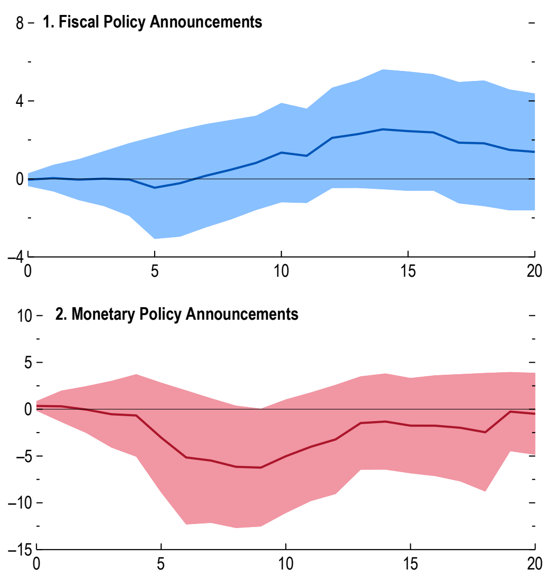
The response of the adjusted market-expectations measure to oil price shocks is very similar to that of the measure that is not cleaned of liquidity premia (Annex Figure 2.3.1).

Effects of policy announcements

Finally, this section analyzes the announcement effects on market-based inflation expectations of the expansionary fiscal and monetary policy measures taken in response to the pandemic. The data on announcements of COVID-19 response policies is from the Yale Program on Financial Stability (YPFS) COVID-19 Financial Response Tracker and covers the period from February 2020 to June 2021. The empirical specification is the same as in equation (2.3.1) except for the inclusion of dummy variables for each of the fiscal and monetary policy announcements, that are equal to 1 on the day of an expansionary announcement and 0 otherwise. In the sample, there are 79 days with announcements of fiscal measures, and 69 days where monetary policy actions. Market-based long-term expectations have not responded, on average, to the policy announcements (Annex Figure 2.3.2). Since the 14 countries in the sample have high central bank credibility and well-anchored inflation expectations, the effects of policy announcements in countries with less well-anchored expectations could

Annex Figure 2.3.2. Response of Five-Year, Five-Year Forward Breakeven Inflation to Policy Announcements
(Basis points)

Fiscal and monetary policy announcements during the pandemic have not caused market-based expectations to increase, on average.



Sources: Bloomberg Finance L.P.; IMF, COVID-19 Policy Tracker; and IMF staff calculations.
Note: The solid lines represent the estimated response and shaded areas represent 95 percent confidence intervals. The *x*-axis indicates the number of days after the policy announcement.

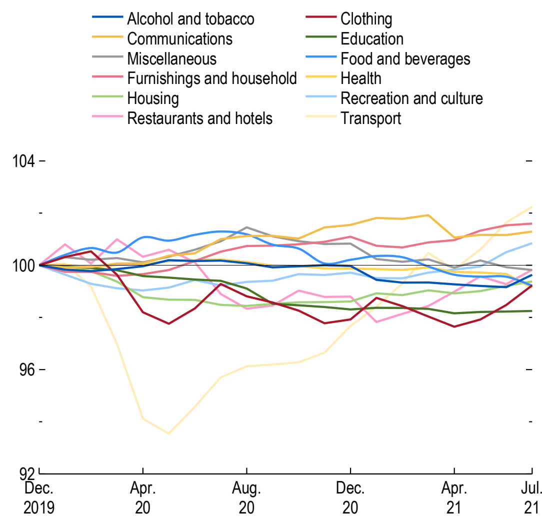
be larger. Moreover, the fiscal policymaking process can be lengthy with information about expected measures possibly being priced-in before the actual announcement.

Annex 2.4. Sectoral Price Dispersion and Inflation

The chapter uses data from the IMF's CPI database, which includes consumer price data for around 150 countries representing 85 percent of global GDP in 2019 in PPP terms. The database includes the headline CPI index as well as 12 harmonized consumption categories (an example of the disaggregation is displayed in Annex Figure 2.4.1). The chapter's measure of sectoral inflation dispersion is the weighted standard deviation of the year-on-year inflation for the 12 consumption components in a given country and month, where the weights are the share of total consumption, also reported in the CPI database.[5] In addition to sectoral inflation dispersion, the chapter uses headline year-on-year monthly inflation from the CPI database. The sample extends from January 2000 to June 2021.

Annex Figure 2.4.1. Sectoral Consumer Price Levels
(Index, December 2019 = 100)

The COVID-19 crisis led to large price movements in some sectors, notably transportation, food, clothing, and communications



Sources: IMF, CPI database; and IMF staff calculations.
Note: The lines are averages weighted by country's purchasing-power-parity GDP.

Supply disruptions: the case of semiconductors

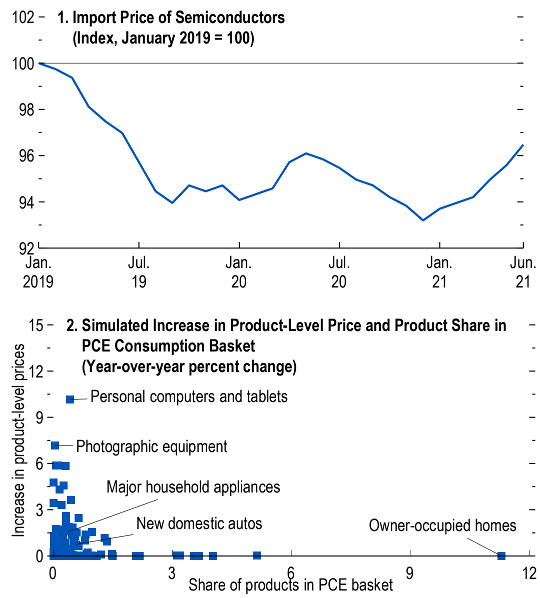
A combination of increased demand for certain products, such as electronics, and stringent lockdown measures to contain the spread of the virus prompted supply chain disruptions and supply shortages in several sectors during the pandemic crisis. One area which has received considerable attention is the semiconductor sector, which has experienced severe shortages since the beginning of the pandemic. What could be the impact of a sharp increase in semiconductors' prices going forward? The first piece of evidence is that the import price of semiconductors did not increase substantially in recent months in the United States, hence indicating moderate risks coming from higher prices of chips produced abroad and imported domestically (Annex Figure 2.4.2, panel 1). Since semiconductors do not enter the consumption basket directly, but are rather used as inputs to produce final goods, a back of the envelope calculation exploiting input-output tables is performed to assess the effects of a potential doubling of semiconductors input prices on goods and services consumed in the United States. Annex Figure 2.4.2, panel 2, shows that categories with the highest increase in inflation as a result of the doubling input price of semiconductors have a very small weight in the personal consumption expenditure (PCE) basket (i.e. personal computers and photographic equipment). On the contrary, consumptions items

[5] China's National Bureau of Statistics does not report consumption shares for inflation component series. We estimate constant shares using a constrained regression of headline inflation on component inflation, where estimated weights are between zero and one and sum to one. Component price data for the US are taken from the Bureau of Labor Statistics and from Statistics Canada for Canada. For Japan and Eurostat-reporting countries, we use the indirect tax-adjusted headline inflation series. Headline inflation rates in 2021 for euro area countries are also adjusted for changes in the consumption baskets.

that exhibit a negligible increase in prices due to the increased semiconductors prices (e.g. housing) have the highest weights in the consumption basket. On average, the overall impact on PCE inflation would be a 0.3 percent increase suggesting that even an extreme scenario in semiconductors input price increase would have a moderate effect on US consumer price inflation.[6]

Annex Figure 2.4.2. Semiconductor Price Effect on Inflation in the United States

The price of semiconductor imports in the United States did not increase substantially since the beginning of the pandemic. Even a potential doubling of the price of semiconductors input will only have minor effect on overall inflation.



Sources: US Bureau of Economic Analysis; US Bureau of Labor Statistics; and IMF staff calculations.
Note: In panel 1, series corresponds to semiconductors and other electronic component manufacturing. In panel 2, products are classified according to the NIPA classification. NIPA = national income and product accounts. PCE = personal consumption expenditures.

VAR based forecasts of inflation risks

To construct dynamic forecasts for inflation, the chapter estimates the following structural VAR for each advanced economy in the sample.[7]

$$\mathbb{Q}^{\tau}(Y_{t+1}|Y_t) = \mu^{\tau} + \delta_1^{\tau} Y_{t+1} + \sum_{s=0}^{S} \delta_{-s}^{\tau} Y_{t-s}, \quad (2.4.1)$$

where Y_t is a vector consisting of 7 endogenous variables including (in order): global commodity prices for energy and food, an external price pressure index that calculates the difference between domestic and import-weighted inflation of trading partners minus changes in the nominal exchange rate (Gopinath 2015; Carrière-Swallow and others 2016), the unemployment rate for advanced economies and year-on-year changes in industrial production for emerging market and developing economies, sectoral inflation dispersion, 3-year ahead inflation expectations from Consensus Forecasts, and finally headline inflation. The above Cholesky ordering means that global energy prices are not allowed to respond to contemporaneous shocks to other variables in the system, food prices only respond to contemporaneous shocks in energy prices, and so on. Headline inflation, on the other hand is allowed to respond to contemporaneous shocks to all other variables.[8] These identifying assumptions are implicit in the strictly lower triangular matrix δ_1^{τ}. Finally, Eq. (2.4.1) extends the traditional linear VAR by estimating a system of quantile regressions instead (Koenker and Xiao 2006; Montes-Rojas 2019; Ghysels, Iania and Striaukas 2018; Boire, Duprey and Ueberfeldt 2021; Chavleishvili and Manganelli 2020).[9]

[6] Krolikowski and Naggert (2021) reach similar conclusions. Namely that semiconductors shortages and their effects on new car prices will subside within the next six to nine months.

[7] Advanced economies include Austria, Belgium, Canada, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hong Kong SAR, Ireland, Israel, Italy, Japan, Korea, Lithuania, Latvia, Netherlands, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Sweden and the United States.

[8] Ramey (2016) contains a helpful discussion on the relation between reduced form VAR and structural interpretations of coefficients implicit in the above Cholesky ordering.

[9] Lopez-Salido and Loria (2020) estimate quantile local projections instead of quantile VAR.

For emerging markets and developing economies, we rely on a dynamic panel version of Eq. (2.4.1):[10]

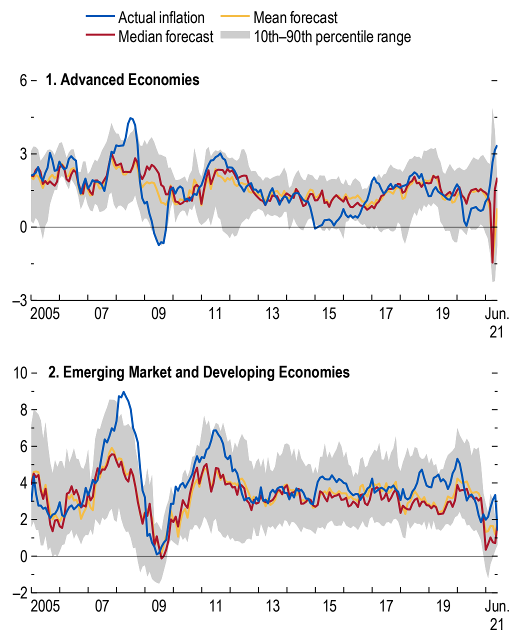
$$\mathbb{Q}^{\tau}\left(Y_{i,t+1}|Y_{i,t}\right) = \mu_i^{\tau} + \delta_1^{\tau}Y_{i,t+1} + \sum_{s=0}^{S} \delta_{-s}^{\tau}Y_{i,t-s},$$

where μ_i^{τ} denotes the country fixed effect for country i in the estimation of conditional quantile τ. This allows us to expand the estimation to many more countries with shorter time series and where single-country VAR estimation is not possible.[11] While we estimate common coefficients across countries (except for the quantile-specific country fixed effects), we proceed with country-specific recursive simulations where initial conditions differ across countries. In all equations, we allow up to 3-month lags.

To assess the fit of the model, we report below the in-sample 12-month ahead headline inflation forecast for AEs and EMDEs separately (Annex Figure 2.4.3). The correlation between actual and mean (median) forecast inflation is 0.53 (0.51) for AEs. Actual inflation exceeds the 10-90 interquantile range in 7 percent of monthly observations in the average sample in AEs, which is lower than the population coverage range of 20 percent.[12] The correlation between actual and mean (median) forecast inflation is 0.73 (0.73) for EMDEs, with 7 percent of monthly observations falling outside the 10-90 predictive interquantile range. While the central tendency forecasts usually fail to predict extreme realizations of inflation—which is to be expected in any linear model—it is reassuring to find that the 10-90[th] percentile range in Annex Figure 2.4.3 typically increases in periods of high headline inflation volatility. This indicates that the quantile regression approach is useful in predicting the balance of risks to the inflation outlook.

Annex Figure 2.4.3. Headline Inflation In-Sample Fit
(Percent)

The VAR model exhibits a good prediction fit for headline inflation for both advanced economies and emerging market and developing economies.



Source: IMF staff estimates.
Note: Figure shows actual and 12-month ahead predicted inflation for advanced economies. Lines are averages weighted by countries' purchasing power parity GDP. See Online Annex 2.1 for further details about the list of countries used in the sample.

For each of the 7 endogenous variables, we estimate individual conditional quantiles from 1 to 99. Because there is no analytical solution for the predictive distribution beyond the next period, we rely on the following algorithm to build recursive medium-term inflation forecasts:

For each simulation $n = 1, \ldots, 1000$:

[10] Emerging markets and developing economies include Bulgaria, Chile, China, Colombia, Ecuador, Egypt, Hungary, Mexico, Malaysia, Pakistan, Philippines, Poland, Russia, Thailand, Turkey, Ukraine, Uruguay, Vietnam and South Africa. We replace the unemployment rate with the year-on-year change in industrial production, which tracks business cycles better in this group of countries.

[11] We also include Estonia, Israel and Singapore in the dynamic panel estimation. However, these three countries are included in Advanced Economies aggregates when building forecast scenarios. In the case of Mexico, we rely on a single-country VAR but include the forecasting results in the EMDE group.

[12] Comparison of these goodness-of-fit measures with the literature is difficult as most studies do not report such summary statistics.

For each variable (in order) $i \in \{\text{nrg}, \text{food}, \text{extern}, \text{unemp}, \text{disper}, \text{expect}, \text{infl}\}$ in every forecast period $h = 1, \dots, H$:

1. Predict next period quantiles of variable i based on the last observation or forecast available and coefficient estimates from Eq. (2.4.1). Rearrange to produce monotone quantile curves (Chernozhukov, Fernández-Val and Galichon 2010).
2. Drawing from a uniform distribution, randomly select a quantile from 1 to 99.
3. Assign the selected conditional quantile as the realization of variable i in the next period.

End.

End.

Country-specific forecasts are summarized by taking the mean, median and interquantile ranges over the 1000 simulations for the H forecast months.

Country groups require one more level of simulation.

For each simulation $n = 1, \dots, 1000$:

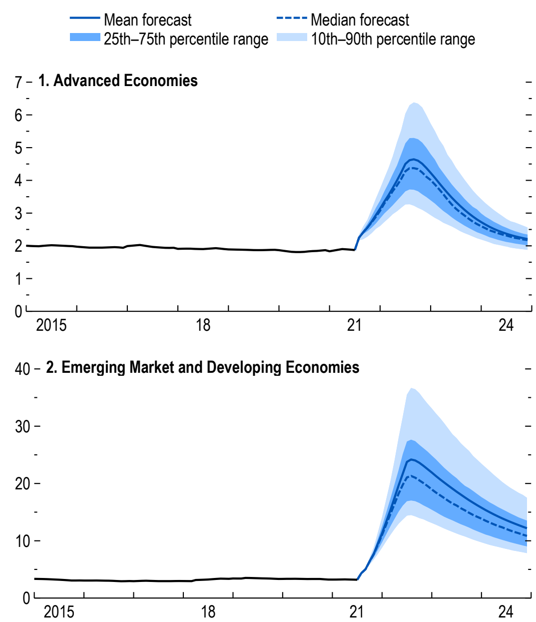
1. For each country in the group, randomly select one simulation forecast path.
2. Calculate the weighted average across all countries using global GDP shares in PPP terms.

End.

Country-group forecasts are summarized by taking the mean, median and interquantile ranges over the 1000 simulations for the H forecast months.

Annex Figure 2.4.4. Inflation Expectations With Adverse Sectoral and Commodity Price Shocks

(Percent)



Sources: Consensus Economics; Haver Analytics; IMF, CPI database; and IMF staff calculations.
Note: Lines are averages weighted by countries' purchasing power parity GDP. Adaptive expectations assume that inflation is driven by the one-year ahead inflation expectations instead of the conventional three-year ahead horizon for 12 consecutive months from July 2021 to June 2022. See Online Annex 2.1 for further details about the list of countries included in the samples.

The chapter presents inflation forecasts for a scenario where the extreme sectoral price shock is combined with a scenario in which expectations become adaptive for 12 consecutive months between July 2021 and June 2022.[13] Figure 2.4.4 reports the forecasts for inflation expectations in such a scenario. Expectations increase on average compared to the baseline forecast, with the peak reaching 4 percent in AEs compared to 2 percent in the baseline and 20 percent in EMDEs compared to a peak of 4 percent in the baseline.

[13] This is modeled by replacing the 3-year ahead inflation forecast in the VAR with the 1-year ahead inflation forecast from Consensus Forecasts for 12 consecutive months in AEs. For EMDES, we replace inflation expectations with last month's inflation.