Online Annex to Chapter 2 of the October 2022 Regional Economic Outlook: Europe

This annex to Chapter 2 of the October 2022 *Regional Economic Outlook: Europe* provides documentation of data sources, country coverage, methodologies, and extensions of the analyses. Section 2.1 summarizes the data sources and country coverage used in the Phillips curve estimation. Section 2.2 provides more details on the Phillips Curve estimation, while Section 2.3 discusses the forecasting based on the empirical Phillips curve. Finally, section 2.4 elaborates on the small dynamic stochastic general equilibrium model used to illustrate the range of possible inflation and policy rate paths.

2.1. Data Sources and Country Coverage

The Phillips curve analysis is conducted for 24 advanced European economies (AE), including Austria, Belgium, Cyprus, Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Ireland, Israel, Italy, Lithuania, Latvia, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and United Kingdom; and 7 emerging European economies (EE), Bulgaria, Croatia, Hungary, Poland, Romania, Russia and Türkiye. The following countries are included only in the panel analyses: Austria, Cyprus, Israel, Russia and Türkiye. The selection of countries in our estimation is based on data availability, in particular of medium-term inflation expectations. Annex Table 2.1.1 summarizes the data sources for the key variables of interest. The analysis is conducted at the quarterly frequency over the period 2000Q1-22Q2.

Annex Table 2.1.1. Data Sources

Variable	Source
Core/Headline consumer price index	Haver Analytics
Three-year-ahead inflation expectations	Consensus Economics
Commodity price (food and energy)	IMF, International Financial Statistics
Bilateral exchange rate against the US dollar	IMF, International Financial Statistics
External price pressure	IMF staff calculations
Producer price index	Haver Analytics
Bilateral exports and imports	IMF, Direction of Trade Statistics
Real GDP	IMF, World Economic Outlook Database
Unemployment rate	IMF, World Economic Outlook Database
Inflation target	Central Banks
Input shortages	European Commission
Labor shortages	European Commission
Vacancy-to-unemployment ratio	Eurostat and IMF staff calculations
Tax contribution to inflation	Eurostat and IMF staff calculations
Administered price contribution to inflation	Eurostat and IMF staff calculations

Sources: IMF staff compilation.

2.2. Determinants of Inflation

2.2.1 Phillips Curve Specification

A Phillips curve is estimated to establish the key drivers of inflation and quantify their relative contribution to the recent surge in prices across Europe. Drawing on past studies (Auer and others, 2017; Bems and others, forthcoming; Chapter 2 of the October 2021 *World Economic Outlook*), the baseline specification augments a standard New Keynesian Phillips curve with variables that proxy for price developments abroad, and global commodity prices:

$$\pi_{i,t} = \beta_1 \pi_{i,t-1} + \beta_2 \pi_{i,t}^{e} + \beta_3 y_{i,t} + \beta_4 Energy_{i,t} + \sum_{j=0}^{4} \beta_j^F \, Food_{i,t-j} + \beta_5 extP_{i,t-1} + FE_i + \varepsilon_{i,t},$$

where $\pi_{i,t}$ is the quarter-over-quarter annualized core (headline) inflation in country *i* in quarter *t*; $\pi_{i,t}^{e}$ denotes three-year-ahead inflation expectations; $y_{i,t}$ is the domestic economic slack measured by the unemployment gap (deviation from the Hodrick-Prescott —HP— filtered unemployment rate); $Energy_{i,t}$ and $Food_{i,t-j}$ are quarterly growth in energy and food prices expressed in domestic currency and weighted by the shares of these items in domestic CPI baskets; $extP_{i,t-1}$ refers to lagged external price pressures; FE_i are country fixed effects; and $\varepsilon_{i,t}$ is the error term.

The external price pressure variable is constructed following Chapter 2 of the October 2021 *World Economic Outlook*. It is defined as the sum of the percent change in the import-weighted producer price index (PPI) of countries *j* from which country *i* imports, the relative changes in bilateral exchange rates against the US dollar e in country *i* and *j*, weighted by country *j*'s share in country *i*'s total imports, $\omega_{ij,t}$, minus the percent change in country's *i* GDP deflator $P_{i,t}$:

$$extP_{i,t} = \sum_{j=1}^{J} \omega_{ij,t} \Delta PPI_{j,t} + \sum_{j=1}^{J} \omega_{ij,t} \left(\Delta e_{i,t} - \Delta e_{j,t}\right) - \Delta ln\left(P_{i,t}\right).$$

The baseline specification includes contemporaneous energy prices and food prices with four lags to account for the different speed of pass-through of food and energy prices to domestic inflation.[1] To introduce forward-looking and backward-looking components of inflation in line with the assumption of inflation equal to expected inflation in the long run, the benchmark specification imposes a constraint on the sum of coefficients on past inflation and inflation expectations to be one, following Galí and Gertler (1999).

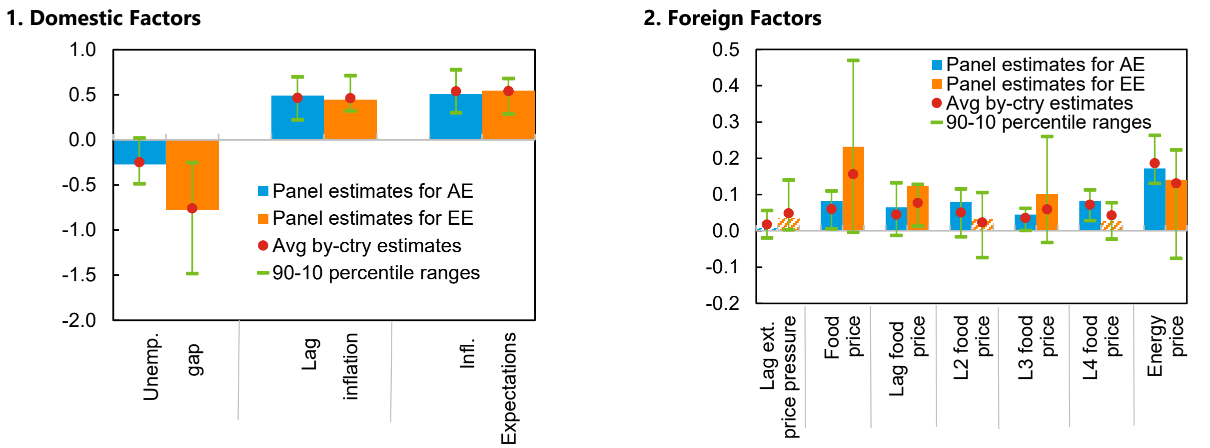
The Phillips curve is first estimated in a panel framework, separately for the group of AE and EE in order to detect potential differences in the relationship between inflation and its Phillips curve determinants among the two sets of countries. This analysis is then repeated separately for each country in the sample with sufficiently long time-series coverage (at least 30 quarters). The country-specific estimates of the relationship between inflation and its drivers are used to quantify the contribution of the various drivers to inflation in each country, as well as to forecast inflation paths under various scenarios as discussed below.

[1] The empirical results confirm that the pass-through of food prices to domestic CPI is slower than the pass-through of energy prices. The coefficient on lagged food price is statistically significant up to the fourth lag.

The estimation results for core and headline inflation are visually summarized in Figure 2.4 and Annex Figure 2.2.1, with panel regression results presented in Annex Table 2.2.1. On average, a 1 percentage point increase in unemployment above its HP trend is associated with a decline in core (headline) core inflation of 0.3 (0.3) percentage points in AE and 0.7 (0.8) percentage points in EE. Inflation expectations and lagged inflation are powerful predictors of future developments of both core and headline inflation. Foreign price developments measured by external price pressure variable and commodity prices are also found to drive core and headline inflation, reflecting their impacts on production costs (Conflitti and Luciani, 2019, and Kilian and Zhou, 2021). The estimated coefficients are roughly in line with the literature of empirical Phillips curves augmented with global factors (Chapter 3 of the October 2018 *World Economic Outlook*; Coibion and others, 2019).

The analysis reveals noteworthy differences between EE and AE. First, the slope of the Phillips curve – the coefficient on the domestic slack variable – is steeper in EE than in AE, for both core and headline inflation. Second, the coefficient on inflation expectations for core inflation is lower in EE (0.4 compared to 0.7 in AE), indicating that price setting is more backward-looking in EE. Third, external price pressures and commodity prices (especially food prices) play a more pronounced role in EE than in AE.

Annex Figure 2.2.1. Phillips Curve Coefficients for Headline Inflation



Sources: Consensus Economics; Haver Analytics; IMF, *World Economic Outlook*; and IMF staff calculations.
Note: The bars display panel regression coefficient estimates. The green line denotes the 90-10 percentile, and the red dot is the average value of the country-level estimates. Panel coefficient estimates, statistically significant at the 10 percent level, are in solid color. AE = advanced Europe; EE = emerging Europe.

Alternative specifications are estimated to test the robustness of these findings. Annex Table 2.2.1 reports (1) the benchmark results, (2) OLS estimates without a constraint on the coefficients on expected and lagged inflation rates, (3) median regression results to account for extreme observations, and (4) constrained regression using output gaps (measured by deviations from HP trends) as a measure of economic slack for AE. The corresponding results for EE are reported in columns (5)-(8). While the reported specifications do not include time fixed effects, the results are qualitatively similar if they are included. Across all specifications, the findings confirm the steeper slope of the Phillips curve and the bigger role of foreign price developments in EE than in AE. The coefficients on economic slack are not statistically significant for EE when measured by the output gap.[2]

[2] In addition to the results in Annex Table 2.2.1, specifications, which include a squared term of the output and unemployment gap to account for potential nonlinear effects at high levels of slack, were also estimated. The results suggest limited evidence of quadratic nonlinear effects in the slack variable in the sample of European economies over this time period.

Annex Table 2.2.1. Phillips Curve Panel Estimation Results

1. Headline inflation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Advanced Europe				Emerging Europe			
VARIABLES	Const Reg	OLS	Median Reg	Output Gap	Const Reg	OLS	Median Reg	Output Gap
Unemployment Gap	-0.272***	-0.261***	-0.184***		-0.781***	-0.819***	-0.489***	
	(0.058)	(0.052)	(0.035)		(0.230)	(0.184)	(0.089)	
Lag of Headline Inflation	0.492***	0.481***	0.398***	0.532***	0.450***	0.407***	0.346***	0.466***
	(0.040)	(0.051)	(0.021)	(0.046)	(0.130)	(0.061)	(0.042)	(0.133)
Inflation Expectations: 3 Years Ahead	0.508***	0.808***	0.964***	0.468***	0.550***	0.796***	0.815***	0.534***
	(0.040)	(0.150)	(0.116)	(0.046)	(0.130)	(0.161)	(0.122)	(0.133)
Lag of External Price Pressure	0.006	0.007	0.006	0.000	0.036	0.043	0.013	0.030
	(0.007)	(0.007)	(0.004)	(0.008)	(0.024)	(0.025)	(0.009)	(0.022)
Food Price	0.082***	0.085***	0.055***	0.079***	0.231***	0.221*	0.088***	0.226***
	(0.015)	(0.011)	(0.009)	(0.015)	(0.067)	(0.094)	(0.015)	(0.069)
Lag of Food Price	0.065***	0.066***	0.049***	0.073***	0.124***	0.108***	0.071***	0.130***
	(0.017)	(0.017)	(0.009)	(0.018)	(0.030)	(0.016)	(0.019)	(0.030)
L2 of Food Price	0.080***	0.082***	0.073***	0.084***	0.031	0.025	0.038**	0.037
	(0.013)	(0.011)	(0.009)	(0.013)	(0.042)	(0.020)	(0.016)	(0.042)
L3 of Food Price	0.045***	0.046***	0.028***	0.038***	0.100**	0.094*	0.053***	0.087**
	(0.012)	(0.009)	(0.009)	(0.012)	(0.041)	(0.048)	(0.016)	(0.040)
L4 of Food Price	0.083***	0.083***	0.045***	0.084***	0.026	0.018	0.042***	0.015
	(0.013)	(0.009)	(0.008)	(0.013)	(0.040)	(0.030)	(0.015)	(0.039)
Energy Price	0.172***	0.173***	0.172***	0.162***	0.140***	0.148***	0.167***	0.133***
	(0.010)	(0.012)	(0.007)	(0.010)	(0.027)	(0.018)	(0.016)	(0.026)
Output Gap				0.092***				0.079
				(0.025)				(0.093)
Observations	1,707	1,707	1,707	1,710	503	503	503	502

2. Core inflation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Advanced Europe				Emerging Europe			
VARIABLES	Const Reg	OLS	Median Reg	Output Gap	Const Reg	OLS	Median Reg	Output Gap
Unemployment Gap	-0.337***	-0.305***	-0.194***		-0.676***	-0.706**	-0.382***	
	(0.097)	(0.064)	(0.027)		(0.179)	(0.244)	(0.078)	
Lag of Core Inflation	0.287*	0.264*	0.451***	0.310*	0.581***	0.543***	0.495***	0.601***
	(0.161)	(0.129)	(0.023)	(0.165)	(0.105)	(0.045)	(0.046)	(0.108)
Inflation Expectations: 3 Years Ahead	0.713***	1.424**	0.644***	0.690***	0.419***	0.656***	0.702***	0.399***
	(0.161)	(0.528)	(0.089)	(0.165)	(0.105)	(0.089)	(0.128)	(0.108)
Lag of External Price Pressure	0.009*	0.011**	0.007***	0.005	0.037**	0.044*	0.011	0.030**
	(0.005)	(0.005)	(0.002)	(0.005)	(0.015)	(0.023)	(0.009)	(0.014)
Food Price	0.065***	0.070***	0.034***	0.059***	0.181***	0.171*	0.071***	0.178***
	(0.015)	(0.019)	(0.005)	(0.015)	(0.054)	(0.071)	(0.015)	(0.056)
Lag of Food Price	0.054***	0.055***	0.044***	0.061***	0.075***	0.056	0.048***	0.087***
	(0.020)	(0.009)	(0.006)	(0.020)	(0.027)	(0.037)	(0.016)	(0.028)
L2 of Food Price	0.045***	0.048***	0.032***	0.050***	-0.001	-0.008	0.022	0.006
	(0.015)	(0.015)	(0.006)	(0.017)	(0.030)	(0.021)	(0.015)	(0.030)
L3 of Food Price	0.077***	0.077***	0.042***	0.072***	0.065**	0.056	0.042***	0.054*
	(0.018)	(0.025)	(0.005)	(0.018)	(0.032)	(0.029)	(0.014)	(0.031)
L4 of Food Price	0.040**	0.040***	0.026***	0.040**	0.053**	0.043***	0.021	0.045*
	(0.019)	(0.010)	(0.006)	(0.019)	(0.026)	(0.004)	(0.013)	(0.026)
Energy Price	0.032***	0.034***	0.018***	0.018*	0.021	0.029	0.031**	0.012
	(0.008)	(0.011)	(0.005)	(0.010)	(0.022)	(0.019)	(0.013)	(0.022)
Output Gap				0.117***				0.097
				(0.036)				(0.076)
Observations	1,707	1,707	1,707	1,710	503	503	503	502

Sources: IMF staff calculations.
Note: Standard errors, reported in parentheses, are corrected for heteroscedasticity and autocorrelations. *** p<0.01, ** p<0.05, * p<0.1. All regressions include country fixed effects.

2.2.2. Contribution to Inflation Dynamics

Following Yellen (2015), the country-specific coefficients are used to compute the contribution from each regressor to inflation in each quarter. Considering the persistence of the inflation process, dynamic simulations of inflation are conducted. These use the coefficient on lagged inflation to attribute fluctuations in past inflation to movements in the Phillips curve explanatory variables.

Specifically, the contribution of explanatory variables x to inflation dynamics in country *i* at time t, $C_{i,t}^{x}$, is calculated by:

$$C_{i,t}^{x} = \hat{\beta}_t^{x} x_{i,t} + \hat{\beta}_1 C_{i,t-1}^{x}$$

where $\hat{\beta}_t^{x}$ is the corresponding coefficient on variable x obtained from country-by-country Phillips curve regressions, and $\hat{\beta}_1$ is the coefficient on lagged inflation.

Figure 2.5 in Chapter 2 shows the cross-country average contribution of each factor to core and headline inflation, expressed as deviations from the inflation target.[3] While conventional drivers of inflation continue to matter in the post-pandemic period, foreign price developments have been a major driver of rising headline and core inflation since 2021, both in AE and EE. By contrast, domestic factors, including inflation expectations, have played modest roles in the recent inflation surge.

These findings are intuitive in light of the dramatic changes in commodity prices in recent months and the still well-anchored inflation expectations. Moreover, while there is anecdotal evidence of diminishing economic slack in many economies in Europe, it is unclear to what extent this is properly captured by conventional unemployment and output gaps given the extraordinary supply shocks that have afflicted European economies since 2020.

2.2.3. Stability of the Phillips Curve

To explore possible structural shifts, the Phillips curve is estimated on a rolling basis, using panel data for 28 countries over 16 quarters. The point estimates along with the 90th percentile confidence intervals of the key inflation drivers are presented in Annex Figure 2.2.2.

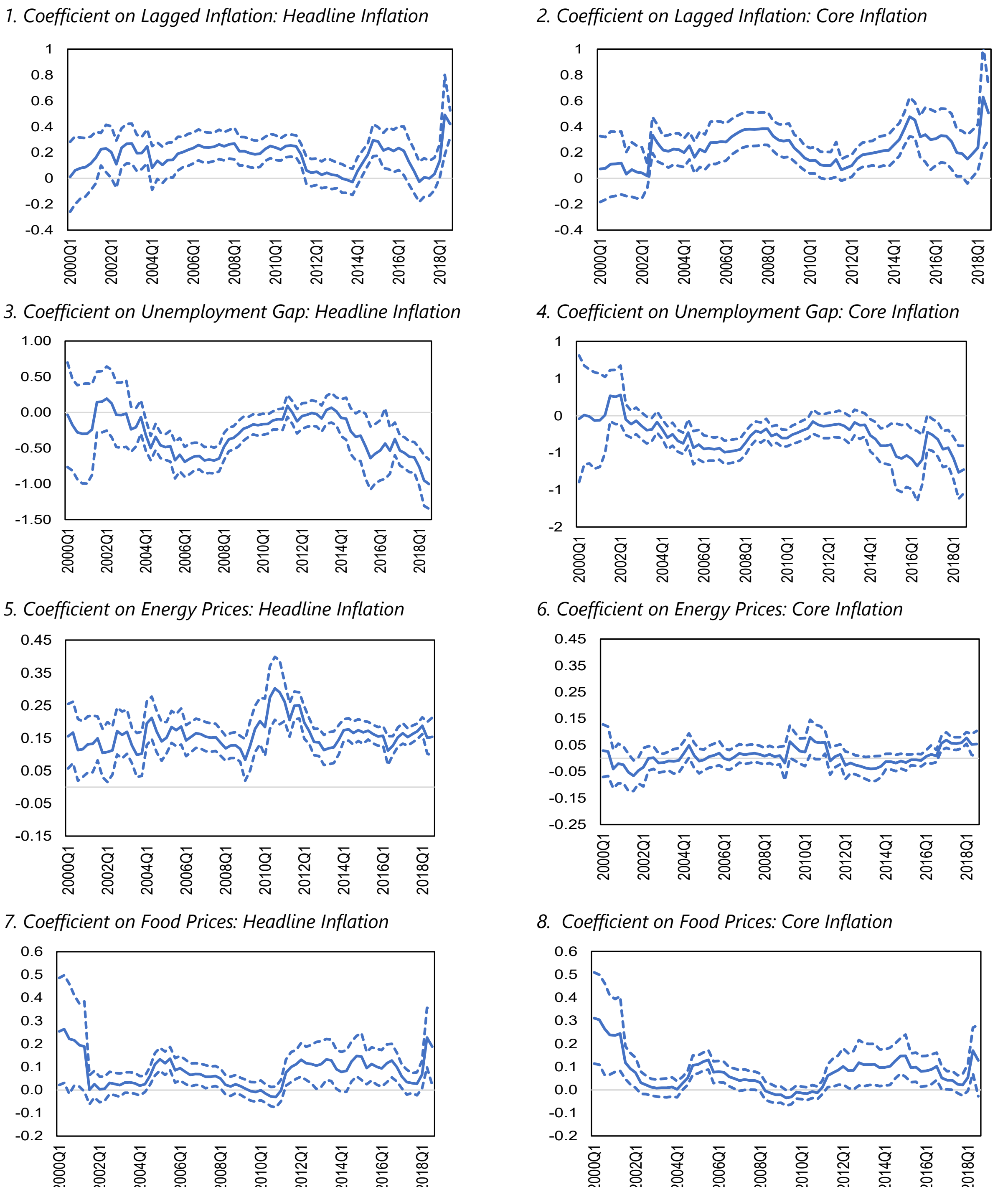
The rolling estimation points to several shifts in the Phillips curve coefficients in recent periods. First, the coefficient on lagged core (headline) inflation is significantly higher in the last 3 rolling sample periods, starting from the 2018Q1-2021Q4 window, suggesting that inflation has become more backward-looking. Likewise, the pass-through of global food prices to domestic inflation increased recently, while the rise in the pass-through of energy prices to core inflation is more moderate and started earlier during the pandemic. The coefficient on the unemployment gaps indicates that the Phillips curve has become steeper, reversing a flattening at the onset of the pandemic and resuming to follow a longer-term steepening trend that started in Europe after the global financial crisis (see for example Ciccarelli and Osbat, 2017).

It is too early to judge whether these findings signal long-lasting shifts in the structural relationships underpinning the inflation process in Europe. Nevertheless, the suggestive signs are worrisome. The increase in the extent to which inflation is influenced by its past values could make it harder to reduce inflation from the multidecade highs that it has reached. The greater pass-through of commodity prices

[3] For the few economies without explicit inflation targets, the analysis assumes a three percent target. The findings are robust to alternative assumptions, such as using moving averages of 10-year-ahead inflation expectations.

into core inflation makes inflation more vulnerable to negative supply shocks that the war in Ukraine and/or the increasingly frequent extreme weather events could trigger.

Annex Figure 2.2.2 Phillips Curve Rolling Regression Results



Sources: Consensus Economics; Haver Analytics; IMF, *World Economic Outlook*; and IMF staff calculations.

Note: The solid line displays the coefficients from rolling regressions on headline inflation (left panels) and core inflation (right panels). The dashed lines show its 10th-90th percentile confidence interval. Each regression covers a rolling window of 16 quarters starting in the quarter indicated on x-axis.

2.2.4. Drivers Beyond Conventional Factors

Given the large share of inflation that cannot be explained by the Phillips curve in recent quarters, correlation exercises attempt to associate unexplained inflation with various country characteristics or policy actions that may not be adequately captured in the standard Phillips curve model. The analysis should be interpreted only as suggestive, due to its limited data coverage.

As presented in Annex Table 2.2.2, regressions of the Phillips curve residuals on variables outside of the Phillips curve model find strong correlations with (i) supply bottlenecks, measured by the share of firms reporting shortages of intermediate inputs as a factor limiting productions and (ii) alternative measures of labor market tightness, such as the vacancy-to-unemployment ratio and the share of firms reporting labor shortages as a factor limiting productions. However, no clear relationship is established with the tax contribution to inflation, and administered price contribution to inflation.

To illustrate how these factors might have contributed to unexplained inflation developments in the post-COVID-19 period, a residual decomposition exercise is conducted by using the estimated historical correlation between the Phillips curve residual and the alternative measures of slack, input shortages and policy measures (Figure 2.6.4). The analysis suggests that input shortages and, to a lesser extent, labor shortages have exerted significant upward pressure on prices in the post-COVID-19 period. In particular, in the first half of 2022, these shortages can potentially explain a sizable share of the Phillips curve residual for both core and headline inflation.

Annex Table 2.2.2. Accounting for Phillips Curve Residuals by Nonconventional Drivers

1. Phillips Curve Residuals for Headline Inflation

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Labor Shortages	0.057***					0.038*
	(0.014)					(0.020)
Inputs Shortages		0.042***				0.025*
		(0.011)				(0.014)
Vacancies-to-unemployment Ratio			0.884			0.190
			(0.543)			(0.572)
Administered Price contribution to Inflation				0.152		0.127
				(0.186)		(0.240)
Tax Contribution to Inflation					0.058	0.078
					(0.221)	(0.218)
Constant	-0.324	-0.111	0.352	0.629***	0.675***	-0.495
	(0.275)	(0.257)	(0.257)	(0.170)	(0.181)	(0.348)
Observations	218	218	217	242	232	188
R-squared	0.070	0.067	0.018	0.006	0.001	0.085

Annex Table 2.2.2. Accounting for Phillips Curve Residuals by Nonconventional Drivers [continued]

2. Phillips Curve Residuals for Core inflation

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Labor Shortages	0.037***					0.019
	(0.010)					(0.012)
Inputs Shortages		0.034***				0.025**
		(0.008)				(0.012)
Vacancies-to-unemployment Ratio			0.713***			0.182
			(0.269)			(0.369)
Administered Price Contribution to Inflation				-0.185		-0.215
				(0.114)		(0.146)
Tax Contribution to Inflation					-0.004	0.059
					(0.160)	(0.163)
Constant	-0.238	-0.233	0.172	0.396***	0.404***	-0.427*
	(0.183)	(0.163)	(0.174)	(0.117)	(0.130)	(0.230)
Observations	218	218	217	242	232	188
R-squared	0.060	0.090	0.025	0.018	0.000	0.114

Sources: Eurostat; Haver Analytics; and IMF staff calculations.

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Input and labor shortages are measured as the share of firms reporting shortages of intermediate inputs or labor as a factor limiting productions. Administered price contribution to inflation is defined as inflation minus inflation excluding administered price. Tax contribution to inflation is defined as inflation minus inflation at constant price.

2.3. Forecasting Based on Phillips Curve

2.3.1 Baseline Inflation Forecasts

Inflation forecasts for the 2022Q3-2023Q4 period presented in Figure 2.7 are produced in two steps. In the first step, projections of the key determinants of inflation are prepared. For some of the explanatory variables, namely, food and energy prices and bilateral exchange rates, the analysis uses the IMF's global assumptions for the October *World Economic Outlook*. Auxiliary models are used to project the other variables in the Phillips curve, namely producer price index and three-year-ahead inflation expectations. The country-specific producer price index is projected based on its historical relationship with world GDP, world commodity prices, and its own lags up to two quarters. Likewise, country-specific three-year-ahead inflation expectations are projected by their historical relationships with the inflation target and inflation expectations in the last five quarters.

In the second step, the Phillips curve coefficients, estimated by country, are used to forecast country-specific inflation between 2022Q3 and 2023Q4 for two scenarios. The "optimistic" scenario assumes the unexplained inflation observed in 2022Q2 vanishes immediately and calculates fitted values of the Phillips curve model in the forecast period. The "conservative" scenario instead assumes that the residual estimated in 2022Q2 gradually decays through a first-order autoregressive process with autocorrelation coefficient of 0.6. Inflation is forecast recursively starting in 2022Q3. Specifically, inflation in 2022Q3 is projected based on actual lagged inflation (i.e., inflation in 2022Q2) and other exogenous variables; and in the following quarter (2022Q4), inflation is further projected by using forecasted inflation in 2022Q3 as lagged inflation. Figure 2.7 reports aggregated inflation across countries, with purchasing-power-parity GDP weights.

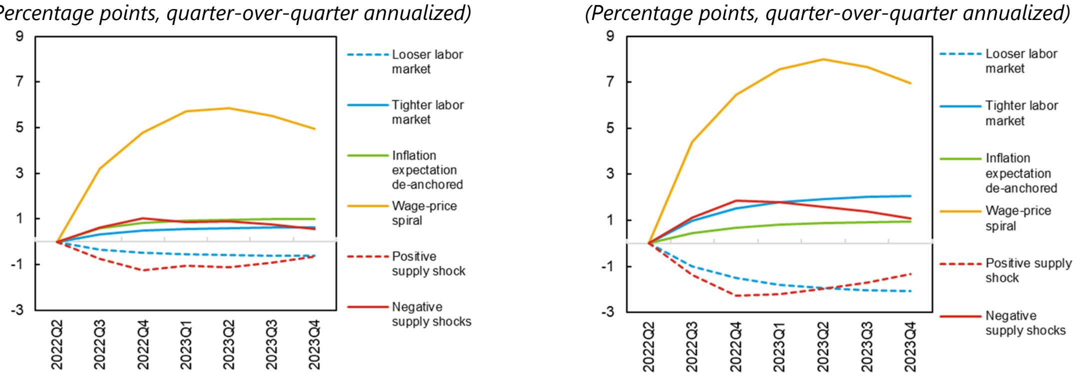
2.3.2. Scenario Analysis

The exercise considers six alternative scenarios for the exogenous explanatory variables as described in Table 2.1. Each scenario entails either different values for a projected explanatory valuable or a different coefficient on lagged inflation. Figure 2.8 and Annex Figure 2.3.1 report projections for core and headline inflation, respectively, under alternative scenarios, expressed as deviations from the baseline. The treatment of 2022Q2 residuals does not affect the simulations because the results are reported as deviations from the baseline forecast.

Annex Figure 2.3.1. Phillips Curve Simulations: Headline Inflation

1.Deviations from baseline: Advanced Europe
(Percentage points, quarter-over-quarter annualized)

2.Deviations from baseline: Emerging Europe
(Percentage points, quarter-over-quarter annualized)



Source: Consensus Economics; IMF, *World Economic Outlook*; and IMF staff calculations.
Note: The lines show the purchasing-power-parity GDP-weighted average of headline inflation paths (in deviation from baseline) under alternative scenarios as described in Table 2.1.

2.4. Model Analysis

2.4.1. Model Overview

The chapter uses a small dynamic stochastic general equilibrium model, calibrated to average AE and average EE, respectively, to examine monetary policy responses and implied macroeconomic impacts. The model is a variant of Galí and Monacelli's (2005) model and describes a small home economy with a representative household that produces tradable goods in a monopolistically competitive fashion with Calvo price setting and trades with the rest of the world under producer currency pricing.[4] Price setting is partially backward-looking as characterized by a lagged term in the Phillips curve. Expectations are rational and the model is solved under full information conditional on the respective shocks hitting the economy.

There are two shocks affecting the economy. A cost-push shock is used to model the inflation rise in the baseline scenario and the two scenarios with additional or less of a cost shock. A demand shock is introduced to model the demand contraction scenario.

The central bank follows a standard Taylor rule, setting the policy rate in response to the levels of CPI inflation and the output gap. The inflation target is set to zero and assumed to be fully credible except in the de-anchoring scenario.

The model equations and the parameter choices are displayed below (Annex Tables 2.4.1 and 2.4.2). AE and EE are assumed to have identical economic structures and only differ with respect to five parameters. Most variables are in percentage deviations from the steady state.

Exceptions are inflation, which is shown as quarter-over-quarter inflation rates, the policy rate in percentage points, and the nominal exchange rate and the terms of trade in log levels. $\kappa_a = \frac{(1-\beta\theta)(1-\theta)}{\theta}(\sigma_a + \varphi)$ is the Phillips curve slope where θ is the share of firms that cannot reset their prices in a given period, φ is the inverse Frisch elasticity and $\sigma_a = \frac{\sigma}{(1-\alpha)+\alpha\omega}$ is risk aversion σ, adjusted for the share of domestically produced goods $(1-\alpha)$ and where $\omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1)$ captures the effect of the substitution elasticities of home vs foreign goods η and of goods from different foreign countries γ. g_t is an exogenous demand shifter relative to GDP assumed to be zero in steady state for simplicity. a_t, y_t^* and π_t^* are treated as exogenous. Θ, Ψ and Γ are functions of $\sigma, \gamma, \varphi, \eta$ and α.

[4] Wages are set by unions in a monopolistically competitive fashion. However, wage inflation does not affect the dynamics of the core model so is not discussed henceforth.

Annex Table 2.4.1. Key Equations and Variables

1. Core Model Equations	
$\pi_t^d = (1-\iota)\beta E_t(\pi_{t+1}^d) + \iota\pi_{t-1}^d + \kappa_a x_t + \mu\, cost_t$	Phillips curve for domestic inflation π_t^d
$x_t = E_t(x_{t+1}) - \frac{1}{\sigma_a}\left[r_t - E_t(\pi_{t+1}^d) - r_t^{nat}\right]$	IS equation for output gap x_t
$r_t = \phi_\pi \pi_t^{cpi} + \phi_x(x_t + \varepsilon_t^{error})$	Monetary policy rule with CPI inflation π_t^{cpi} and policy error ε_t^{error}
$r_t^{nat} = -\sigma_a \Gamma(1-\rho_a)a_t + \alpha\sigma_a(\Theta+\Psi)E_t(\Delta y_{t+1}^*) + \frac{-\sigma_a}{\sigma_a+\varphi}\Delta g_t$	Natural rate of interest r_t^{nat} and demand shifter g_t
2. Other Endogenous Variables	
$x_t = y_t - y_t^{nat}$	Output gap, output y_t and natural output y_t^{nat}
$y_t = a_t + n_t$	Production function in TFP a_t and hours worked n_t
$y_t^{nat} = \Gamma a_t + \alpha\Psi y_t^* + \frac{\sigma_a}{\sigma_a+\varphi} g_t$	Natural output, driven by a_t, g_t and foreign output y_t^*
$y_t = c_t + g_t + \alpha\frac{\omega}{\sigma}s_t$	Market clearing with consumption c_t and terms of trade s_t
$\Delta s_t = \pi_t^* - \pi_t^d + \Delta e_t$	Terms of trade s_t, exch. rate e_t and foreign inflation π_t^*
$\pi_t^{cpi} = \pi_t^d + \alpha\Delta s_t$	CPI inflation
$nx_t = \alpha\left(\frac{\omega}{\sigma} - 1\right)s_t$	Net exports
3. Exogenous Processes	
$cost_t = \rho_{cost} cost_{t-1} + \varepsilon_t^{cost}$	Cost-push shock
$g_t = \rho_g g_{t-1} + \varepsilon_t^g$	Demand shock

2.4.2. Baseline and Scenario Calibration

The differences in parameter choice across the two regions are as follows: Compared to AE, EE is assumed to have (i) more frequent price setting by firms—once every 9 months on average compared to once every year; (ii) a smaller import share in consumption; (iii) a higher substitution elasticity of home-versus foreign goods; (iv) a larger backward-looking component in price setting and (v) a larger cost shock. The parameter choices imply three differences that will be crucial for the differences in simulation results. First, a cost shock hitting EE has much more severe inflation implications. Second, the Phillips curve is twice as steep in EE than in AE, their slope parameter is 0.69 compared to 0.34 in AE, rendering monetary policy more effective on the one hand and monetary policy errors more costly on the other hand. Third, the higher degree of backward-looking price setting behavior in EE renders any increase in inflation significantly more persistent.

For the baseline scenario, we assume that a single cost shock hits the economy with its size and persistence chosen to roughly match the baseline inflation trajectory in Figure 2.7. AE and EE are hit by the same shock with the same degree of persistence, but the effect on EE is increased by the scaling factor μ. For the negative/positive supply shock scenario the cost-push shock size is chosen to match the scenario in Figure 2.8, while keeping the autoregressive term of the cost shock as in the baseline scenario. In the less (more) slack scenarios the ε_t^{error} in the Taylor rule is set to minus (plus) 2 percent for six periods, capturing a mismeasurement of the output gap by the central bank causing higher (lower) than desired policy rates. For the de-anchoring scenario, a quasi-permanent shock to the Phillips curve is calibrated in such a way that inflation rises by one percentage point in the shock period. In the wage-price spiral scenario the backward-looking parameters in the Phillips curve are raised to 0.8 for both AE and EE, the degree of backward-looking inflation formation as estimated for the pre-1990 period. The size of the demand shock and its persistence are calibrated to generate an output contraction of 1 percent below the baseline in the shock period.

Annex Table 2.4.2. Model Calibration

	Advanced Europe	Emerging Europe	
α	0.29	0.21	Calibrated to reflect respective trade openness
β	0.99	0.99	Time preference reflecting 4 percent steady state real rate
γ	1	1	Galí and Monacelli (2005)
φ	3	3	Galí and Monacelli (2005)
η	1.2	1.8	
σ	1	1	Galí and Monacelli (2005)
ι	0.29	0.58	See Annex Table 2.2.1, lower panel
θ	0.75	0.66	Calibrated to match estimated Phillips curve slopes in Annex Table 2.2.1
ϕ_π	1.5	1.5	Standard Taylor rule
ϕ_x	0.5	0.5	Standard Taylor rule
ρ_{cost}	0.7	0.7	Calibrated to match baseline inflation
ρ_g	0.7	0.7	Calibrated to generate 1 percent output contraction on impact
μ	1	3	Capturing the relative exposure to cost shocks, see Annex 2.2.

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