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Understanding the International Rise and Fall of Inflation Since 2020[1]

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This paper analyzes inflation dynamics in 21 advanced and emerging market economies since 2020. We decompose inflation into core inflation as measured by the weighted median inflation rate, and headline shocks—deviations of headline inflation from core. Headline shocks occurred largely on account of energy price changes, although food price changes and indicators of supply chain problems also played a role. We explain the evolution of core inflation with two factors: the strength of macroeconomic conditions—measured by the unemployment gap, the output gap, and the ratio of job vacancies to unemployment—and the pass-through into core inflation from past headline shocks. We conclude that the international rise and fall of inflation since 2020 largely reflected the direct and pass-through effects of headline shocks. Macroeconomic conditions generally played a secondary role. In the United States, estimated price pressures from strong macroeconomic conditions had been greater than in other economies but have eased.

Keywords: inflation, inflation shocks, core inflation, median inflation, labor market tightness, Phillips Curve.

JEL classification: E31, E32, E24.

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Understanding the International Rise and Fall of Inflation Since 2020

1. Introduction

After three decades of price stability, world inflation surged to unexpectedly high levels in 2021 and 2022, reaching 9.5 percent year-on-year in the third quarter of 2022, up from 4.2 percent a year earlier. The phenomenon was global: inflation in advanced economies rose from 3.5 percent to 7.9 percent over the same period, while in emerging market and developing economies, it rose from 4.9 percent to 10.8 percent.[2] Even Japan, previously unable to raise inflation, experienced an inflation rate close to 4 percent in the fourth quarter of 2022, up from 0.5 percent a year earlier.

Most policymakers and economists failed to predict the intensity and persistence of this inflation surge and were slow to react. By 2022, inflation had become an acute problem for central bankers. What followed was one of the most synchronized tightening of monetary policy on record. Advanced economies and emerging markets alike raised policy rates. Then, almost as suddenly as it rose, world inflation started to ebb, decreasing to 5.8 percent by the fourth quarter of 2023 on a year-on-year basis. In advanced economies, inflation decreased to 3.1 percent, while in emerging markets and developing economies, the decrease was more modest, to 8.0 percent.

This rise—and subsequent fall—of global inflation has triggered numerous studies on the drivers of inflation, most of which focus on specific countries.[3] But the rise and fall of inflation was global and this suggests that a global analysis is needed. In this paper, we examine the behavior of inflation for 21 advanced and emerging market economies.

Two broad explanations are competing. The first one is that inflation rose at the same time in most countries because they were subjected—to varying degrees—to a similar sequence of shocks: the COVID-19 pandemic, mobility restrictions, and the associated set of economic policy measures—especially the extent of fiscal and monetary support. This explanation emphasizes domestic drivers. More generous fiscal and monetary support, tighter labor markets or less-well anchored inflation expectations would translate into higher inflation.

The second explanation is that inflation rose everywhere at the same time because global causes were at play, not because local shocks were identical across countries. The surge in energy and food prices, rendered especially acute following Russia's invasion of Ukraine, triggered an energy crisis with features similar to that of the oil price shocks of the 1970s, a series of events that were also caused by geopolitical events. The 1970s crises too sparked a sharp increase in global inflation, which lasted well into the following decade. Higher exposure to the surge in oil, gas or food prices would then account for the stronger surge in domestic inflation.

The two explanations are not neatly orthogonal. For instance, global energy prices—which declined precipitously in early 2020 had rebounded to their 2018 peak by August 2021, when worries about a possible invasion of Ukraine by Russia started to surface. They then approximately doubled by August 2022. The initial rebound may have reflected strong global demand fueled by pandemic-related support programs. Nevertheless, most countries, in isolation, are unable to impact global commodity prices, and hence the question of whether domestic factors or global ones are the main drivers of their inflation trajectories remains valid. That said, the effect of global factors, such as international energy prices, on domestic inflation would also depend on local policies such as administrative price measures and subsidies.

We start with a cross-sectional examination, which we then complement with country-level analysis. In the cross-sectional analysis, we examine the relation between headline and core inflation, and inflation expectations with two variables that feature prominently in discussions of inflation during the pandemic: country-specific energy price inflation and labor market tightness. For each country, we measure the change in a twelve-month specific measure of inflation (headline, core, expectations) between December 2020 and the country-specific peak of headline inflation ("the rise"), and then the change in that measure of inflation from the aforementioned peak to March 2024 ("the fall"). We correlate these changes with measures of the change in energy price inflation and labor market tightness over the same two sub-periods. This lets us explore the correlation between country-specific drivers of inflation within each episode, and also across the two episodes.

For the country-level analysis, a central feature of our approach is to decompose headline inflation into core (underlying) inflation, and deviations of headline from core. Building on work by Ball, Leigh, and Mishra (2022) and Dao and others (2023) for the United States and the euro area, respectively, we seek to explain core inflation by long-term inflation expectations and the level of tightness in the labor market, and to explain the non-core component of headline inflation by relative price changes in energy and other industry-specific changes. We also study the pass-through over time from these relative price shocks to core inflation, which can occur through the effects of headline inflation on wages, near-term inflation expectations, and costs of

[2] These rates are PPP-weighted averages based on headline inflation data in the April 2024 IMF *World Economic Outlook* database.

[3] A notable exception is the study by Bernanke and Blanchard (2024a) who focus on eleven advanced economies.

production.

Our measure of core inflation is the weighted median inflation, which systematically strips out the effects of unusually large price changes in certain—possibly time-varying—industries. This variable isolates the core component of inflation more effectively than a more traditional core measure that excludes food and energy prices when, as during the COVID-19 era, volatile shocks also emanated from sectors other than food and energy (see Ball and others 2021).

We begin with a country-level exploration of the empirical drivers of headline inflation shocks, the deviation of headline inflation from core inflation. We find that three factors played a dominant role across the 21 countries we study: energy price inflation, food price inflation, and shipping cost inflation, as measured by the Harper charter rate. Taken together, these three variables account for between 21 percent and 94 percent of the variation in headline inflation shocks, depending on the country, with energy price inflation by far the dominant factor.

Next, we study the behavior of core inflation. We estimate the relationship between the inflation gap, defined as the difference between core inflation and longer-term expected inflation, as a function of macroeconomic slack (measured by the unemployment gap, the output gap, and the ratio of job vacancies to unemployment) and the passthrough of headline inflation shocks into core inflation. Importantly, we allow for nonlinearities, both for the relation with macroeconomic slack and for the relation between headline inflation shocks and core inflation. Recent theoretical work has emphasized the importance of such nonlinearities (for example, Benigno and Eggertsson, 2023).

Putting together our estimated results for headline inflation shocks and core inflation, we assess how much of the rise—and subsequent fall—in headline inflation can be attributed to inflation expectations, macroeconomic slack, headline inflation shocks (including those due to energy prices), and the passthrough of headline inflation shocks to core inflation.

We conclude that relative price shocks (notably to the price of energy) and their pass-through into core played the dominant role in driving the inflation movements. Macroeconomic strength and changes in longer-term inflation expectations contributed modestly on average. We also find significant country-specific variation around these results. For the United States, estimated price pressures from strong macroeconomic conditions have eased over the past two years but had been greater than for other economies.

2. The Rise and Fall of Inflation

To set the stage for our empirical analysis, we first document the rise and fall in headline inflation, core inflation, and inflation expectations since 2020.

Figure 1 summarizes the evolution of inflation and inflation expectations, as well as their distribution for 21 countries for which we have both headline and core (weighted median) inflation.[4] The figure reports the sample median as well as the interquartile range.

For the median economy in the sample, headline inflation rose from 0.7 percent (at a twelve-month rate) in December 2020 to a peak of 8.6 percent in August 2022, before falling to 3.1 percent in March 2024—a sizeable reversion toward the pre-pandemic (2017-2019) median of 2.0 percent. The dispersion of headline inflation across economies, measured by the interquartile range (shaded area) widened as the median level of inflation rose and then narrowed as it receded.

Core inflation moved more moderately than headline inflation for the median economy. It rose from 1.2 percent in December 2020 to a peak of 6.2 percent in February 2023, before falling to 2.8 percent in March 2024.

Short-term (twelve-month-ahead) inflation expectations—which we measure based on forecasts of professional forecasters surveyed by Consensus Economics—moved by even less than headline inflation. They rose from a median of 1.6 percent in December 2020 to a peak of 5.6 percent in August 2022, then declined to 2.9 percent in March 2024.[5]

[4] Headline inflation refers to CPI inflation except for the euro area, where it refers to HICP inflation. Weighted median inflation data come from the Federal Reserve Bank of Cleveland for the United States; Statistics Canada for Canada; and are computed by IMF staff for the remaining cases.

[5] Monthly Consensus Economics surveys contain information on current- and next-calendar-year expected inflation. We construct twelve-month-ahead or near-term expected inflation series as the weighted sum of monthly vintages following Buono and Formai (2018).

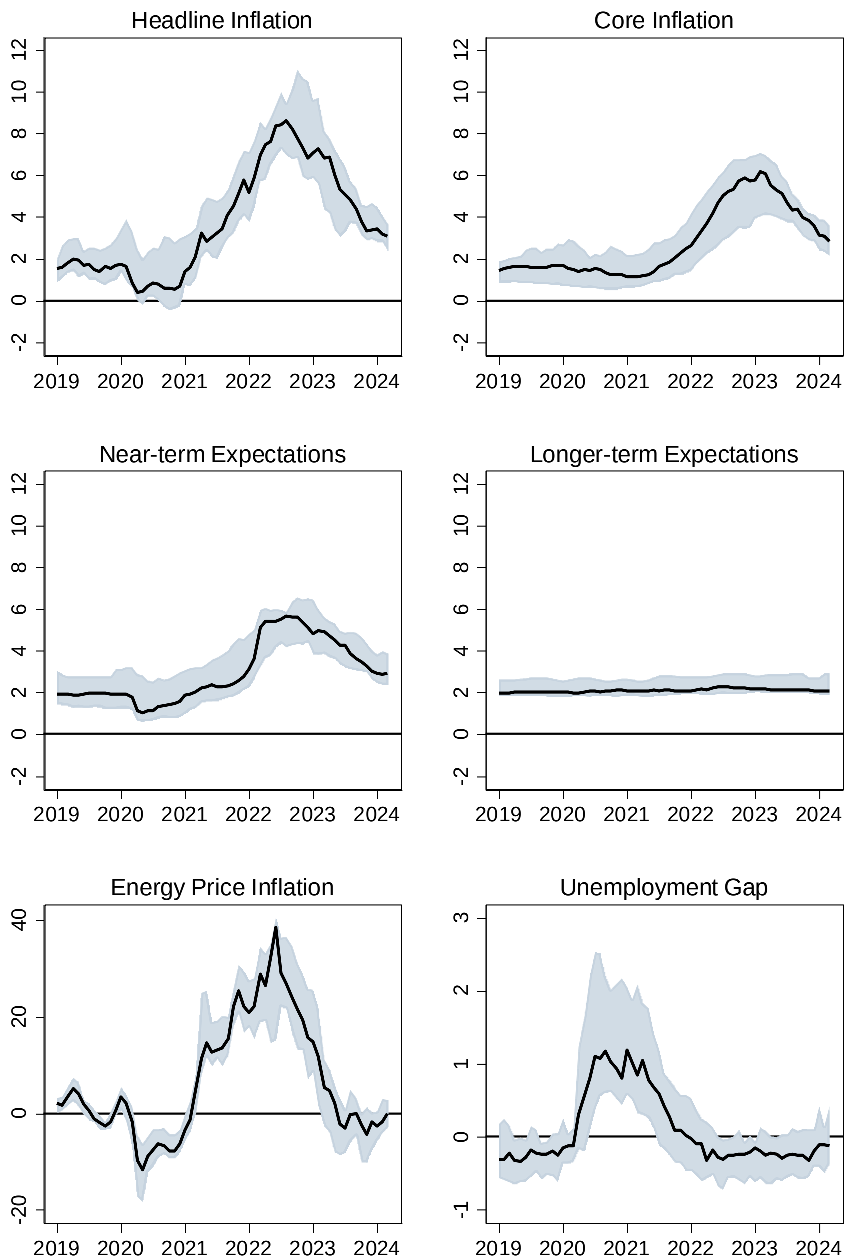

Fig. 1. Rise and Fall of Headline and Core Inflation, and of Inflation Expectations, 2020–2024 (Twelve-month rate; percent; and percent of labor force)
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: Chart reports median and interquartile range (shading) for 21 economies. "Core inflation" is the weighted median inflation rate. "Near-term expectations" based on twelve-month ahead forecast derived from Consensus Economics forecasts. "Longer-term expectations" denotes ten-year forecast from Consensus Economics except for United States, where it denotes ten-year forecast from Federal Reserve Bank of Philadelphia Survey of Professional Forecasters, and euro area, where it denotes five-year forecast from ECB Survey of Professional Forecasters. "Energy price inflation" denotes twelve-month energy consumer price inflation. Unemployment gap denotes difference between monthly unemployment rate and natural unemployment rate, available for 20 countries (except India).

Longer-term inflation expectations have been broadly stable, with the cross-country median stable at 2.1 percent between December 2020 and March 2024.[6] This anchoring of longer-term expectations is consistent with the notion that inflation targets have been credible as a result of clear monetary policy communication and restrictive policies, which other studies have analyzed (for example, Gáti, 2022).

[6] Longer-term expectations are measured using ten-year forecasts from Consensus Economics except for the United States, for which they are measured using ten-year forecasts from the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters, and for the euro area, where they are measured based on five-year forecasts from the ECB Survey of Professional Forecasters.

Figure 1 also reports the international evolution of two factors that have featured prominently in discussions of pandemic-era inflation: energy price inflation and labor market tightness, measured here by the deviation of unemployment from its natural rate—the unemployment gap.[7]

We see that energy consumer price inflation moved closely with the aforementioned rise and fall of headline inflation, although by an approximately six times larger magnitude.[8] From December 2020 to its peak in June 2022, energy price rose by 44 percentage points to a peak of 38 percent (at a twelve-month rate) before largely dissipating in the second half of 2023. Energy prices rose sharply following Russia's invasion of Ukraine in February 2022.

As to labor market tightness, the unemployment gap declined during the period that inflation rose, but co-movement with inflation is less striking. For the median economy, the unemployment gap fell from 0.8 percentage point in December 2020, indicating a weak labor market, to a low of –0.3 percentage point in November 2023, indicating a tighter-than-normal market. However, because the median unemployment gap continued to decline even after headline inflation had peaked and was falling, it is less closely associated with inflation dynamics during this period than is energy price inflation.

Overall, this initial examination suggests that the rise and fall of headline inflation occurred jointly with a large movement in energy price inflation as well as with a more gradual movement in core inflation. Inflation expectations rose over short-term horizons but remained stable over longer-term ones, suggesting that forecasters generally perceived the rise in inflation as temporary.

3. Cross-section Evidence: The Roles of Energy Prices and Economic Slack

We next provide a cross-sectional assessment of how the aforementioned correlates of inflation—energy prices and labor market tightness—related to the rise and fall of inflation. This is a natural starting point for examining international drivers, both at the local and at the global levels.

Figure 2 focuses on two periods covering, first, the rise in headline inflation from December 2020 to its country-specific headline inflation peak; and second, the fall in headline inflation from the peak to March 2024. Red country labels indicate the rising inflation period; blue labels indicate the disinflation phase.

The first panel of Figure 2 (top left) reports the relation between the change in headline inflation and the change in energy price inflation. We see a positive relation for each period with R-squared statistics of, respectively 12 percent and 15 percent.[9] A much stronger relation, with an R-squared of 75 percent holds when considering the co-movement between the two periods jointly in a pooled regression.

The second panel of Figure 2 (top-right) reports a puzzling lack of correlation between changes in energy price inflation and core inflation across countries. When the change in energy price inflation is regressed on the change in core (weighted median) inflation, the R-squared is zero for both the inflation rise and disinflation periods. This lack of correlation occurs despite numerous hypothetical channels through which movements in energy prices could pass through into changes in core inflation, including wages or other costs of producing output, as emphasized by Blanchard (2022), di Giovanni and others (2022), and Bernanke and Blanchard (2024b), among others. The co-movement between energy price inflation and core inflation is visible when the two periods are considered jointly in a pooled regression, but the absence of a within-period cross-country correlation is surprising. (As we discuss in what follows, this puzzle resolves after accounting for country-specific differences in the strength of energy-price pass-through.) Figure 2 (lower-left panel) illustrates, nevertheless, that energy price changes have been correlated with changes in twelve-month-ahead inflation expectation across countries.

Finally, to examine the role of macroeconomic conditions in shaping inflation, Figure 2 reports the bivariate relation between the change in core inflation and the change in the unemployment gap (lower-right panel). The results have the expected sign, with falling unemployment associated with higher core inflation. However, the strength of the relation is weak, even when the two periods are considered jointly in a pooled regression.

[7] Estimates of the natural rate come from IMF staff or, where unavailable, are obtained using the Hodrick-Prescott filter. The IMF staff natural rate estimates come from the April 2024 *World Economic Outlook* (WEO) database at the annual frequency. For cases where these estimates are unavailable, we apply the Hodrick-Prescott filter to unemployment data and forecasts through 2029 (to address the end-point problem) from the April 2024 WEO database at the annual frequency with a conventional smoothing parameter (λ) of 100. For our monthly analysis, we allocate these annual natural rate estimates to June of each year and interpolate between these months.

[8] "Energy" denotes the Energy component of the CPI except for the euro area, where it denotes the HICP Electricity, Gas and Other Fuels component.

[9] Annex Table 1 reports the months with the country-specific peaks in headline inflation for each of the 21 economies considered, which we use for the paper's analysis. For most countries, the peak in the twelve-month headline inflation rate occurred in the second half of 2022. Annex Table 2 reports the bivariate estimation results underlying the regression lines in Figure 2.

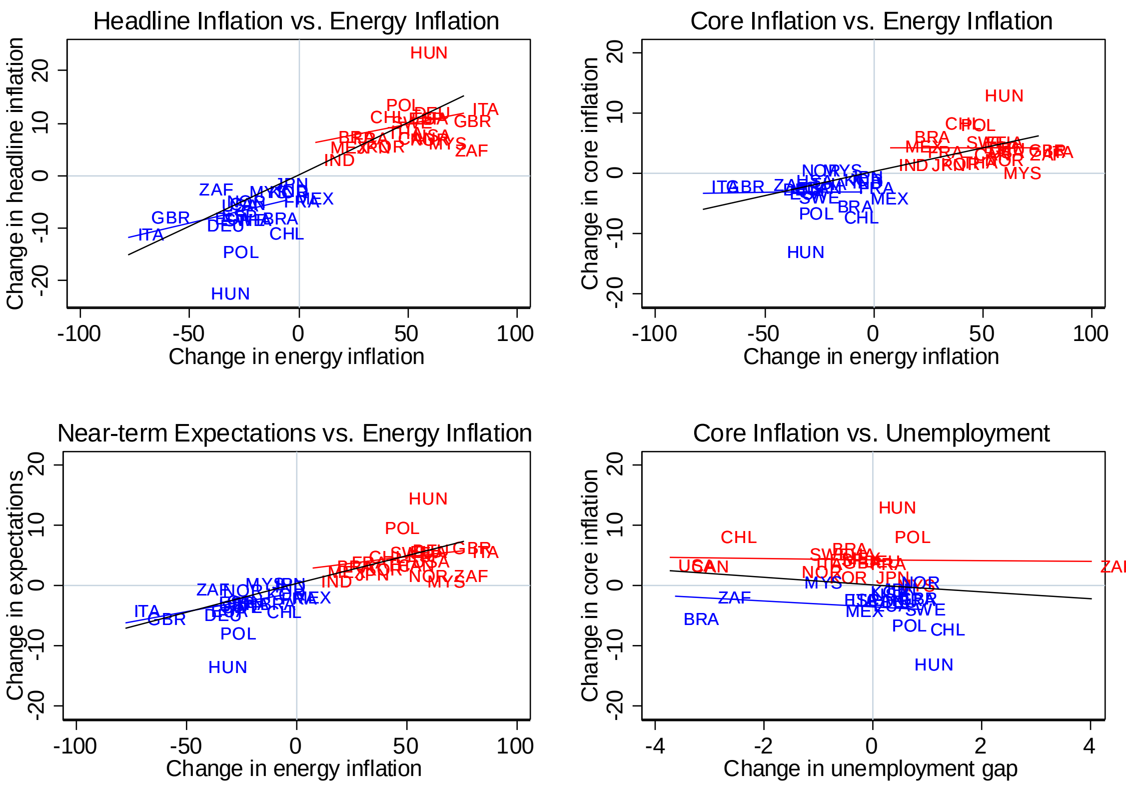

Fig. 2. Cross-Section Evidence: The Role of Energy Price Inflation and Unemployment (Percentage points).
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: "Core inflation" denotes the weighted median inflation rate. "Near-term expectations" are based on twelve-month-ahead forecast derived from Consensus Economics forecasts. Red labels denote changes from December 2020 to month of the country-specific peak in headline inflation, with red line indicating the associated linear regression. Blue labels denote the change from country-specific peak to the latest value (March 2024), with blue line indicating the associated linear regression. Black line indicates pooled regression across both time intervals. Data labels indicate International Organization for Standardization (ISO) country codes except for EUA (euro area).

Overall, the pooled regression analysis based on co-movement between the two periods is consistent with the notion that energy price movements have played a central role in driving inflation and inflation expectations since 2020. The analysis also confirms that movements in labor market tightness have on average, played a relatively minor role. However, the cross-country analysis within each period provides much less definitive evidence, suggesting that country-specific sensitivities to energy prices may be playing a central role.

To make progress on such country-specific sensitivities, we now move from cross-sectional exploration to country-by-country analysis.

4. Inflation Drivers at the Country Level

Our framework for studying inflation at the country level extends the approach of Ball, Leigh, and Mishra (2022) and Dao and others (2023) who focused on inflation in the United States and the euro area to more economies. We decompose headline inflation into core inflation and deviations of headline from core.

(1) headline inflation = core inflation + headline shocks

Our measure of core (underlying) inflation is weighted median inflation, which strips out the effects of unusually large price changes in certain industries. Our inflation decomposition into core inflation and headline shocks could also be viewed as distinguishing between inflation in a sticky price (core) and flexible-price sector (headline or relative price shocks) respectively, as in Aoki (2001). Unlike Aoki (2001), we do not impose that the passthrough from flexible price shocks to sticky price inflation arises only because of contemporaneous substitution effects. In our empirical model, we allow for a potentially richer passthrough from headline shock to core inflation, as the initial relative price shock is transmitted -possibly with lags- through wage setting and the input-output production structure.

Figure 3 reports this decomposition for the 21 economies in the sample. It reports the change in headline inflation (twelve-month rate) from December 2020 to the country-specific peak (left panel) and its fall from the peak to March 2024 (right panel). We see that in most (though not all) cases, both the rise and the fall in headline inflation reflected contributions (in the same direction) from headline inflation shocks and from core inflation.

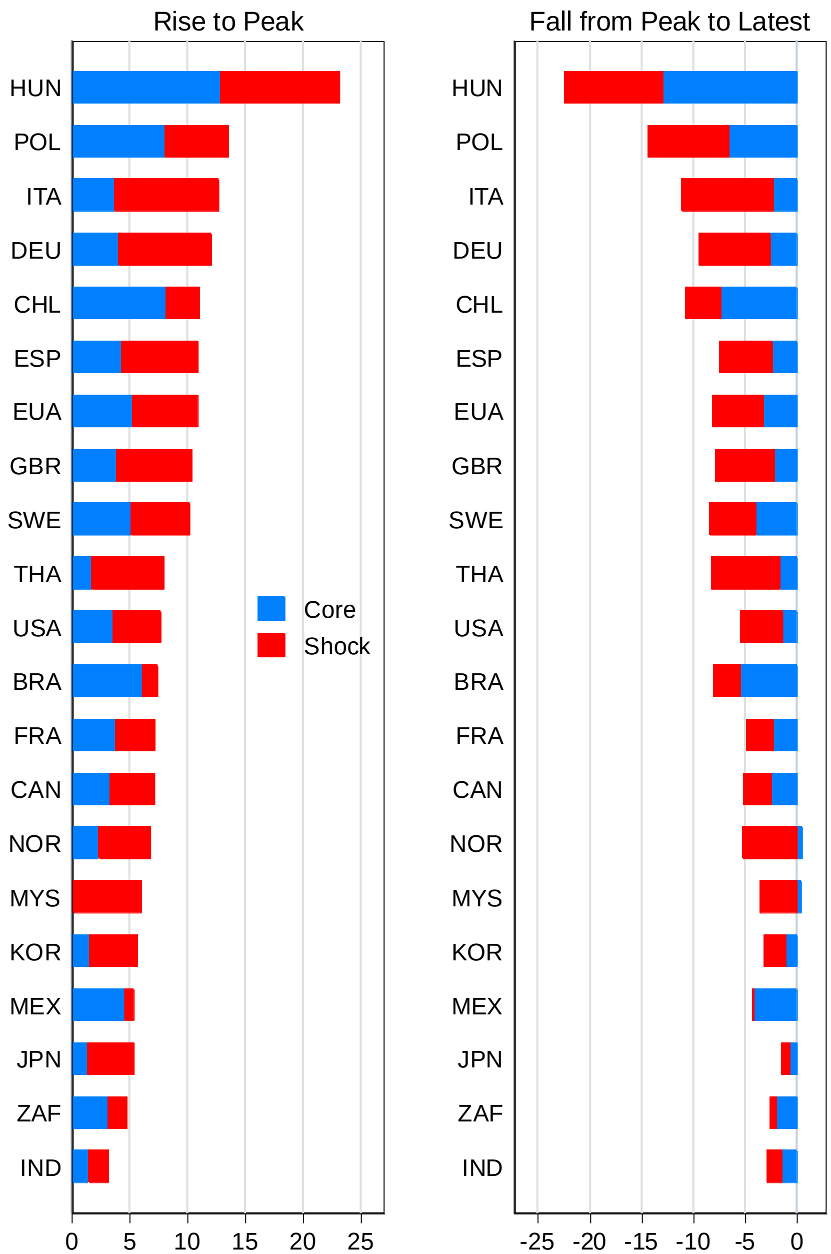

Fig. 3. Decomposition of Change in Headline Inflation, Core Inflation, and Headline Inflation Shocks, 2020–2024, for 21 Economies (Decomposition of change in twelve-month headline inflation from December 2020 to peak in twelve-month headline inflation; and from peak to latest observation; percentage points).
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: Core inflation is the weighted median inflation rate. Data labels in the figure use International Organization for Standardization (ISO) country codes except for EUA (euro area). Latest observation is for March 2024.

4.1. Explaining Headline Shocks

We now seek to explain the headline inflation shocks focusing on ten candidate variables that have featured prominently in discussions of inflation since the onset of the pandemic. The candidates include the afore-mentioned energy price inflation, as well as measures of supply chain disruptions and shortages, measures of the severity of COVID-19-related lockdowns, and changes in the prices of specific industries, such as food and auto-related industries.

Table 1 reports a heat map with the R-squared statistics for bivariate relations between the monthly headline inflation shocks and each of the ten candidate variables considered for each of the 21 economies, as well as for a pooled regression.

Table 1. Explaining Headline Inflation Shocks, January 2020 – March 2024. (R-squared Statistics for Bivariate Regressions of Headline Inflation Shocks on Correlates. Dependent variable: monthly headline inflation shock.)

	Energy price inflation	Food price inflation	Harper charter rate	Backlogs of work	Global supply chain pressure index	Suppliers' delivery times	COVID-19 deaths, monthly	Dollar exchange rate, % change	NEER, % change	Weighted average of car inflation
Brazil	0.364	0.065	0.041	0.159	0.002	0.094	0.027	0.106	0.054	0.133
Canada	0.570	0.009	0.097	0.351	0.008	0.022	0.040	0.122	0.080	
Chile	0.210	0.040	0.224		0.166		0.036	0.001	0.005	
Euro area	0.623	0.017	0.224	0.165	0.093	0.133		0.134	0.074	
France	0.501	0.009	0.129	0.091	0.058	0.067	0.178	0.035	0.038	0.040
Germany	0.461	0.122	0.116	0.025	0.029	0.055	0.100	0.092	0.029	0.005
Hungary	0.559	0.418	0.191		0.016	0.237	0.298	0.006	0.008	0.006
India	0.006	0.920	0.001	0.020	0.004	0.099	0.001	0.006	0.002	
Italy	0.699	0.184	0.129	0.051	0.084	0.079	0.161	0.026	0.000	0.038
Japan	0.170	0.306	0.066	0.054	0.003	0.007	0.088	0.000	0.010	0.000
Korea	0.058	0.197	0.109		0.007	0.016	0.031	0.007	0.012	
Malaysia	0.182	0.014	0.010		0.001	0.023	0.010	0.105	0.050	
Mexico	0.412	0.257	0.001	0.014	0.000	0.005	0.001	0.072	0.049	0.001
Norway	0.334	0.074	0.066		0.046	0.064	0.014	0.004	0.012	
Poland	0.672	0.169	0.249		0.138	0.064	0.150	0.083	0.038	
South Africa	0.451	0.004	0.009	0.001	0.001	0.050	0.000	0.034	0.000	0.528
Spain	0.736	0.006	0.092	0.074	0.043	0.128	0.012	0.020	0.020	0.004
Sweden	0.755	0.007	0.122		0.036	0.033	0.054	0.000	0.001	0.000
Thailand	0.621	0.157	0.105		0.052	0.052	0.029	0.024	0.027	
United Kingdom	0.537	0.119	0.246	0.163	0.092	0.033	0.192	0.019	0.002	0.013
United States	0.685	0.002	0.082	0.473	0.112	0.219	0.017		0.036	0.319
Pooled	0.268	0.129	0.068	0.059	0.027	0.014	0.000	0.000	0.000	0.000

Notes: Relative energy, food, and auto-related price inflation variables are computed by subtracting median inflation from energy, food, and auto-related price inflation, respectively, in monthly annualized terms. Backlogs of work and suppliers' delivery times are taken from IHS Markit Economics. The Harper charter rate reflects the worldwide price evolution of the charter market for container ships, and this variable is taken from Harper Petersen Holding GmbH. The global supply chain pressure index variable is sourced from Federal Reserve Bank of New York. COVID-19 deaths are from the Oxford Covid-19 Government Response Tracker.

We see that the three variables with the most explanatory power are, in order of importance (based on the R-squared from the pooled regression): relative energy-price inflation, defined as energy price inflation minus median inflation; relative food-price inflation, measured as food price inflation minus median inflation, and global shipping costs, measured by the Harper charter rate. To highlight the relative size of the R-squared statistics, the table's elements are color coded, with a darker shade indicating a better fit. The R-squared statistic for energy price inflation is the highest for 17 out of the 21 economies considered.

Annex Table 3 reports multivariate regressions for the three top variables identified in Table 1. In these multivariate regressions, the estimated coefficient on energy price inflation is positive and statistically significant in all 21 cases. Food price inflation also has a positive and statistically significant coefficient estimate in eleven cases. The results for shipping costs are statistically significant in seven cases. The overall explanatory power for the three variables, measured by the R-squared statistic, ranges from 21 percent for Malaysia to 94 percent for India. Annex Figure 1 reports the actual and fitted values of the monthly headline inflation shocks for each of the 21 economies based on the three variables used in the multivariate regressions. The fitted value of headline shocks based on the three variables generally follow the actual values closely.

Figure 4 reports a decomposition of the twelve-month headline inflation shocks (derived from the monthly fitted values) based on the country-by-country estimation results. Once again, we see that energy price inflation plays, in most cases, a dominant role in explaining the rise of headline inflation shocks through the (country-specific) peak, as well as the fall from the peak to the latest observation. Food and shipping costs contribute to headline inflation shocks in the same direction for most cases, with some exceptions, including India.[10]

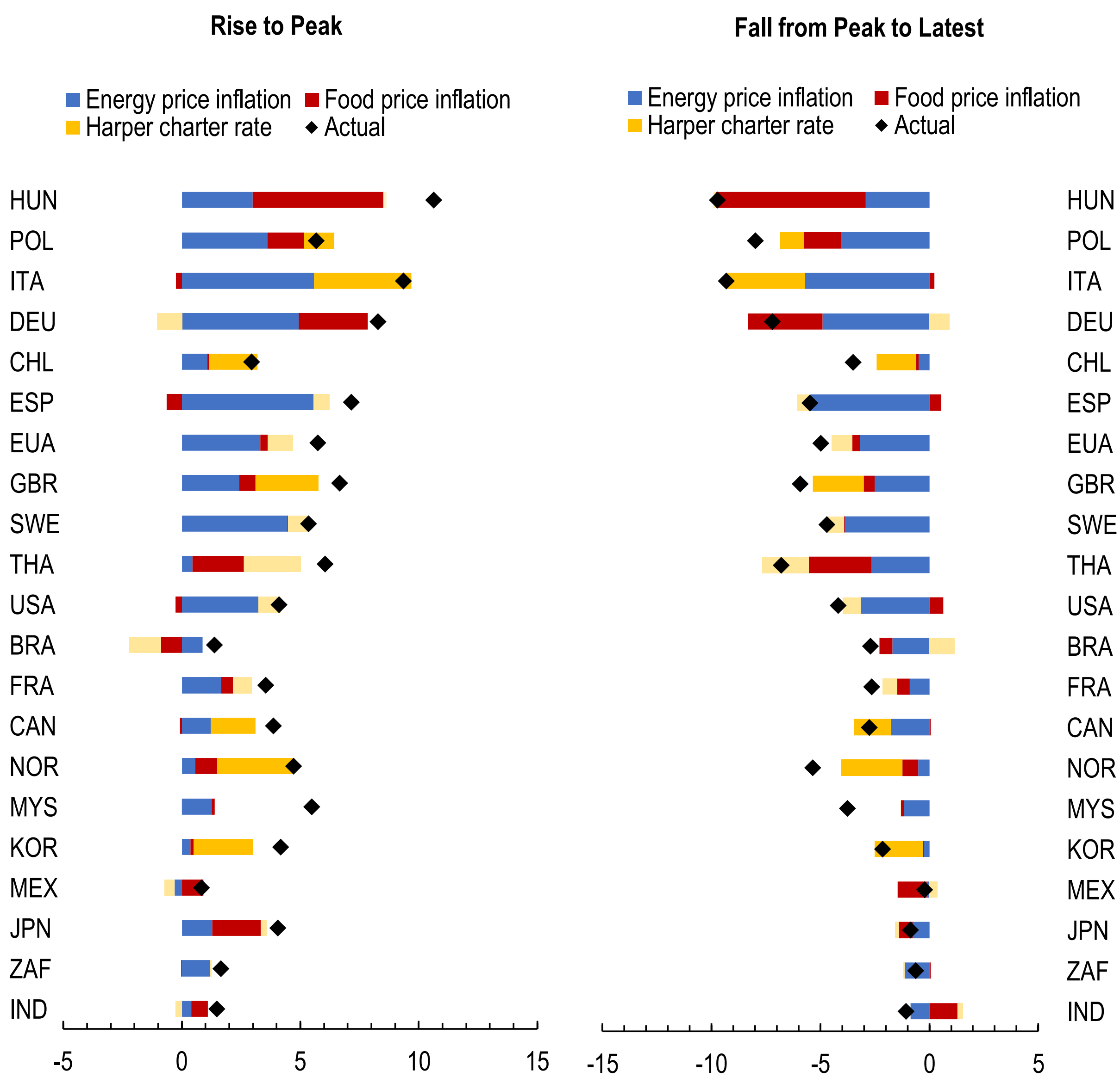

Fig. 4. Headline Shock Decomposition (12-month rates, percentage points).
Notes: The estimated coefficients in Annex Table 3 are used to compute the predicted values of the headline inflation shock for each country based on three drivers: relative energy inflation, relative food inflation, and the Harper charter rate. The twelve-month averages for the predicted components are then computed. The bars reported in the figure are calculated as changes in the twelve-month predicted values from the initial value in December 2020 to the date of the peak in twelve-month headline inflation and from the peak to the latest datapoint (March 2024). The lighter shades for the Harper charter rate denote statistically

[10] Although the R-squared is high for India (Annex Table 3), there is a significant residual (difference between actual and predicted headline shock) reported in Figure 4. This reflects variation over time in the estimated error term. In particular, there is a large negative error term estimated for March 2024 and a small positive one for the peak in April 2022. Hence the difference is a large negative residual reported in the last row of the right panel “Fall from Peak to Latest” in Figure 4.

insignificant effects from Annex Table 3. The initial, peak, and latest dates are as in Figure 3. The "Actual" values for each country correspond to the "Shock" bars in Figure 3.

In Annex Table 4 we also present a version of the multivariate regressions based on the country-specific top three variables identified based on the R-squared statistics in Table 1.[11] For 17 out of 21 countries, energy price inflation is the most important driver of headline inflation shocks, while there is more cross-country variation in the second and third most important headline shock drivers. For example, for the United States, as in Ball, Leigh, and Mishra (2022), we find high explanatory power from a combination of three variables: changes in energy prices; backlogs of work; and changes in prices in auto-related industries. A regression of headline shocks on these variables has an R-squared of 93 percent for the United States. For India, a combination of food-price shocks, backlogs of work, and supplier delivery times has high explanatory power, with an R-squared of 93 percent.

4.2. Explaining Core Inflation

To understand the evolution of core inflation for each economy, we use a Phillips curve framework that focuses on the role of three variables: expected inflation, macroeconomic conditions, and headline-inflation shocks. The first two are the variables in the textbook Phillips curve, and the third captures the pass-through of headline inflation into core that may occur through wages, but importantly through other channels, such as other costs of producing output, channels emphasized by economists such as Blanchard (2022) and di Giovanni and others (2022).

The equation estimated is:

(2) $\pi = \pi^e + f(Y) + g(H) + \varepsilon$

where π is the monthly annualized core (weighted median) inflation rate; and π^e is expected inflation. We follow studies such as Hazell and others (2022) by measuring expected inflation with longer-term survey expectations. As in Ball, Leigh and Mishra (2022), when estimating the Phillips curve specifications, we assume that core inflation responds one-for-one to movements in longer-term expected inflation.[12]

The Y term denotes the strength of macroeconomic conditions averaged over the current and previous eleven months. Our baseline measure for Y is the IMF staff estimate of the unemployment gap averaged over the current and previous 11 months. For the emerging market economies in the sample, however, monthly data for unemployment are only available for a relatively short period or not available at all, and so for those cases our measure of Y is the output gap—the gap between actual real GDP and estimated potential real GDP—which is available for a longer period. We construct the output gap using quarterly real GDP data—we interpolate between the quarterly observations to obtain a monthly series—and IMF staff estimates of potential output.[13] Both the unemployment gap and the output gap are conventional measures of macroeconomic conditions in the literature.

For the United States, however, we follow recent studies and measure macroeconomic conditions based on the ratio of vacancies to unemployment (V/U). This approach is preferable to the unemployment gap for the COVID-19 period in light of the substantial shift in the US Beveridge curve relation between vacancies and unemployment, as illustrated in Annex Figure 4. As Ball, Leigh and Mishra (2022) explain, this Beveridge curve shift implies a corresponding upward shift in the conventional unemployment-based Phillips curve, with higher inflation for any given level of unemployment. Using the conventional (unemployment gap) specification in this context would thus fail to adequately account for the rise in inflation due to this shock. Annex Figure 4 also illustrates the Beveridge curve for three other economies for which we have data on job vacancies—the euro area, the United Kingdom, and Canada.[14] We conclude that Canada also experienced a shift in the Beveridge curve during the pandemic. Accordingly, our measure of Y is the average ratio of vacancies to unemployment over the current and previous eleven months for both the United States and Canada. For the remaining economies, the conventional unemployment gap (or

[11] Annex Table 5 lists the top three variables identified for each country. Annex Figures 2 and 3 document, respectively, the corresponding actual and fitted values and the decomposition exercise.

[12] This one-for-one relation is, as Ball, Leigh, and Mishra (2022) explain, consistent with the derivation by Hazell and others (2022) in a New Keynesian framework under the assumption that shocks to the unemployment gap and cost-push shocks are transitory.

[13] The IMF staff potential output estimates come from the April 2024 WEO database at the annual frequency. For our monthly analysis, we allocate these annual potential output estimates to June of each year and interpolate between these months.

[14] For the United States, the data on vacancies come from the Bureau of Labor Statistics (BLS) Job Openings and Labor Turnover Survey (JOLTS) starting from 2001 and we extend the data backwards in time using Barnichon's (2010) dataset. For Canada, the data come from Statistics Canada starting from 2015 and we extend the data backwards in time using the vacancy rate dataset of Bounajm, Roc, and Zhang (2024). For the euro area, the vacancy rate data come from Eurostat, start in 2006, and are for industry, construction, and services (except activities of households as employers and extra-territorial organizations and bodies). For the United Kingdom the data for vacancies come from the Office of National Statistics Vacancy Survey.

output gap) specification remains appropriate.

The H term is the average of headline inflation shocks over the current and previous 11 months, and its inclusion in equation (2) captures the pass-through of these headline shocks to core inflation. Having H as an additive term in the core inflation Phillips curve resembles the inclusion of supply or relative price shocks as in Aoki (2001) and Roberts (1995). A key difference is the lag structure of the H term which effectively allows for a richer set of transmission channels from headline shocks to core inflation.

The f(.) and g(.) terms are functions which allow for non-linearities in a flexible way. We explore the possibility of nonlinearities by considering both quadratic and cubic functions. For the United States and Canada, the two economies with a V/U specification, we follow Ball, Leigh and Mishra (2022) and consider cubic functions for f(.) and g(.) for our baseline estimation results. Such non-linearities have been shown to be highly relevant for euro area and US inflation during the pandemic, as in Ball, Leigh, and Mishra (2022) and Dao and others (2023). They can arise in theoretical models such as Ball and Mankiw (1994) where relative price shocks have asymmetric effects on overall inflation in the presence of menu costs and trend inflation. For the remaining economies, we follow Dao and others (2023) and consider quadratic functions. In two cases (the United Kingdom and Italy), however, we find no evidence of such nonlinearities—the quadratic terms are statistically insignificant—and therefore estimate a linear specification. The specifications include a constant term unless it is found to be statistically indistinguishable from zero.[15]

Based on data availability, our estimation of Phillips curves focuses on fourteen economies.[16] Annex Table 6 reports the estimation results for each of the fourteen economies. The table also indicates the measure of slack used as well as the first year of the sample.

In most cases, the equation for the monthly core inflation rate fits well, with an adjusted R-squared statistic above 40 percent in most (9 out 14 cases). The main exception is Japan, for which the Phillips curve equation estimated has an adjusted R-squared statistic of less than 5 percent and the estimate of the slope coefficient is highly imprecise. For the United States and the euro area, the results are similar to those of, respectively, Ball, Leigh and Mishra (2022) and Dao and others (2023), which were based on a shorter sample.

To illustrate the estimation results, Annex Figure 5 reports the slope functions over the economies' respective samples. In several, though not all, cases we see that the relationship with macroeconomic conditions is nonlinear, with a steeper slope when the output is above potential and when labor markets are tight (see country-specific estimates in Annex Table 6).

The relation between core inflation and macroeconomic conditions in our analysis can in principle reflect channels that run beyond wage pressures from the labor market. To shed light on the possibility of such other channels, Annex Figure 6 reports, for the United States, the slope of the relation between V/U and core inflation first as in our baseline specification and then after controlling for wage growth in the equation. If the only salient channel through which V/U relates to core inflation is wages, the relation should flatten out after controlling for wage growth. Instead, we see that the slope of the relation flattens only slightly after controlling for wage growth and remains overwhelmingly significant economically and statistically. This result suggests that the V/U variable reflects broader macroeconomic conditions that relate to the prices of goods and services beyond the wage channel. Such a broader measure of price pressures from macroeconomic conditions could reflect the impact of labor market tightness on firms' marginal costs that go beyond wages. These price pressures could be driven by elevated current and future effective hiring costs as in Ravenna and Walsh (2001) or arise in models with binding supply constraints and price-wage disconnect such as Fornaro (2024).

We also see strong evidence of nonlinearity in the relationship between core inflation and headline inflation shocks (H) in most cases. In addition, there is evidence of asymmetry, with positive headline shocks associated with a stronger movement in core inflation and negative headline shocks associated with a relatively decline in core inflation.
As Annex Table 7 reports, these results are robust, changing little on average across countries when outlier observations are excluded (using Cook's distance method). Importantly, however, our results reveal the importance of measuring core inflation using weighted median inflation: when repeating the estimation using the traditional measure of core inflation based on excluding food and energy prices (XFE), the fit of the core inflation equation drops by more than half, as Annex Table 8 reports. The adjusted R-squared drops from an average of 45 percent across countries for the baseline equation for monthly annualized

[15] Based on the V/U specification, in the absence of estimates of the natural rate of V/U, a constant term is necessary. A constant term can also arise due to measurement error in π^e, or if the unemployment gap, output gap or headline-inflation shocks terms have a non-zero mean. For the purposes of decomposing the change in inflation over time in the decomposition exercise that follow further below, the constant term will play no role.

[16] The ten advanced economies are Canada, the euro area, France, Germany, Italy, Japan, Spain, Sweden, the United Kingdom, and the United States. The four emerging market economies are Brazil, Chile, India, and Poland.

core inflation using weighted median inflation to only 18 percent when using XFE inflation. Studies that find that "outlier-exclusion" measure of core, such as medians and trimmed means, are more closely related to macroeconomic conditions, including the unemployment rate, than are "fixed-industry exclusion" measures, such as XFE inflation, include, for the euro area, Ball and Mazumder (2011) and, for the United States, Verbrugge (2021).

4.3. Accounting for the Rise and Fall in Headline Inflation

We now conduct an accounting exercise for the sources of the rise and fall in headline inflation since December 2020 based on our estimation results. In this exercise, we augment the fitted values for core inflation based on the estimation results reported in Annex Table 6 with the fitted values for headline-inflation shocks based on the estimation results reported in Annex Table 3. We derive twelve-month inflation rates from the fitted values for monthly annualized rates.[17]

Figure 5 reports the results for four large economies—the United States, the euro area, the United Kingdom, and Brazil.

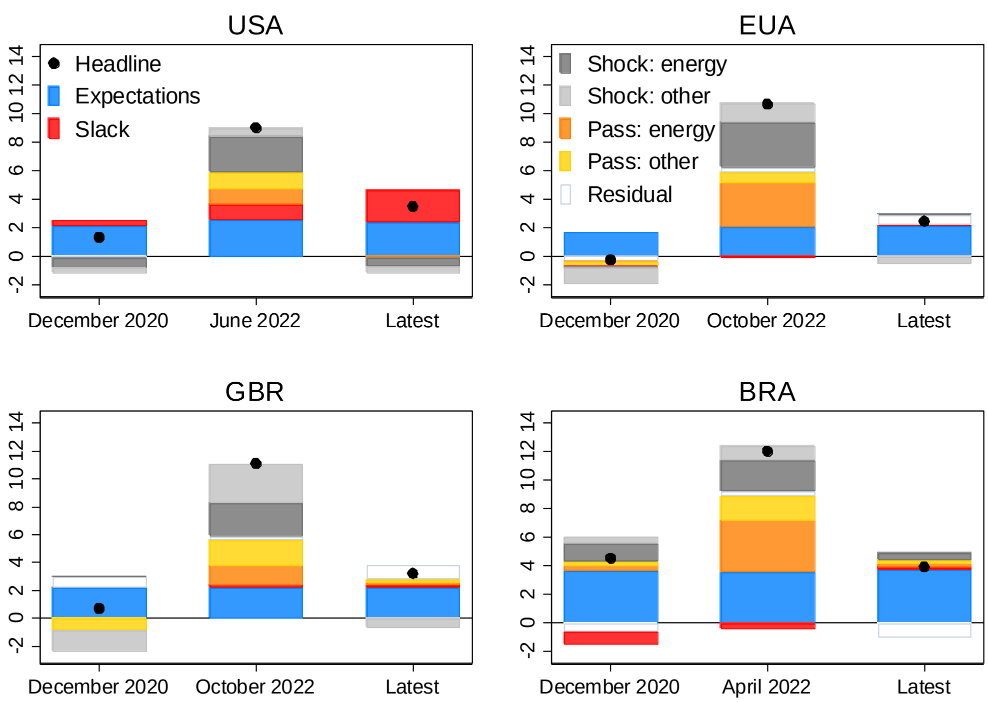

Fig. 5. Contributions to Headline Inflation, 2020-2024: United States, Euro Area, United Kingdom, and Brazil (Decomposition of twelve-month headline inflation in December 2020, month of peak, and March 2024; percentage points).
Sources: Haver analytics; Federal Reserve Bank of Cleveland; and authors' calculations.
Notes: "Shock" denotes contribution of headline inflation shocks (energy or other). "Pass" denotes pass-through from headline inflation shocks (energy or other) into core inflation. "Energy" denotes contribution of relative energy prices. "Expected inflation" denotes contribution of change in long-term inflation expectations to change in headline inflation. "Slack" denotes contribution of change in economic slack (ratio of vacancies to unemployed for United States; output gap for Brazil); and unemployment gap (euro area and United Kingdom). Based on estimates in Annex Table 3 and Annex Table 6. For United Kingdom, residual includes constant term estimate. Data labels in the figure use International Organization for Standardization (ISO) country codes except for EUA (euro area). Latest observation is for March 2024.

We see that much of the rise in US headline inflation to its peak in June 2022 (at a twelve-month rate) reflects the onset of headline inflation shocks (grey bars)—notably to the price of energy—and the pass-through into core inflation (orange and gold bars).[18] A strengthening in macroeconomic conditions (red bars) plays a sizeable but secondary role. These US results are for CPI inflation, but Annex Figure 7 repeats the exercise for PCE inflation, yielding similar results.

[17] To decompose the headline-inflation shocks into the part due to energy price fluctuations and the part due to other factors, we use the fitted values reported in Figure 4. To derive the pass-through effects, we take these fitted values of headline-inflation shocks and combine them with the pass-through coefficient estimates reported in Annex Table 6. For the pass-through effects of other headline-inflation shocks, we take the part of the headline-inflation shocks not explained by energy prices reported in Figure 5 and, similarly, combine them with the pass-through coefficient estimates.
[18] For the United States, the results for June 2022 in Figure 6 show substantial pass-through from past headline shocks not associated with energy prices (golden bars). This contribution reflects the temporary run-up in shipping costs earlier in the pandemic, and the lagged pass-through relation with core inflation.

The decline in US twelve-month headline inflation since its peak in June 2022 mainly reflects the fading of headline inflation shocks and of the associated pass-through. But the fall in inflation after the peak in core inflation in February 2023 reflects approximately equally the easing in macroeconomic strength (a decline in V/U) and the fading of pass-through from headline shocks, as Figure 6 reports.[19] Moreover, the contribution of V/U to US *monthly* inflation has declined significantly since the peak in both headline and core inflation, as the lower panel of Figure 6 reports. The estimated contribution of V/U to US monthly inflation in March 2024 is only one-third of its size in February 2023. At the same time, the lower panel of Figure 6 illustrates how annualized monthly headline inflation (denoted by black dots) is, as of March 2024, only modestly lower than in February 2023 on account of two opposing developments: the positive contribution of V/U (red bars) has faded, but so has the negative contribution of headline inflation shocks (grey bars). Without this disinflationary contribution from the lower V/U, monthly annualized headline inflation would have been about 2.5 percentage points higher in March 2024. Nevertheless, the contribution of V/U to inflation as of March 2024 remains substantial.

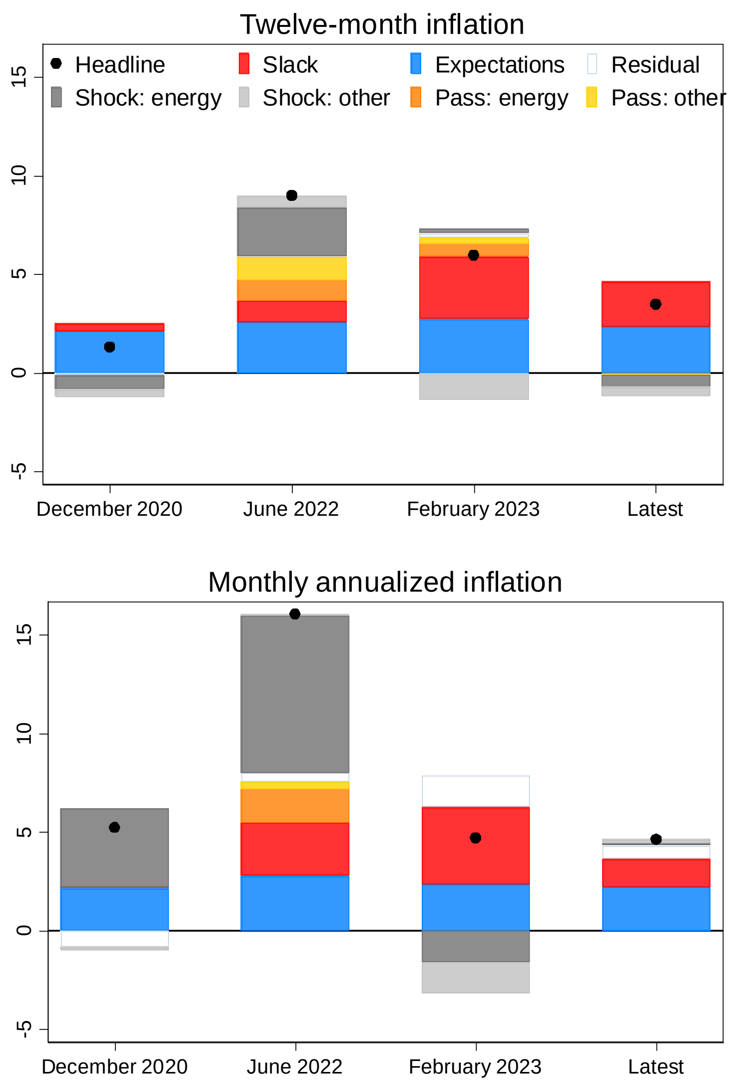

Fig. 6. United States: Contributions to Headline Inflation, 2020-2024 (Decomposition of headline inflation; percentage points).
Sources: Haver analytics; Federal Reserve Bank of Cleveland; and authors' calculations.

[19] The contribution of V/U to twelve-month US inflation initially increases after June 2022, reflecting our estimated lagged relation between macroeconomic conditions and core inflation. A further reason why the contribution of V/U to twelve-month inflation rises after June 2022 is that to derive fitted values of twelve-month inflation, we use the fitted values from our equation for monthly core inflation for the current and past eleven months. As a result of these calculations, the estimated contribution of V/U to twelve-month inflation in March 2024 reflects the level of V/U during the 24-month period ending in March 2024, which is on average greater than its corresponding average through June 2022.

Note: "Shock" denotes contribution of headline inflation shocks (energy or other). "Pass" denotes pass-through from headline inflation shocks (energy or other) into core inflation. "Energy" denotes contribution of relative energy prices. "Expected inflation" denotes contribution of change in long-term inflation expectations to change in headline inflation. "Slack" denotes contribution of change in economic slack (ratio of vacancies to unemployed for United States). Based on estimates in Annex Table 3 and Annex Table 6. Figure reports results for December 2020, June 2022 (peak in headline inflation), February 2023 (peak in core inflation), and latest observation (March 2024).

For the other three economies reported in Figure 5, the contribution of macroeconomic strength is significantly smaller than for the United States. For these economies, the direct and pass-through contributions of headline inflation shocks (including those stemming from changes in energy prices) have generally played a larger role in explaining the rise and fall of headline inflation. For these economies, the measure of macroeconomic conditions is, as already explained, the conventional unemployment gap, given little evidence of a Beveridge curve shift.

A natural question is whether our use of V/U data is driving our finding of a larger contribution of macroeconomic strength to inflation in the case of the United States. The answer is no. The estimated contribution of macroeconomic conditions to inflation for the United States remains larger than for the euro area and the United Kingdom even if we use V/U data and the same cubic specification used for the United States. The estimated contribution of V/U to twelve-month inflation for the latest available observation (the first quarter of 2024 for the euro area and January 2024 for the United Kingdom) is then 0.9 percentage point and 0.5 percentage point for the euro area and United Kingdom, respectively compared to 2.3 percentage points for the United States (for March 2024). In addition, these computations for the euro area and the United Kingdom are highly imprecise as the V/U coefficient estimates in the underlying inflation equation are statistically indistinguishable from zero.[20]

Figure 7 reports the decomposition results for all fourteen economies. The left panel reports a decomposition of the change in headline inflation (twelve-month rate) from December 2020 to the country-specific peak, and the right panel decomposes the change from the peak to the latest observation (March 2024).

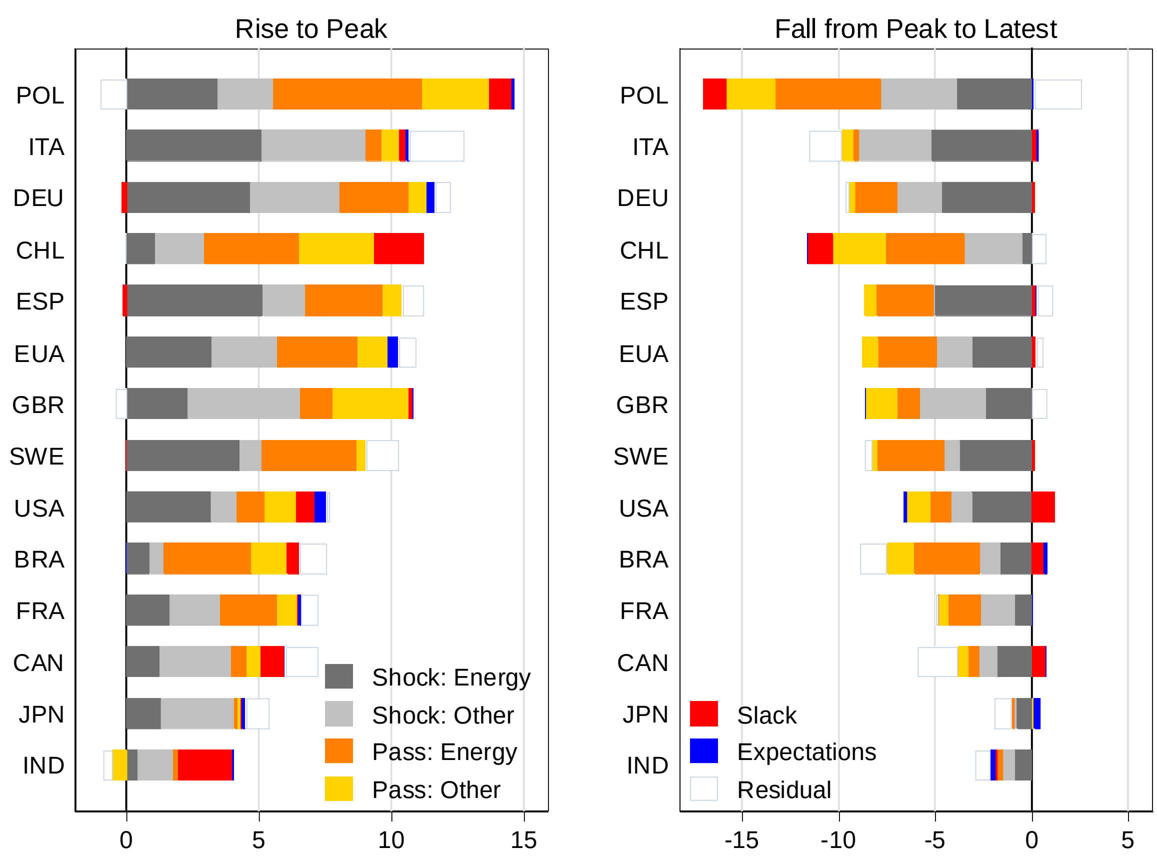

Fig. 7. Accounting for the Rise and Fall in Headline Inflation, 2020-2024: Fourteen Economies (Decomposition of change in twelve-month headline inflation from December 2020 to peak in 12-month headline inflation; and from peak to March 2024; percentage points).

[20] The *p*-values for the V/U coefficient estimates in the cubic specification estimated for the euro area and the United Kingdom are greater than 30 percent and 60 percent, respectively. By contrast, the V/U coefficient estimates for the United States are statistically significant (column 14 of Annex Table 6). For Brazil—the fourth economy included in Figure 5—sufficient time series data for vacancies are not available.

Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Notes: "Shock" denotes contribution of headline inflation shocks (energy or other). "Pass" denotes pass-through from headline inflation shocks (energy or other) into core inflation. "Energy" denotes contribution of relative energy prices. "Expected inflation" denotes contribution of change in long-term inflation expectations to change in headline inflation. "Slack" denotes contribution of change in economic slack (ratio of vacancies to unemployed for United States and Canada; output gap for Brazil, Chile, India, Poland); and unemployment gap (the remaining seven economies). Based on estimates in Annex Table 3 and Annex Table 6. Latest observation is for March 2024.

For most countries, the results highlight the strong role of energy price shocks and their pass-through into core in driving headline inflation. On average, these two components together account for about 49 percent and 62 percent of the rise and fall of headline inflation, respectively. The results also reveal significant differences in the magnitude of this factor across economies. For example, for Germany, the direct contribution to the rise in inflation from energy prices (via headline shocks) is nearly three times larger than for France, and the associated pass-through contribution is over 20 percent larger. This finding is consistent with the conclusion of Dao and others (2023) that differences in the implementation of energy price measures between these two countries, with France relying more on energy price-suppressing measures than Germany, contributed materially to different inflation outcomes across the two economies, an issue to which we return in what follows.

The strength of macroeconomic conditions (red bars) and changes in longer-term inflation expectations (blue bars) contribute only modestly to explaining the rise and fall in inflation in most cases. The share of macroeconomic strength in accounting for the rise in inflation is below 9 percent on average. In some cases, such as India, the positive contribution of macroeconomic conditions to the rise in inflation from December 2020 to its peak reflects recovery from a negative output gap in 2020 rather than a positive output gap. For Japan, the direct contribution of headline inflation shocks (principally from food price movements) accounts for almost the entire rise in inflation.

In complementary work for eleven advanced economies, Blanchard and Bernanke (2024a) similarly conclude that most of the movement in inflation since 2020 can be explained by price shocks, and not by pressure from the labor market. Our two studies come very much to the same conclusions, with minor but interesting differences, such as a larger quantitative role that we find for V/U in explaining price pressures in the United States. This difference reflects the inclusion of V/U in our equation for overall core inflation, while the approach of Bernanke and Blanchard focuses only on the relationship of V/U with wage inflation. As already mentioned, in Annex Figure 6, we report that V/U has explanatory power for core inflation beyond its relationship with wage growth, consistent with it reflecting broader macroeconomic strength beyond wage pressures. The figure also illustrates our finding of non-linearity, with a stronger V/U contribution to inflation at higher levels of V/U, in line with recent theoretical model predictions (Benigno and Eggertsson 2023, for example), while the Bernanke and Blanchard estimates are for a linear specification.

5. Adjusting Cross-Section Passthrough Estimates for Country-specific Coefficients

We now revisit the puzzling lack of correlation between core inflation and energy price inflation across countries reported in Section 1 (in Figure 2; top-right panel) —despite a strong global co-movement—and ask whether adjusting for country-specific coefficients resolves the puzzle. In addressing this puzzle, we draw on the findings in Sections 2 and 3 that the estimates of our headline-inflation shock and core inflation equation coefficients vary substantially across economies.

The top panel of Figure 8 repeats the puzzle, this time for the fourteen economies for which we have core inflation equation estimates. It plots the change in core inflation on the vertical axis and the change in energy price inflation on the horizontal axis. For both the period covering the rise in headline inflation (red line) and for the subsequent disinflation period (blue line) changes in energy price inflation and core inflation are uncorrelated across countries. The R-squared statistics are 0 percent and 2 percent for the rise and fall periods, respectively. Poland provides a good example of the puzzle: it has a rise in energy price inflation of 36 percentage points in the period covering the rise in inflation followed by a fall of 39 percentage points in the disinflation phase—near the cross-country average. However, Poland's core inflation rises by much more and then falls by much more than the simple cross-section estimates can explain.

The second panel of Figure 8 shows a resolution of the puzzle. It repeats the exercise, but this time the horizontal axis reports the contribution to core inflation from energy price inflation based on the estimated core inflation equation. These estimated contributions correspond, for each country, to those already reported in Figure 7 (orange bars). We see that the fit is now tight, with an R-squared of 79 percent and 76 percent in the inflation rise and fall samples, respectively. Again, Poland is a good example. Its large rise in core inflation is now explained almost entirely by the fact that its estimated energy pass-through contributions are particularly large. In other words, Poland *did* experience a larger rise in core inflation than other countries, but this is what we should expect based on its strong country-specific estimate of pass-through.[21]

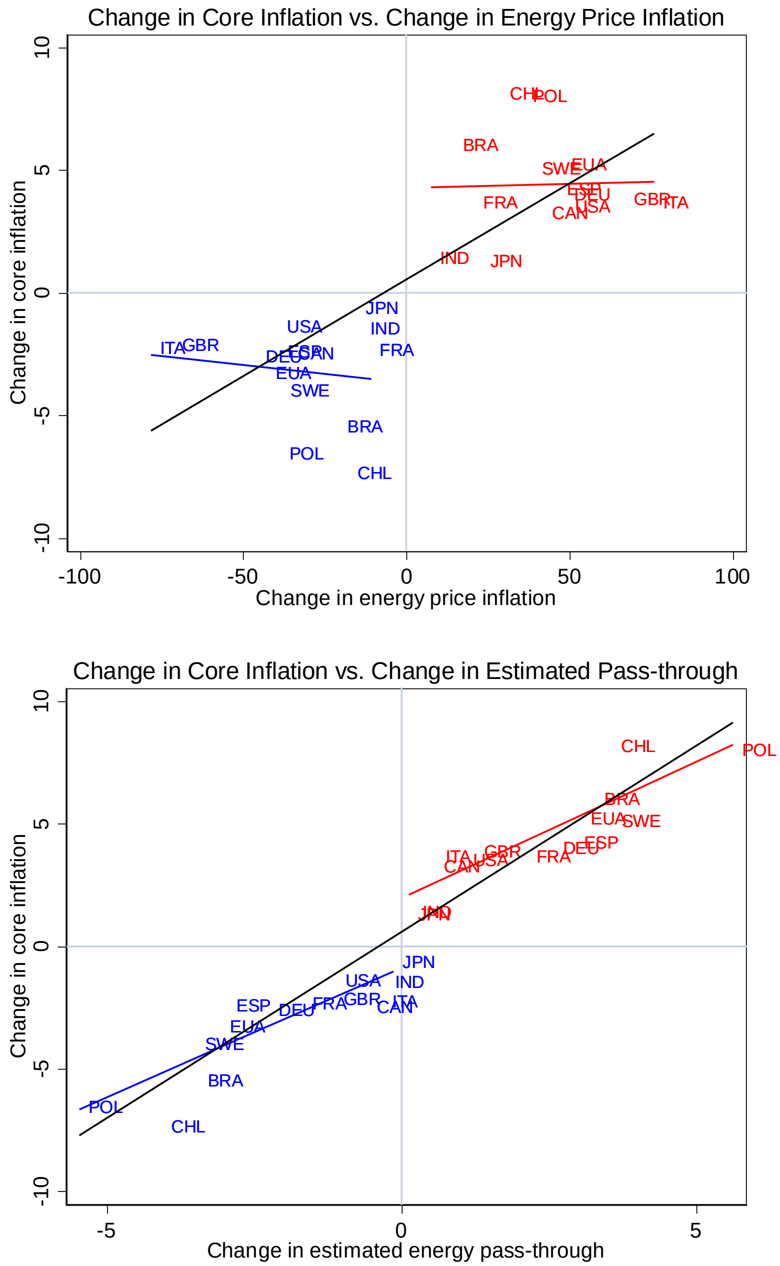

Fig. 8. Core Inflation vs. Energy Inflation and Estimated Pass-through, 2020-2024 (12-month rate; percentage points).
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Notes: Change in estimated pass-through indicates estimated contribution to core inflation from energy price inflation, as reported in Figure 8. Red labels denote changes from December 2020 to month of peak in headline inflation, with red line indicating the associated regression. Blue labels denote the change from peak to March 2024, with blue line indicating the associated regression. Black line indicates cross-section regression across both time intervals.

6. Explaining Cross-Country Variation in Passthrough of Energy Prices into Core Inflation

We have seen that the degree of energy price passthrough into core inflation differs across countries. This cross-country

[21] The total pass-through estimates reported in the lower panel of Figure 7 reflect both the size of the country-specific headline inflation shocks explained by energy as well as the country-specific pass-through coefficients. In a similar exercise, Ball, Leigh, and Loungani (2017) find that accounting for country-specific coefficients in Okun's Law resolves the puzzling lack of correlation across countries in unemployment and output during the Great Recession of 2008-2009.

heterogeneity in inflation outcomes reflects the flexibility of our framework, which utilizes a common empirical specification but allows for (i) country-specific responses of headline shocks to common global shocks; and (ii) country-specific degrees to which the shocks pass through into core inflation. What explains these differences across countries? In addressing this question, we focus on the estimated contribution of energy price inflation to core inflation for each country, as reported in Figure 7 (orange bars).

Our starting point is the observation that these differences in energy price pass-through depend crucially on two factors: (i) the fraction of headline shocks H that are explained by energy prices (as reported in Figure 4); and (ii) how strongly headline shocks pass through into core inflation (based on the estimated slope functions g(H) illustrated in the lower panel of Annex Figure 5, panel B). We therefore investigate the extent to which differences in (i) or in (ii) explain differences in energy-price pass-through.

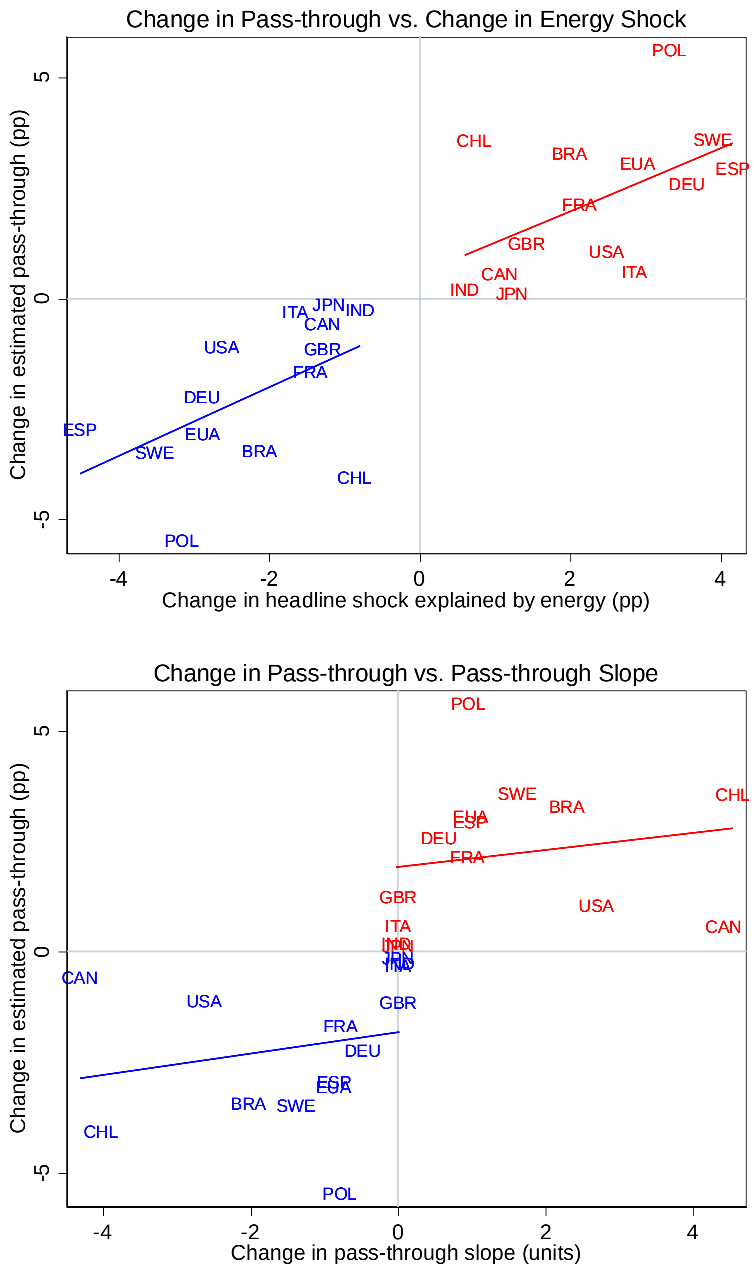

Fig. 9. Change in energy price passthrough vs. change in components.
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Notes: Vertical axis reports estimated contribution to core inflation from energy price inflation (pass-through), as reported in Figure 8 (orange bars). In top panel,

horizontal axis reports change over the two respective periods in headline shock explained by energy price inflation, as reported in Figure 4 but averaged over twelve months. In the lower panel, horizontal axis reports change over the two respective periods in slope coefficient for relation between core inflation and headline inflation shocks. See text for details on calculation of the pass-through slope coefficient. Red labels denote changes from December 2020 to month of peak in headline inflation. Blue labels denote the change from peak to March 2024. Lines indicate the associated regression fit. “pp” denotes percentage points.

We can gain an insight into this question from Figure 9, which plots the estimated degree of energy-price pass-through into core inflation against the two factors. For the fourteen economies for which we have estimates, we see that the first factor has played the dominant role. The upper panel of Figure 9 reports that factor (i)—the share of headline shocks explained by energy price inflation—has a clear positive bivariate relation with the estimated degree of energy-price pass-through, with R-squared statistics of 27 percent and 28 percent for the periods of rising and falling inflation, respectively. The lower panel reports that factor (ii)—the strength with which headline shocks pass through into core inflation—contributed relatively little, with R-squared statics of 3 percent and 5 percent for the two periods, respectively.[22]

Next, we look for fundamental determinants that could explain the cross-country differences in each of the two factors. Differences in country-specific energy price policies, including tax changes or subsidies motivated by reducing the impact of energy supply shocks on consumer prices, could explain differences in factor (i)—the contribution of energy price inflation to headline shocks. The importance of the interaction between common shocks and country-specific institutions for inflation outcomes is akin to the determinants of varying unemployment outcomes across European economies in the twentieth century as analyzed prominently by Blanchard and Wolfers (2000). Accordingly, as we report in Figure 10, we find a negative relation between the size of energy price-suppressing measures and the size of the headline inflation shock explained by energy price inflation based on available data on the size of price-suppressing measures in percent of GDP implemented during 2022-23 in the European Union (taken from Arregui and others 2022). France, for example, had relatively large price-suppressing fiscal measures during 2022-23, amounting to 3 percent of GDP, and a relatively low estimated contribution of energy-price inflation to headline shocks. These results—although based on a small cross-section sample—are broadly consistent with assessments that fiscal energy price measures contributed to dampening inflation in the euro area (see Dao and others, 2023). We also consider whether cross-country differences in measures of wage indexation or intensity of energy use explain the difference we find in factor (ii)—the strength with which headline shocks pass through into core inflation—but find inconclusive results. We leave a deeper investigation of these issues for future research.

[22] In the upper panel of Figure 9, the horizontal axis reports the change in the twelve-month energy-price inflation contribution to twelve-month core inflation. In the lower panel, the horizontal axis reports the change in the slope of core inflation with respect to the headline-inflation shock (evaluated at the average size of the shock across the fourteen economies) during the periods of increasing and decreasing inflation, respectively. The slope is computed based on the coefficients in Annex Table 6. For countries with a linear pass-through relation, the slope (derivative of the core inflation gap with respect to “H”) is simply the estimated coefficient on the "H" term in the table. For countries with a quadratic relation between core inflation and “H,” the slope is $g_1 + 2g_2\widehat{H}$ where g_1 is the coefficient on the “H” term, g_2 is the coefficient on the “H-squared” term, and $\widehat{H}$ is the average of the headline-inflation shock during the period of interest. For countries with a cubic relation, the slope is $g_1 + 2g_2\widehat{H} + 3g_3\widehat{H}^2$ where g_3 is the coefficient on the “H-cubed” term, and $\widehat{H}^2$ is the average of the headline-inflation shock, squared, during the period of interest.

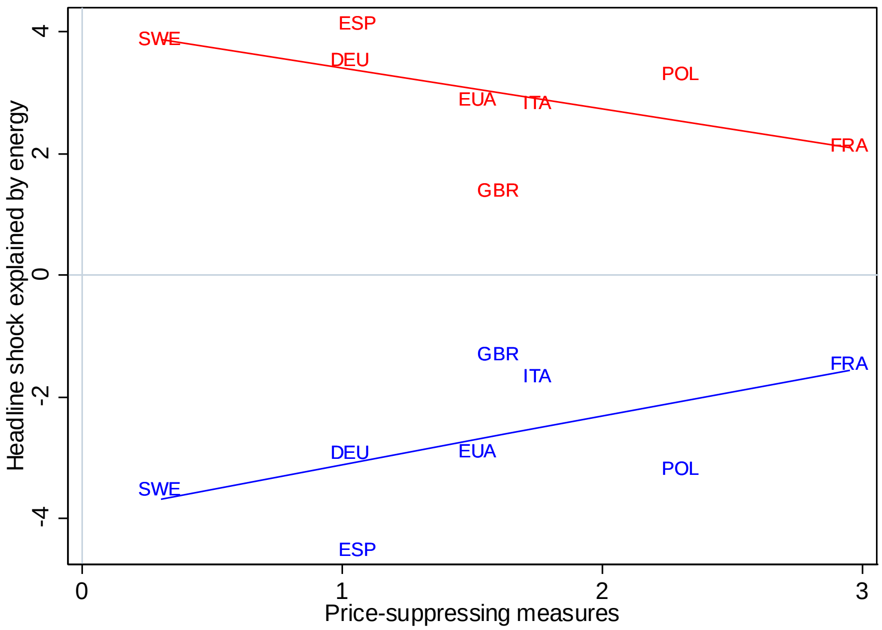

Fig. 10. Energy Headline Shock vs. Price-suppressing Measures (12-month average rate; percentage points).
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Notes: Horizontal axis reports total size of price-suppressing measures during 2022-23 in percent of GDP from Arregui and others (2022). Vertical axis reports headline shock explained by energy price inflation, as reported in Figure 4 but averaged over twelve months. Red labels denote changes from December 2020 to month of peak in headline inflation. Blue labels denote the change from peak to March 2024. Lines indicate the associated regression fit.

7. Conclusion

Our results strongly suggest that global drivers, especially the sharp movement in energy prices, played a dominant role in driving the international rise and fall in inflation since 2020. Local policies also played a role. First, the transmission of headline shocks to underlying inflation was shaped by local characteristics. It is only after accounting for country-specific passthrough coefficients that our analysis is able to account for the rise and fall in inflation both within and across countries. Second, local policies, especially monetary policy, had a critical role to play. Throughout this episode, long-term inflation expectations remained very well anchored. This suggests central banks retained credibility and this helped to avoid wage-price spirals.

Further research should help to elucidate the drivers of global factors. For energy prices, the spike following Russia's invasion of Ukraine is consistent with the notion that geopolitical factors rather than near-term economic factors played a dominant role, as in several past historical episodes. However, the contribution of macroeconomic policies, including fiscal and monetary stimulus, in raising energy prices could also be explored. Investigating the underlying determinants of the diversity of Phillips curve coefficients that we find is another priority.

There is one important exception to the broad pattern described above: the United States. In this case, more than for the other countries that we consider, macroeconomic conditions have eased but remain strong and continue to put pressure on underlying inflation even as the effects of earlier headline inflation shocks have faded. The strength of US aggregate demand likely reflects many contributing factors, including an expansionary fiscal stance, large household savings accumulated during the pandemic, and a high share of fixed rate mortgages, which have buffered households against increases in policy rates. Disentangling the relative contributions of these factors is a priority for future research.

Turning to the future, we do not conduct forecasts in this paper. However, our estimates suggest that the role of relative price shocks and their pass-through into core has at this point largely faded, facilitating the convergence of inflation to target-consistent levels. The continued stability of long-term inflation expectations on average across economies is also facilitating the return of inflation to target. The contribution of macroeconomic conditions to inflation is currently modest, with the main exception of the United States. For that country, the contribution of strong macroeconomic conditions has already significantly eased since early 2023 but remains material. In this case, a further cooling of labor markets with either higher unemployment or a fall in vacancies appears necessary for the further convergence of inflation to target.

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Annex

Annex Table 1. Peak Dates for Headline Inflation

Country Code	Peak Month
BRA	2022m4
CAN	2022m6
CHL	2022m8
DEU	2022m10
ESP	2022m7
EUA	2022m10
FRA	2023m2
GBR	2022m10
HUN	2023m1
IND	2022m4
ITA	2022m11
JPN	2023m1
KOR	2022m7
MEX	2022m8
MYS	2021m4
NOR	2022m10
POL	2023m2
SWE	2022m12
THA	2022m8
USA	2022m6
ZAF	2022m7

Source: IMF WEO, Haver, authors' calculations.
Note: Table reports month of peak in twelve-month headline inflation. Country labels indicate International Organization for Standardization (ISO) country codes except for EUA (euro area).

Annex Table 2. Cross-Section Estimates Underlying Results Reported in Figure 2

Headline Inflation vs. Energy Inflation

	(1) Rise	(2) Fall	(3) Overall
Slope	0.082*	0.099**	0.197***
	(0.039)	(0.038)	(0.020)
Constant	5.822***	-3.996***	0.298
	(1.372)	(1.266)	(0.742)
Observations	21	21	42
R-squared	0.122	0.149	0.751

Core Inflation vs. Energy Inflation

	(1) Rise	(2) Fall	(3) Overall
Slope	0.000	0.003	0.079***
	(0.024)	(0.024)	(0.013)
Constant	4.174***	-2.974***	0.325
	(1.142)	(0.977)	(0.521)
Observations	21	21	42
R-squared	0.000	0.000	0.501

Near-term Expectations vs. Energy Inflation

	(1) Rise	(2) Fall	(3) Overall
Slope	0.042	0.065**	0.094***
	(0.026)	(0.024)	(0.013)
Constant	2.721***	-1.057	0.295
	(0.935)	(0.739)	(0.472)
Observations	21	21	42
R-squared	0.062	0.154	0.626

Core Inflation vs. Unemployment

	(1) Rise	(2) Fall	(3) Overall
Slope	-0.093	-0.457	-0.606
	(0.296)	(0.719)	(0.619)
Constant	4.381***	-3.437***	0.235
	(0.793)	(0.872)	(0.944)
Observations	19	19	38
R-squared	0.003	0.029	0.031

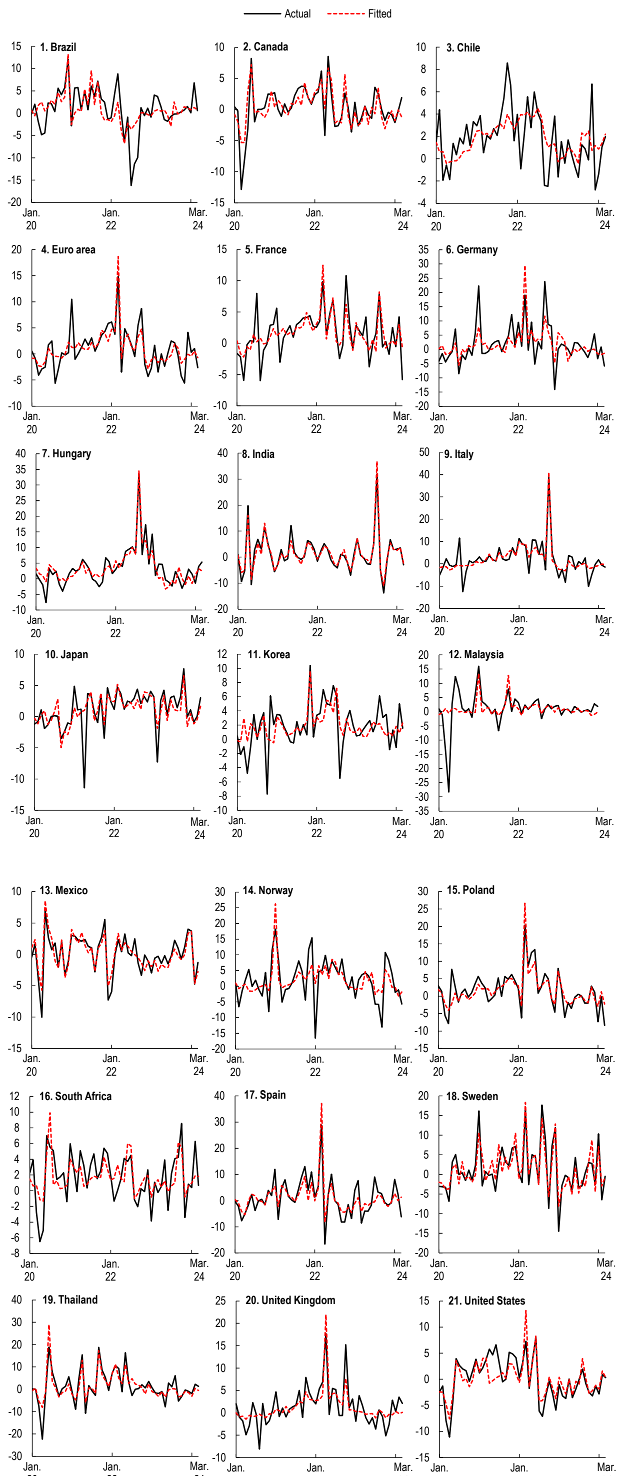
Note: Four panels of table report estimation results underlying the corresponding regression lines reported in the four panels of Figure 2. In each panel; column (1) reports results for changes from December 2020 to month of the country-specific peak in headline inflation; column (2) reports results for change from peak to the latest value (March 2024); and column (3) reports results for pooled regression across both time intervals. “Core inflation” denotes weighted median inflation. “Unemployment” denotes difference between unemployment rate and estimate of natural unemployment rate. Robust standard errors in parentheses.
***p < .01, **p < .05, and *p < .10

Annex Table 3. Explaining Headline Inflation Shocks, January 2020 - March 2024
(Dependent variable: Headline-inflation shock at monthly annualized rate)

	Economies	Energy price inflation	Food price inflation	Harper charter rate	Constant	Observations	R-squared
(1)	**Brazil**	0.081***	0.122*	-0.000	0.931	51	0.434
		(0.014)	(0.066)	(0.001)	(0.853)		
(2)	**Canada**	0.053***	-0.018	0.001**	-1.428**	51	0.619
		(0.010)	(0.069)	(0.000)	(0.608)		
(3)	**Chile**	0.053***	0.010	0.001*	0.342	51	0.303
		(0.017)	(0.052)	(0.000)	(0.514)		
(4)	**Euro area**	0.062***	0.031	0.000	-0.434	51	0.641
		(0.012)	(0.058)	(0.000)	(0.664)		
(5)	**France**	0.067***	0.045	0.000	0.084	51	0.536
		(0.010)	(0.051)	(0.000)	(0.725)		
(6)	**Germany**	0.081***	0.194**	-0.000	0.296	51	0.545
		(0.027)	(0.083)	(0.001)	(1.109)		
(7)	**Hungary**	0.062***	0.176***	0.000	0.880	51	0.820
		(0.005)	(0.037)	(0.000)	(0.749)		
(8)	**India**	0.074**	0.438***	-0.000	0.469	51	0.937
		(0.031)	(0.036)	(0.000)	(0.433)		
(9)	**Italy**	0.042***	-0.026	0.001***	-1.655	51	0.760
		(0.003)	(0.103)	(0.000)	(1.028)		
(10)	**Japan**	0.060*	0.315***	0.000	-0.341	51	0.475
		(0.032)	(0.064)	(0.000)	(0.663)		
(11)	**Korea**	0.014**	0.158***	0.001**	-0.468	51	0.339
		(0.005)	(0.033)	(0.000)	(0.722)		
(12)	**Malaysia**	0.010***	0.340**	-0.000	-0.230	49	0.209
		(0.002)	(0.146)	(0.001)	(1.726)		
(13)	**Mexico**	0.083***	0.314***	-0.000	-0.722*	51	0.790
		(0.011)	(0.031)	(0.000)	(0.395)		
(14)	**Norway**	0.016***	0.118***	0.001*	-1.105	51	0.462
		(0.005)	(0.038)	(0.001)	(1.047)		
(15)	**Poland**	0.093***	0.095**	0.001*	-0.529	51	0.739
		(0.019)	(0.042)	(0.000)	(0.713)		
(16)	**South Africa**	0.028***	-0.023	0.000	1.092	51	0.452
		(0.006)	(0.066)	(0.000)	(0.669)		
(17)	**Spain**	0.070***	-0.074	0.000	-0.191	51	0.741
		(0.013)	(0.114)	(0.000)	(0.883)		
(18)	**Sweden**	0.087***	0.003	0.000	-0.550	51	0.760
		(0.009)	(0.051)	(0.000)	(0.760)		
(19)	**Thailand**	0.061***	0.347***	0.001	-1.971**	51	0.746
		(0.014)	(0.101)	(0.000)	(0.977)		
(20)	**United Kingdom**	0.018***	0.047	0.001**	-0.922	51	0.623
		(0.004)	(0.057)	(0.000)	(0.764)		
(21)	**United States**	0.073***	-0.093	0.000	-1.062*	51	0.693
		(0.012)	(0.117)	(0.000)	(0.538)		

Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: Note: Headline-inflation shock denotes deviation of headline inflation from core (weighted median) inflation. Sample covers January 2020 – March 2024. For Malaysia, sample ends in January 2024. Relative energy and food price inflation are computed by subtracting median inflation from energy and food price inflation, respectively, in monthly annualized terms. Huber-White standard errors in parentheses.
***p < .01, **p < .05, and *p < .10

Annex Figure 1. Explaining Headline-inflation Shocks
Actual vs. Fitted Values
(Monthly annualized rate; percentage points)



Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: Figure reports actual and fitted values of headline inflation shocks based on estimation results reported in Annex Table 3.

Annex Table 4. Explaining Headline Inflation Shocks, January 2020 - March 2024: Country Specific Factors

(Dependent variable: Headline inflation shock at monthly annualized rate)

	Economies	Energy price inflation	Backlogs of work	Weighted average of car inflation	Dollar exchange rate, % change	Harper charter rate	Global supply chain pressure index	COVID-19 deaths, monthly	Food price inflation	Suppliers' delivery times	NEER, % change	Constant	Observations	R-squared
(1)	Brazil	0.073***	0.323**	0.060*								-14.414*	51	0.472
		(0.016)	(0.154)	(0.035)								(7.322)		
(2)	Canada	0.047***	0.305***		-0.012							-14.871***	51	0.766
		(0.006)	(0.058)		(0.014)							(2.762)		
(3)	Chile	0.054***				0.000	0.347*					0.293	51	0.334
		(0.015)				(0.000)	(0.178)					(0.511)		
(4)	Euro area	0.061***	0.056			0.000						-2.968	51	0.643
		(0.011)	(0.045)			(0.000)						(1.932)		
(5)	France	0.064***				-0.000		0.000**				-0.494	51	0.567
		(0.008)				(0.000)		(0.000)				(0.773)		
(6)	Germany	0.081***				-0.000			0.194**			0.296	51	0.545
		(0.027)				(0.001)			(0.083)			(1.109)		
(7)	Hungary	0.061***						0.000**	0.143***			-0.049	51	0.838
		(0.004)						(0.000)	(0.034)			(0.592)		
(8)	India		0.178						0.427***	-0.223**		2.271	51	0.926
			(0.129)						(0.025)	(0.103)		(4.894)		
(9)	Italy	0.040***						0.000**	0.028			-1.081	51	0.726
		(0.004)						(0.000)	(0.117)			(1.086)		
(10)	Japan	0.062**						0.000	0.315***			-0.210	51	0.474
		(0.028)						(0.000)	(0.073)			(0.443)		
(11)	Korea	0.014**				0.001**			0.158***			-0.468	51	0.339
		(0.005)				(0.000)			(0.033)			(0.722)		
(12)	Malaysia	0.009***			-0.104*						-0.030	1.000	49	0.268
		(0.002)			(0.059)						(0.083)	(0.695)		
(13)	Mexico	0.080***			-0.003*				0.309***			-0.902***	51	0.795
		(0.010)			(0.002)				(0.030)			(0.254)		
(14)	Norway	0.016***				0.001*			0.118***			-1.105	51	0.462
		(0.005)				(0.001)			(0.038)			(1.047)		
(15)	Poland	0.093***				0.001*			0.095**			-0.529	51	0.739
		(0.019)				(0.000)			(0.042)			(0.713)		
(16)	South Africa	-0.045***		0.224***						0.080**		-2.647*	51	0.598
		(0.013)		(0.040)						(0.035)		(1.511)		
(17)	Spain	0.071***				-0.000				-0.020		0.742	51	0.736
		(0.015)				(0.000)				(0.057)		(2.446)		
(18)	Sweden	0.087***				0.000		-0.000				-0.550	51	0.760
		(0.009)				(0.000)		(0.000)				(0.767)		
(19)	Thailand	0.061***				0.001			0.347***			-1.971**	51	0.746
		(0.014)				(0.000)			(0.101)			(0.977)		
(20)	United Kingdom	0.018***				0.001		0.000				-1.459*	51	0.628
		(0.004)				(0.000)		(0.000)				(0.797)		
(21)	United States	0.062***	0.162***	0.084***								-9.230***	51	0.929
		(0.007)	(0.044)	(0.011)								(2.222)		

Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: Headline-inflation shock denotes deviation of headline inflation from core (weighted median) inflation. Sample covers January 2020 – March 2024. For Malaysia, sample ends in January 2024. Relative energy, food, and auto-related price inflation variables are created by subtracting median inflation from energy, food, and auto-related price inflation respectively, in monthly annualized terms. Backlogs of work and suppliers' delivery times variables are taken from IHS Markit Economics. The Harper charter rate reflects the worldwide price evolution of the charter market for container ships, and this variable is taken from Harper Petersen Holding GmbH. Global supply chain pressure index variable is sourced from Federal Reserve Bank of New York. COVID-19 deaths variable is from Oxford Covid-19 Government Response Tracker. Huber-White standard errors in parentheses.
***p < .01, **p < .05, and *p < .10

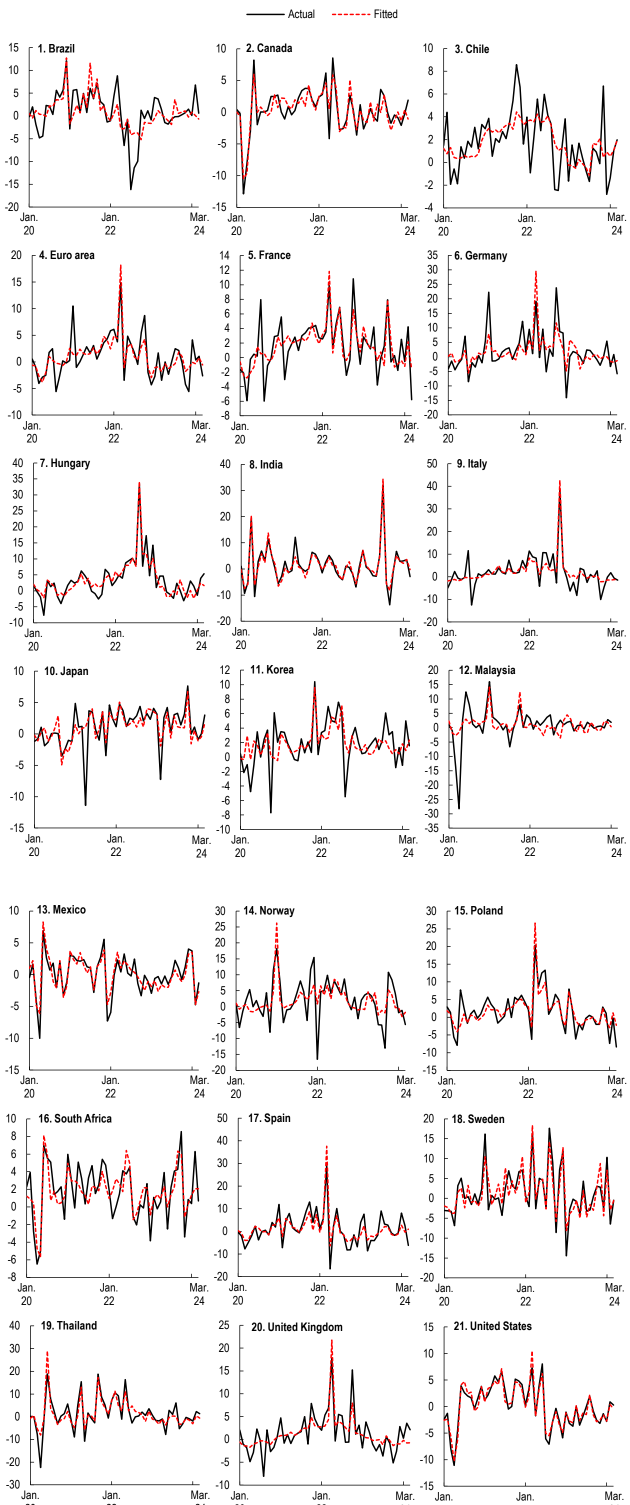
Annex Table 5. Top Three Drivers of Headline Inflation Shocks

	Top1	Top2	Top3
Brazil	Energy price inflation	Backlogs of work	Weighted average of car inflation
Canada	Energy price inflation	Backlogs of work	Dollar exchange rate, % change
Chile	Harper charter rate	Energy price inflation	Global supply chain pressure index
Euro area	Energy price inflation	Harper charter rate	Backlogs of work
France	Energy price inflation	COVID-19 deaths, monthly	Harper charter rate
Germany	Energy price inflation	Food price inflation	Harper charter rate
Hungary	Energy price inflation	Food price inflation	COVID-19 deaths, monthly
India	Food price inflation	Suppliers' delivery times	Backlogs of work
Italy	Energy price inflation	Food price inflation	COVID-19 deaths, monthly
Japan	Food price inflation	Energy price inflation	COVID-19 deaths, monthly
Korea	Food price inflation	Harper charter rate	Energy price inflation
Malaysia	Energy price inflation	Dollar exchange rate, % change	NEER, % change
Mexico	Energy price inflation	Food price inflation	Dollar exchange rate, % change
Norway	Energy price inflation	Food price inflation	Harper charter rate
Poland	Energy price inflation	Harper charter rate	Food price inflation
South Africa	Weighted average of car inflation	Energy price inflation	Suppliers' delivery times
Spain	Energy price inflation	Suppliers' delivery times	Harper charter rate
Sweden	Energy price inflation	Harper charter rate	COVID-19 deaths, monthly
Thailand	Energy price inflation	Food price inflation	Harper charter rate
United Kingdom	Energy price inflation	Harper charter rate	COVID-19 deaths, monthly
United States	Energy price inflation	Backlogs of work	Weighted average of car inflation

Notes. The top three drivers reported in the table are based on the highest bivariate R-squared statistics reported in Table 1.

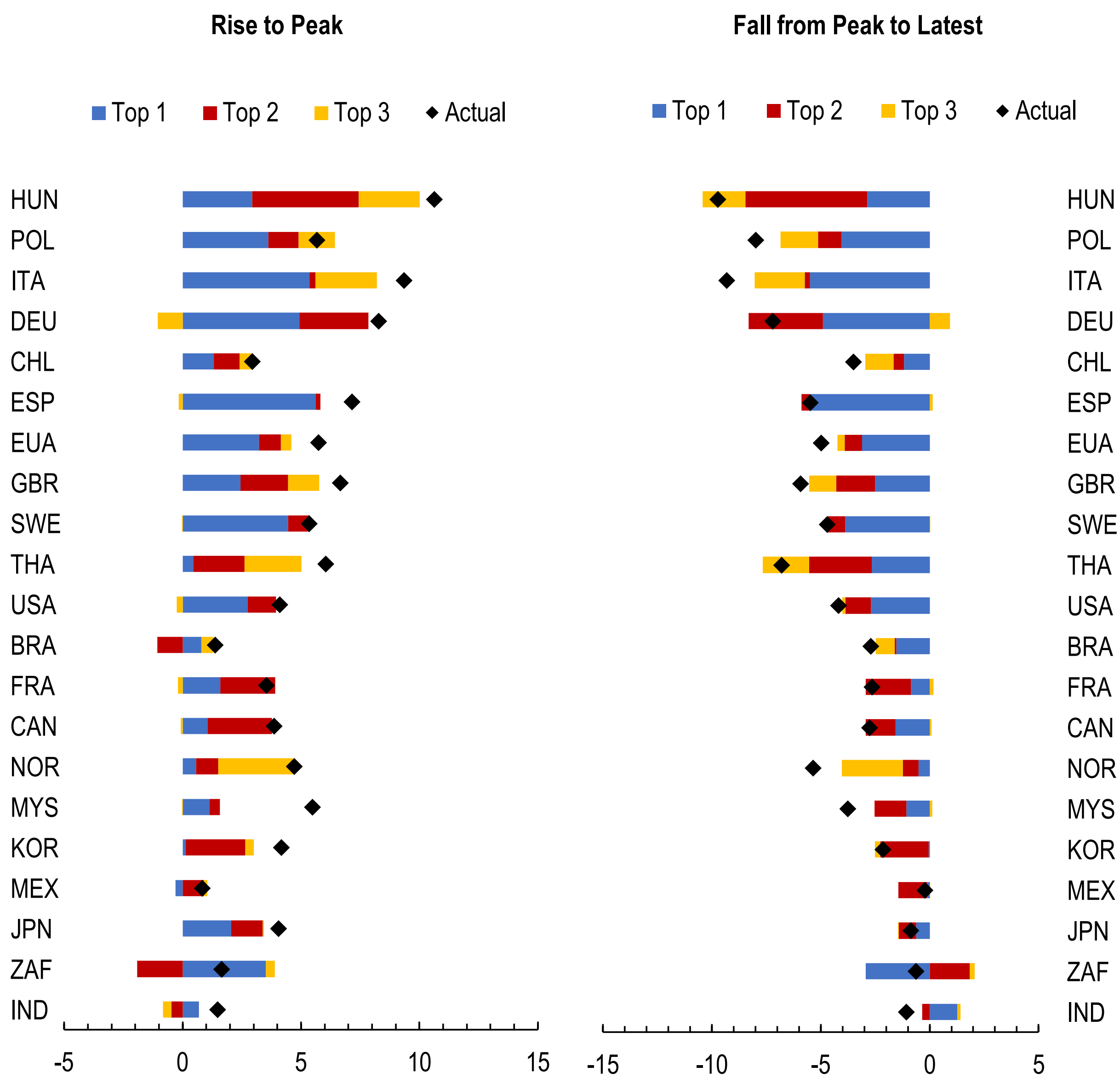
Annex Figure 2. Explaining Headline-inflation Shocks (country specific)
Actual vs. Fitted Values

(Percent; monthly annualized rate)



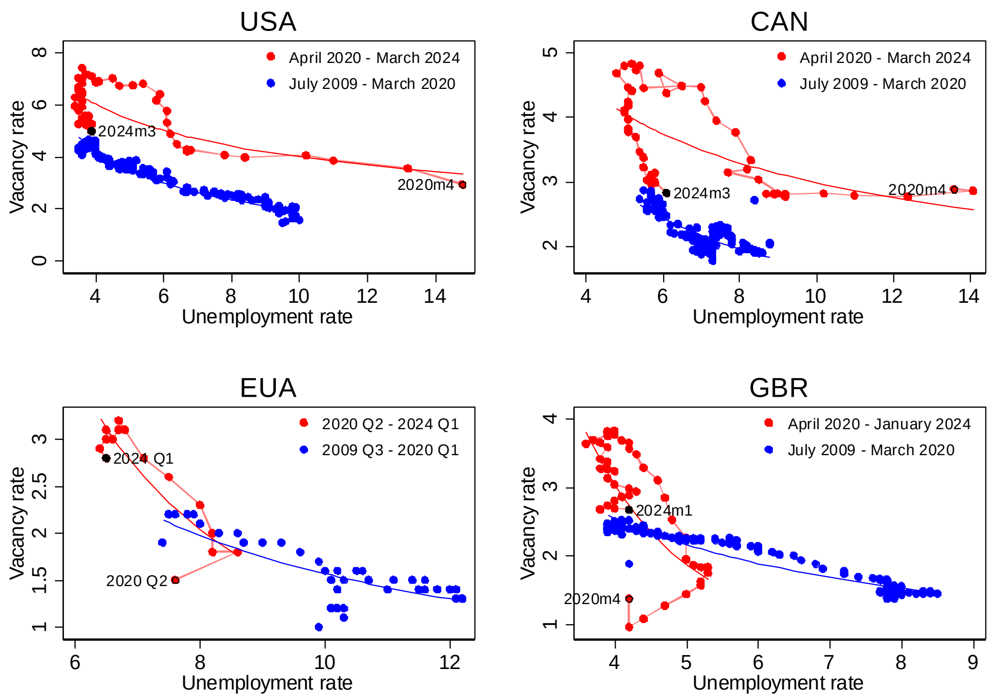
Sources: Haver analytics; Federal Reserve Bank of Cleveland; Statistics Canada; and authors' calculations.
Note: Figure reports actual and fitted values of headline inflation shocks based on estimation results reported in Annex Table 4.

Annex Figure 3. Headline Shock Decomposition with Country-specific Components
(Twelve-month rates; percentage points)



Notes. See notes to Figure 4. For the top three country-specific components, refer to list in Annex Table 5.

Annex Figure 4. The Beveridge Curve in the United States, Canada, the Euro Area, and the United Kingdom, 2009–2024
(Percent of filled and unfiled vacancies; percent of labor force)



Source: US Bureau of Labor Statistics, Statistics Canada, Eurostat, Office of National Statistics, and authors' calculations
Note: Chart reports log-linear curves fitted to each period. For the United States, July 2009 – March 2020 covers the pre-COVID-19 expansion and the first month of the COVID-19 era, based on NBER business cycle dates. For Canada, euro area, and United Kingdom, periods displayed correspondingly. Data labels in the figure use International Organization for Standardization (ISO) country codes except for EUA (euro area).

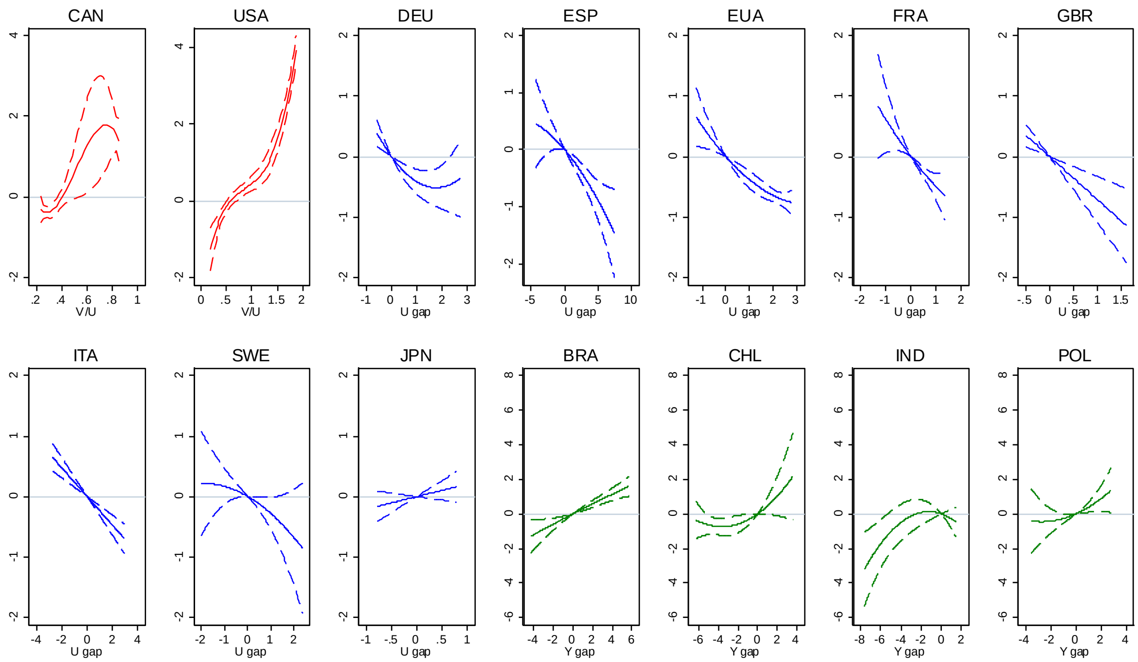
Annex Table 6. Phillips Curve Estimates: Median Inflation

	(1) DEU	(2) ESP	(3) FRA	(4) SWE	(5) EUA	(6) GBR	(7) ITA	(8) JPN	(9) BRA	(10) CHL	(11) IND	(12) POL	(13) CAN	(14) USA
Slack	-0.580***	-0.140***	-0.558***	-0.225**	-0.445***	-0.716***	-0.236***	0.206	0.293***	0.403*	-0.206	0.327**	0.525***	0.433***
	(0.158)	(0.049)	(0.131)	(0.110)	(0.127)	(0.196)	(0.042)	(0.164)	(0.069)	(0.206)	(0.254)	(0.126)	(0.181)	(0.078)
Slack-squared	0.164**	-0.008	0.055	-0.058	0.062				-0.002	0.055	-0.082**	0.059	0.305	-0.205*
	(0.076)	(0.011)	(0.170)	(0.090)	(0.056)				(0.013)	(0.042)	(0.040)	(0.069)	(0.232)	(0.105)
Slack-cubed													-0.087	0.115***
													(0.072)	(0.032)
H	0.308***	0.159	0.147	0.007	0.576***	0.843***	0.421***	0.107	0.302**	-0.073	0.458***	0.445	0.069	0.014
	(0.103)	(0.112)	(0.134)	(0.231)	(0.079)	(0.080)	(0.045)	(0.133)	(0.140)	(0.695)	(0.158)	(0.291)	(0.146)	(0.073)
H-squared	0.072***	0.121***	0.182***	0.267***	0.130***				0.293***	0.580***	-0.004	0.183***	0.127***	0.081***
	(0.025)	(0.019)	(0.045)	(0.060)	(0.023)				(0.061)	(0.177)	(0.046)	(0.050)	(0.049)	(0.018)
H-cubed													0.070**	0.042***
													(0.034)	(0.011)
Constant	-0.793***	-0.680***	-0.917***	-0.636***		-0.301**	-0.728***	-1.141***		-1.579**	-0.612**	-0.659*	-0.194*	0.124
	(0.066)	(0.241)	(0.138)	(0.159)		(0.133)	(0.095)	(0.061)		(0.645)	(0.246)	(0.368)	(0.100)	(0.078)
Observations	327	255	399	348	267	376	327	279	201	171	106	207	363	460
R-squared	0.570	0.480	0.504	0.317	0.758	0.317	0.538	0.0398	0.470	0.490	0.211	0.653	0.332	0.623
Measure of slack	U gap	U gap	U gap	U gap	U gap	U gap	U gap	U gap	Y gap	Y gap	Y gap	Y gap	V/U	V/U
Sample start year	1997	2003	1991	1995	2002	1992	1997	2001	2007	2010	2015	2007	1994	1985

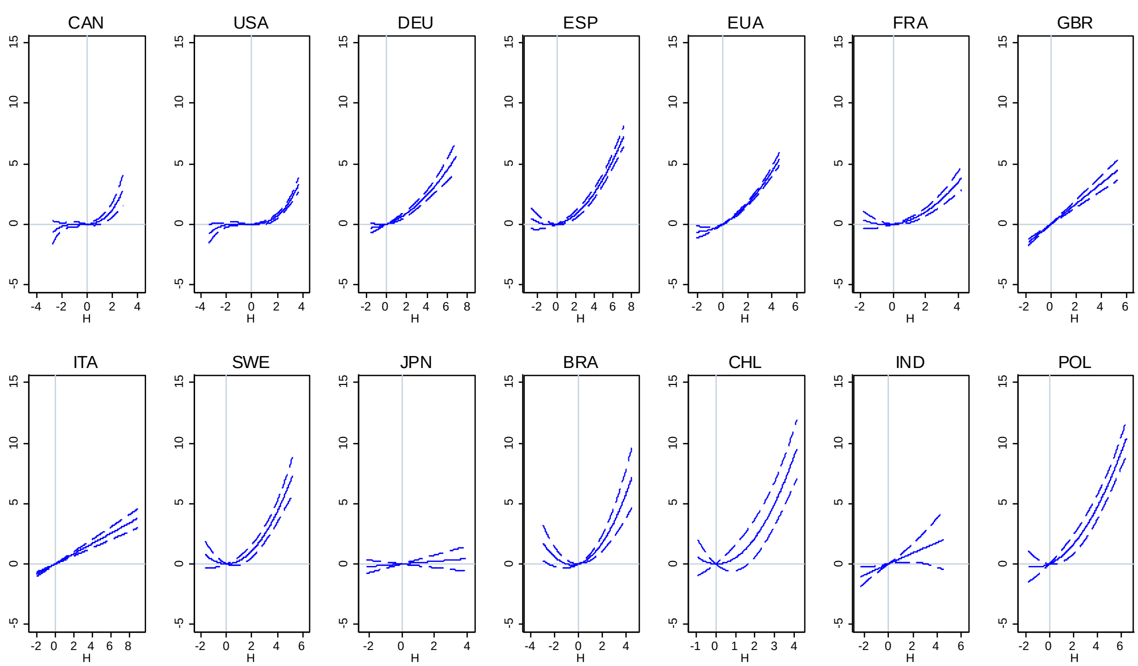
Note: "Slack" denotes contribution of change in economic slack. "U gap" denotes unemployment gap (twelve-month average). "Y gap" denotes output gap (four quarter average). "V/U" denotes ratio of vacancies to unemployed (twelve-month average). For comparability across economies in table, V/U variable is standardized before estimation. "H" denotes headline inflation shock (twelve-month average). Newey-West standard errors with twelve lags (monthly data) in parentheses. Data labels in the table use International Organization for Standardization (ISO) country codes except for EUA (euro area).
***p < .01, **p < .05, and *p < .10

Annex Figure 5. Estimated Inflation Gap as a Function of Slack and Headline Inflation Shocks (Percentage points; monthly data)

Panel A: Estimated inflation gap vs. economic slack measures



Panel B: Estimated inflation gap vs. headline inflation shock



Note: Panel A reports fitted values for economic slack terms from equation estimates reported in Annex Table 6. “V/U” denotes the ratio of vacancies to unemployment; “U gap” denotes the unemployment gap; and “Y gap” denotes the output gap. Panel B reports fitted values for headline inflation shock (H) terms. Dotted lines indicate 95 percent confidence interval. Inflation gap denotes monthly annualized median CPI inflation minus long-term inflation expectations. Data labels in the figure use International Organization for Standardization (ISO) country codes except for EUA (euro area).

Annex Table 7. Robustness: Excluding Outliers. Phillips Curve Estimates

	(1) DEU	(2) ESP	(3) FRA	(4) SWE	(5) EUA	(6) GBR	(7) ITA	(8) JPN	(9) BRA	(10) CHL	(11) IND	(12) POL	(13) CAN	(14) USA
Slack	-0.629***	-0.113***	-0.702***	-0.289***	-0.538***	-0.829***	-0.228***	0.209	0.305***	0.234	-0.313	0.377***	0.453***	0.436***
	(0.149)	(0.036)	(0.074)	(0.071)	(0.124)	(0.135)	(0.038)	(0.133)	(0.069)	(0.150)	(0.216)	(0.108)	(0.107)	(0.072)
Slack-squared	0.189***	-0.008	0.198	0.011	0.101*				-0.004	0.024	-0.096***	0.053	0.245*	-0.171**
	(0.068)	(0.007)	(0.121)	(0.077)	(0.053)				(0.012)	(0.030)	(0.034)	(0.061)	(0.145)	(0.082)
Slack-cubed													-0.066	0.099***
													(0.040)	(0.026)
H	0.214***	0.204***	0.002	-0.061	0.560***	0.820***	0.411***	0.075	0.205	-0.862	0.322**	0.302	-0.043	0.039
	(0.059)	(0.075)	(0.109)	(0.133)	(0.065)	(0.076)	(0.038)	(0.064)	(0.141)	(0.626)	(0.141)	(0.231)	(0.101)	(0.068)
H-squared	0.103***	0.116***	0.201***	0.214***	0.140***				0.347***	0.801***	-0.004	0.202***	0.082**	0.114***
	(0.014)	(0.017)	(0.042)	(0.051)	(0.017)				(0.028)	(0.154)	(0.054)	(0.036)	(0.038)	(0.017)
H-cubed													0.089***	0.039***
													(0.022)	(0.011)
Constant	-0.834***	-0.890***	-0.857***	-0.713***		-0.360***	-0.753***	-1.159***		-1.012*	-0.488**	-0.727**	-0.159	0.087
	(0.064)	(0.135)	(0.124)	(0.123)		(0.116)	(0.085)	(0.054)		(0.540)	(0.220)	(0.326)	(0.104)	(0.078)
Observations	312	240	372	323	251	358	312	258	187	166	100	195	338	434
R-squared	0.639	0.560	0.486	0.164	0.755	0.291	0.499	0.0437	0.455	0.555	0.251	0.569	0.149	0.556
Measure of slack	U gap	U gap	U gap	U gap	U gap	U gap	U gap	U gap	Y gap	Y gap	Y gap	Y gap	V/U	V/U
Sample start year	1997	2003	1991	1995	2002	1992	1997	2001	2007	2010	2015	2007	1994	1985

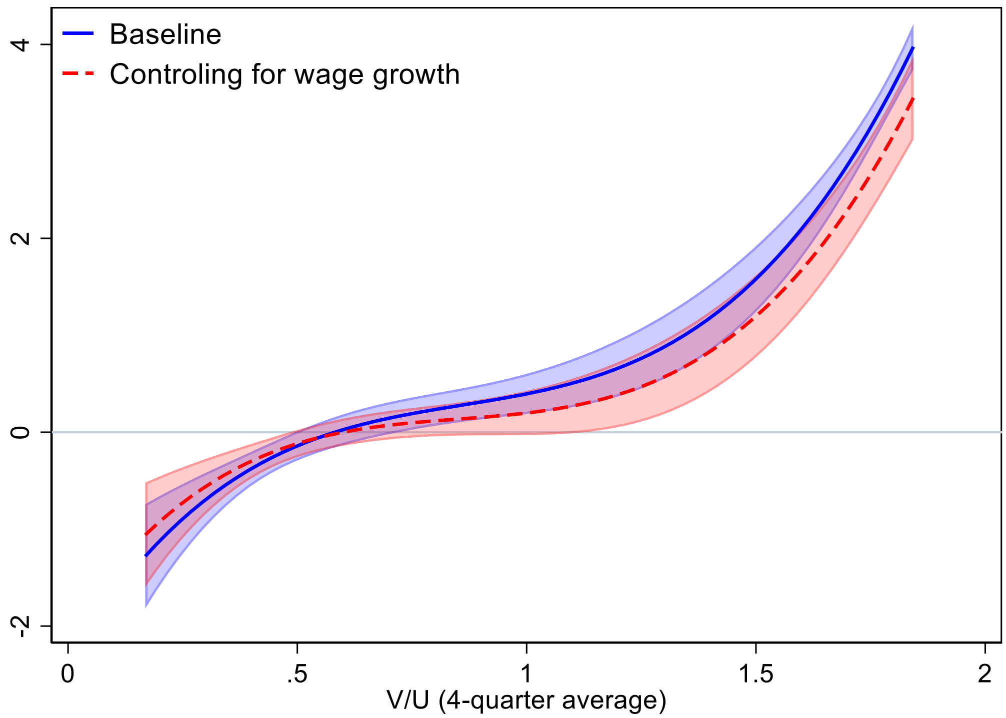
Notes: Table reports estimation results based on same specifications as in Annex Table 6 but with outliers excluded based on Cook's distance. Observations where Cook's distance exceeds $4/N$, where N is the sample size, are discarded. Newey-West standard errors with twelve lags (monthly data) in parentheses. Data labels in the table use International Organization for Standardization (ISO) country codes except for EUA (euro area).
***p < .01, **p < .05, and *p < .10

Annex Table 8. Robustness: Core Inflation based on Excluding Food and Energy. Phillips Curve Estimates

	(1) DEU	(2) ESP	(3) FRA	(4) SWE	(5) EUA	(6) GBR	(7) ITA	(8) JPN	(9) BRA	(10) CHL	(11) IND	(12) POL	(13) CAN	(14) USA
Slack	-0.097	-0.148***	-0.580***	-0.095	-0.421*	-0.615	-0.196**	-0.346	0.379***	0.473	-0.027	0.607***	0.330	0.455*
	(0.329)	(0.057)	(0.169)	(0.110)	(0.250)	(0.440)	(0.093)	(0.380)	(0.086)	(0.346)	(0.329)	(0.189)	(0.263)	(0.237)
Slack-squared	-0.022	-0.012	-0.279	0.008	-0.005				0.008	0.112	0.006	0.157**	0.466*	-0.136
	(0.169)	(0.013)	(0.274)	(0.124)	(0.110)				(0.016)	(0.071)	(0.045)	(0.078)	(0.270)	(0.160)
Slack-cubed													-0.110	0.060
													(0.079)	(0.064)
H	0.034	0.093	0.282	0.120	0.260	0.677***	0.600***	0.428**	0.146	0.046	0.129	0.699**	0.094	0.205
	(0.184)	(0.130)	(0.215)	(0.260)	(0.165)	(0.242)	(0.182)	(0.210)	(0.199)	(0.968)	(0.170)	(0.346)	(0.259)	(0.199)
H-squared	0.350***	0.185***	0.371**	0.703***	0.270***				0.377***	0.300	-0.001	0.659***	-0.010	0.072
	(0.058)	(0.023)	(0.155)	(0.115)	(0.060)				(0.057)	(0.287)	(0.046)	(0.109)	(0.180)	(0.054)
H-cubed													0.078	0.003
													(0.092)	(0.031)
Constant	-0.500***	-0.095	-0.209	-0.906***		-0.261	0.161	-1.219***		-0.803	0.468	-0.854**	-0.466***	-0.059
	(0.161)	(0.238)	(0.190)	(0.248)		(0.282)	(0.168)	(0.144)		(0.497)	(0.404)	(0.420)	(0.174)	(0.136)
Observations	339	348	399	348	268	407	399	339	202	171	142	312	363	460
R-squared	0.149	0.172	0.134	0.210	0.385	0.0799	0.0878	0.0170	0.384	0.144	-0.0197	0.518	0.0802	0.188
Measure of slack	U gap	U gap	U gap	U gap	U gap	U gap	U gap	U gap	Y gap	Y gap	Y gap	Y gap	V/U	V/U
Sample start year	1996	1995	1991	1995	2001	1990	1991	1996	2007	2010	2012	1998	1994	1985

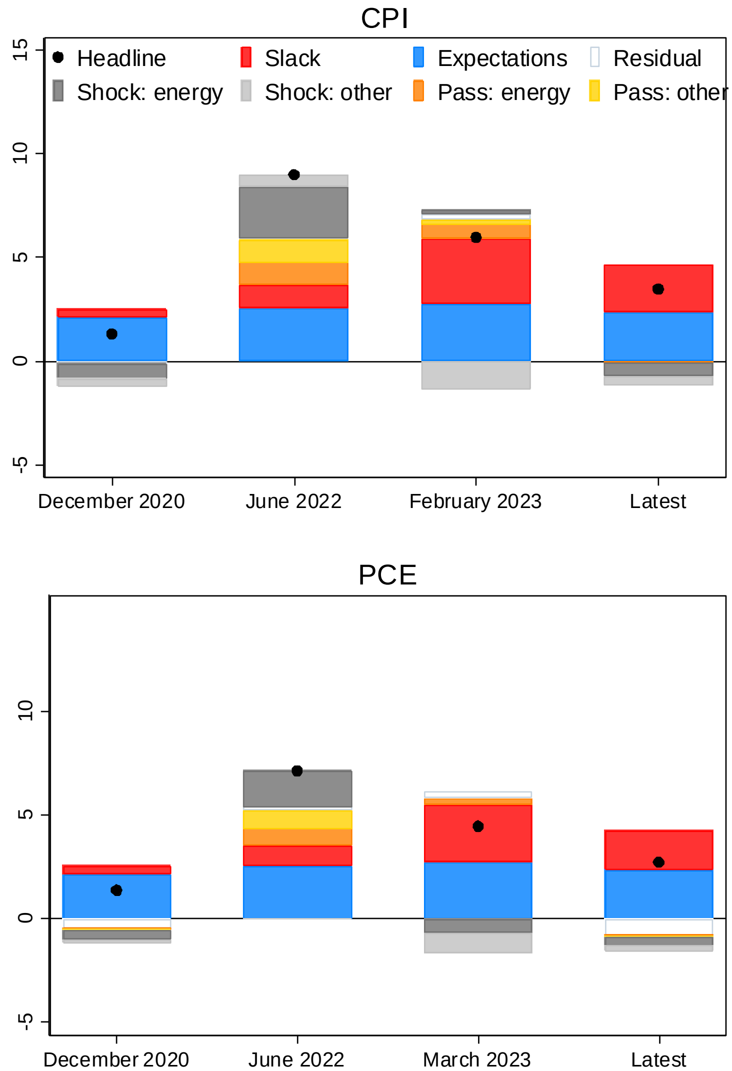
Notes: Table reports estimation results based on same specifications as in Annex Table 6 but with core inflation measured by monthly annualized inflation excluding food and energy (XFE) instead of with weighted median inflation. Newey-West standard errors with twelve lags (monthly data) in parentheses. Data labels in the table use International Organization for Standardization (ISO) country codes except for EUA (euro area).
***p < .01, **p < .05, and *p < .10

Annex Figure 6. Estimated Inflation Gap as a Function of Slack: United States
(Percentage points; quarterly data)



Sources: Consensus Economics; authors' calculations.
Note: "Baseline" indicates fitted values for V/U slack terms from quarterly data version of equation estimates reported in Annex Table 6 for the United States. "Controlling for wage growth" indicates fitted values after controlling for four-quarter average of wage growth based on the US Employment Cost Index for Private Industry Workers. Bands indicate 95 percent confidence interval. Inflation gap denotes quarterly annualized median CPI inflation minus long-term inflation expectations.

Annex Figure 7. United States: Contributions to CPI and PCE Inflation, 2020-2024
(Decomposition of headline CPI and PCE inflation; twelve-month rate; percentage points)



Sources: Haver analytics; Federal Reserve Bank of Cleveland; and authors' calculations.
Note: "Shock" denotes contribution of headline inflation shocks (energy or other). "Pass" denotes pass-through from headline inflation shocks (energy or other) into core inflation. "Energy" denotes contribution of relative energy prices. "Expected inflation" denotes contribution of change in long-term inflation expectations to change in headline inflation. "Slack" denotes contribution of change in economic slack (ratio of vacancies to unemployed for United States). Figure reports results for December 2020, June 2022 (peak in headline CPI and PCE inflation), February 2023 (peak in core CPI inflation), March 2023 (peak in core PCE inflation), and latest observation (March 2024).