Online Annex to Chapter 2 of the November 2023 Regional Economic Outlook: Europe

This annex to Chapter two of the November 2023 Regional Economic Outlook: Europe provides documentation of data sources, country coverage, and methodologies. Section 2.1 summarizes the data sources and country coverage used in the empirical analysis and provides more details on key data series. Section 2.2 provides details on the wage Phillips curve estimation. Section 2.3 elaborates on the interacted panel vector autoregression estimation. Finally, section 2.4 describes the system of equations for wage and inflation projections.

2.1 Data sources and description

2.1.1 Data sources

The wage Phillips curve estimation is conducted for 15 advanced European (AE) countries (excluding CESEE), including Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and United Kingdom; and 11 central, eastern, and southeastern European (CESEE) countries, including Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia and Slovenia. The selection of countries in our estimation is based on data availability, in particular of medium-term inflation expectations (2-years ahead). The sample of countries covers 94 percent and 91 percent of GDP, respectively, of AE and CESEE (excluding Belarus, Russia, Türkiye, and Ukraine). The interacted panel vector autoregression estimation additionally includes Cyprus, Luxembourg, and Malta in the AE sample. Both analyses are conducted at the quarterly frequency using available data over the period 1991Q1-23Q2. Annex Table 2.1.1 summarizes the data sources for the key variables of interest.

Annex Table 2.1.1. Data sources

Variable	Source
Compensation of Employees	Haver Analytics
Total Hours Worked	Haver Analytics
Nominal and Real Gross Domestic Product (GDP)	Haver Analytics and IMF, World Economic Outlook Database
Headline and Core Consumer Price Index	Haver Analytics and IMF, World Economic Outlook Database
Labor Productivity (real gross value added / total hours worked)	Haver Analytics and IMF staff calculations
Inflation Expectations (2-year ahead)	Consensus Economics
Unemployment Gap	Haver Analytics and IMF staff calculations
Import Price Index (price deflator for imports of goods and services)	Haver Analytics, IMF, World Economic Outlook Database, and IMF staff calculations
Vacancy-to-unemployment Ratio	Haver Analytics
Nominal GDP in Purchasing-power-parity Dollars	IMF, World Economic Outlook Database
Output Gap	Haver Analytics and IMF staff calculations
Monetary Policy Stance (change in ex-ante real interest rates)	Haver Analytics, Consensus Economics, and IMF staff calculations
Profitability (Gross operating surplus and mixed income for nonfinancial corporations in percent of nominal GDP)	Haver Analytics and IMF staff calculations
Inflation Anchoring Index (Chapter 3 of October 2018 World Economic Outlook)	Consensus Economics and IMF staff calculations
Index of Central Bank Transparency	Dincer, Eichengreen, and Geraats (2022)

Sources: IMF staff compilation.

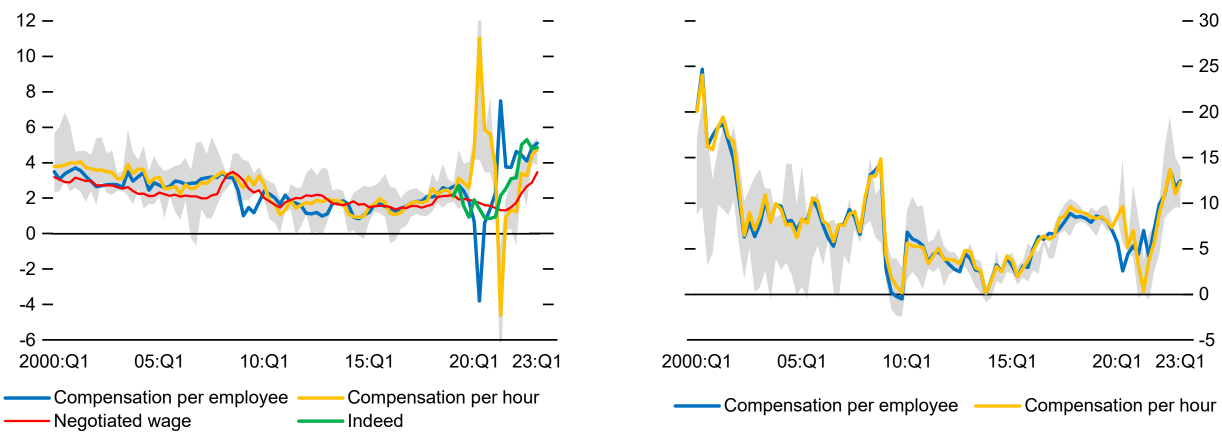
2.1.2 Alternative measures of wages and slacks

Wages are measured by compensation per hours worked, where compensation data are drawn from the national accounts and include wages and salaries, and social security contributions. Alternatively, wages can be measured by compensation per employee, which would allow greater country coverage. The two measures of wages historically moved closely with each other. However, during the pandemic, number of hours worked and number of hours paid largely deviated in countries that used short-time work schemes. This caused large spikes in wage series and a major disconnect between compensation per hour worked and per employee. Alternative data series on wages available for a subset of countries, in particular wages advertised in job postings from *Indeed* database and negotiated wage growth, do not exhibit major distortions during the pandemic. Despite the dispersion in 2020 and 2021, developments in different wage indicators start to comove again from around 2022.

Annex Figure 2.1.1. Comparison of wage measures

1. Wage developments in AE
(Percent; year-over-year growth)

2. Wage developments in CESEE
(Percent; year-over-year growth)

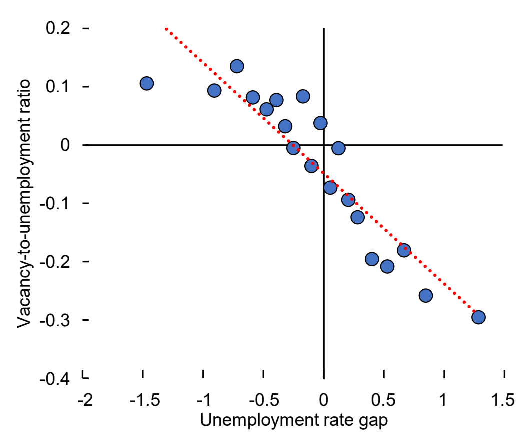


Sources: Haver Analytics, Eurostat, Indeed, Wage Tracker, and IMF staff calculations.

Note: PPP-GDP averages across countries with available data. Compensation per hour and compensation per employee are available for all countries in our sample. Negotiated wages are available for France, Germany, Italy, Netherlands, and Spain. Indeed wages are available for France, Germany, Italy, Ireland, Netherlands, and Spain. The shaded area represents inter-quartile ranges for compensation per hour worked.

The quantitative analysis in the chapter measures labor market slack by unemployment gaps from the Hodrick-Prescott filtered unemployment rate. While some argue that post-pandemic labor market slack is better captured by vacancy-to-unemployment (VU) ratio (see Bernanke and Blanchard, 2023), the VU ratio is not widely available for our sample of countries until around 2010. At the individual country level, a bin-scatter plot of VU ratios and unemployment gaps, both of which are expressed as deviations from their country averages, also show a clear negative correlation in the post pandemic period (Annex Figure 2.1.2).

Annex Figure 2.1.2. Correlation between VU ratios and Unemployment Gaps
(Deviation from 2019Q4)



Source: Eurostat, Haver analytics, and IMF staff calculations.

Note: Both vacancy-to-unemployment ratios and unemployment gaps are deviations from their country means. Outliers (top and bottom 5%) are excluded.

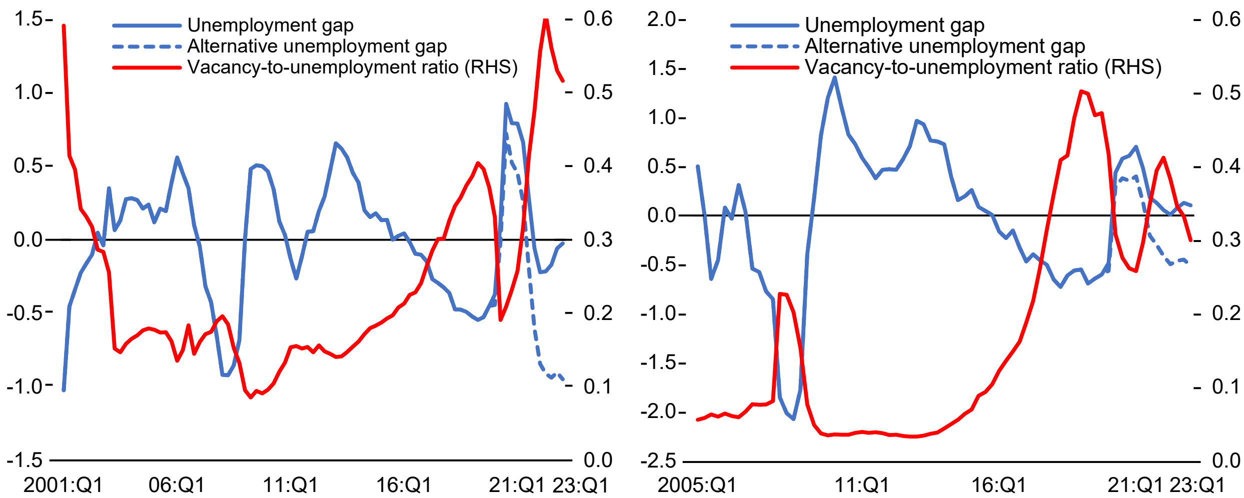
An alternative measure of unemployment gaps is considered in light of a weakened correlation between the VU ratio and unemployment gap in the recent period. Annex Figure 2.1.3 shows that, on average, the VU ratio and the unemployment gap comove negatively. However, unemployment gaps indicate greater labor market slack compared to the level before the pandemic in 2019, while the VU ratios indicate smaller slack in AE. As discussed in Chapter 2, there are arguments suggesting labor market slack as measured by the unemployment gap may be overstated. In light of this, an alternative unemployment gap is calculated by holding the natural unemployment rate at the 2019Q4 level from that point onward, which comoves more closely with the VU ratio in recent periods (Figure 2.1.3).

Annex Figure 2.1.3. Comparison of slack measures

1. VU ratio and unemployment gaps for AE excl CESEE

(left axis: ratio, right axis: percent)

2. VU ratios and unemployment gaps for CESEE



Sources: Eurostat, Haver analytics, and IMF staff calculations.
Note: PPP-GDP weighted averages. Alternative unemployment gaps are calculated by holding the natural rate of unemployment unchanged after 2019Q4.

2.1.3 Decomposition of Total Hours Worked

This section explains how total hours worked are decomposed into (i) average weekly hours worked per worker, (ii) decline in unemployment rate, (iii) labor force participation, (iv) population aging, (v) domestic population, and (vi) immigration (foreign population share).

Total hours worked are divided into average hours worked per week per employed worker (intensive margin), *h*, and the number of employed workers, *EMP* (extensive margin). The latter term can be further decomposed into different labor market elements as follows:

$$TotalHoursWorked = h * EMP_w$$

$$= h * \left(\frac{EMP_w}{LF_w}\right) * \left(\frac{LF_w}{POP_w}\right) * \left(\frac{POP_w}{POP_{all}}\right) * POP_{all,d} * \left(\frac{POP_{all,d} + POP_{all,f}}{POP_{all,d}}\right), \qquad (1)$$

where *h* is average hours worked, EMP_w is number of employed for working age population (*w*) (15 to 64 years old), LF_w is the number of people in the labor force (either employed or unemployed) for working age population, POP_w is working age population, POP_{all} is the population of 15 years old and above, $POP_{all,d}$ is domestic population, and $POP_{all,f}$ is foreign population. This can be written as:

$$= h * (1 - UR_w) * LFP_w * \left(\frac{POP_w}{POP_{all}}\right) * POP_{all,d} * \left(\frac{1}{\theta_d}\right), \qquad (2)$$

where UR_w is the unemployment rate, LFP_w is the labor force participation rate, $\left(\frac{POP_w}{POP_{all}}\right)$ is the share of working age population in total population, $POP_{all,d}$ is domestic population, and $\frac{1}{\theta_d}$ captures the share of foreign population (the inverse of native population share θ_d). Taking the log difference between period t and t-1 yields a decomposition of the change in total hours worked into the six components.

2.2 Drivers of Wage Growth

The chapter estimates a wage Phillips curve augmented with an error correction term for wage deviations from long-term trends to establish the key drivers of wage growth. The system of equations is estimated in two steps, following Engle and Granger (1987), by (1) estimating the long-run equation and (2) using the residuals from the cointegrating regression to estimate the short-run wage equation.

2.2.1 Long run wage equation

In the long run, the model assumes that real wages are determined by productivity and a deterministic trend. The link between real wages and labor productivity is well anchored in economic theory and follows the relationship between real wages and marginal product of labor. The baseline specification is written as a cointegrating equation:

$$\log w_{i,t}/p_{i,t} = \gamma_1 + \gamma_2 \log g_{i,t} + \gamma_3 \tau_t + \epsilon_{i,t}, \qquad (3)$$

where p is price level, g is labor productivity, and τ is a linear time trend, respectively, for country i and quarter t. The error term $\epsilon_{i,t}$ represents real wage gaps from the productivity trend and is used in the short-run analysis in the following section.

The model allows a linear trend. This represents long-term factors such as a demographic trend that can affect the real wage-productivity relationship, which may not be captured precisely within the finite sample. For example, if there is a higher share of old workers, the share of workers with high wages would increase due to the seniority, creating a positive link between the share of real wages and the work force ages. This relationship may not be fully captured by productivity. While the demographics implied trend itself may adjust in the future, within our sample period, the trend may generate upward pressures on real wages.

The equation is estimated for individual countries to allow heterogeneity in the strength of the wage-productivity relationship. At the panel level, a cointegration test of Pedroni (1999) finds that real wages and labor productivity are cointegrated in all country-panels, if country-specific cointegrating vectors are allowed. The country-level regressions, however, do not necessarily find the existence of a cointegrating relationship in all the countries. Of 26 countries in our sample, the null hypothesis of no-cointegrating relationship is rejected at 10 percent statistical significance for 16 countries. For some countries which have shorter sample periods, the residuals are found to be non-stationary within the analyzed period. The residuals, labelled real wage gaps (see Figure 2.4 in chapter 2), are obtained from the specification with a linear trend.

2.2.2 Short-run wage equation

A hybrid wage-Phillips curve augmented with an error correction term is estimated to describe the dynamics of wages by key drivers. Drawing on past studies (Bernanke and Blanchard, 2023; Chapter 2 of the October 2022 *World Economic Outlook*; and Chapter 2 of the October 2018 *Regional Economic Outlook: Europe*, among others), the benchmark specification relates wage inflation to lagged wage growth, wage expectations, real wage gaps from trend productivity, domestic slack, labor productivity, and cost-push shocks:

$$\Delta w_{i.t} = \alpha_i + \sum_{l=1}^{4} \beta_{1l} \Delta w_{i,t-l} + \beta_2 E_t(\Delta w_{i,t+1}) + \beta_3 EC_{i,t-1} + \beta_4 u_{i,t} + \beta_5 \Delta g_{i,t} + \beta_6 \Delta p_{i.t}^m + \varepsilon_{i,t}, \qquad (4)$$

where α_i reflects a country-specific constant, Δw is the quarter-over-quarter annualized wage growth; E(Δw) is a measure of medium-term wage expectations, proxied by two-year-ahead inflation expectations; EC measures catchup of wages to long-run equilibrium using an error-correction term obtained from the long-run wage equation, u is a measure of labor market slack measured by unemployment rates' deviation from the Hodrick-Prescott (HP) filtered unemployment rate, Δg is labor productivity growth, and Δp^m refers to import price growth, respectively, for country i and quarter t. All growth rates are calculated by log differences.

The benchmark specification includes quarterly lagged wage growth up to eight lags. This relatively long lag selection is guided by statistical significance of lagged wage growth in our sample. In addition, to introduce forward-looking and backward-looking components of wage inflation consistent with wage inflation equal to expected wage inflation in the long run, the benchmark specification imposes a constraint on the sum of coefficients on past wage inflation and inflation expectation to be one.

The wage Phillips curve is first estimated in a panel framework, separately for the group of AE and CESEE in order to detect potential differences in the relationship between wage inflation and its determinants among the two sets of countries. This analysis is then repeated separately for each country in the sample. The country-specific estimate of the relationship between wage growth and its drivers are used to quantify the contribution of the various drivers to wage inflation in each country, as well as to forecast wage growth, described in the last section.

The panel estimation results are presented in Annex Table 2.2.1. Columns 1 and 4 report the results with all available data for AE and CESEE, respectively. The other columns repeat the same regression using the pre-pandemic data only (columns 2 and 5) and excluding the pandemic periods (columns 3 and 6). The coefficient on lagged wage growth is sensitive to the choice of sample period reflecting distortions in wage growth during the pandemic especially for AE (see Section 2.1.2). The results excluding the pandemic observations are similar to the pre-pandemic estimates, reflecting limited availability of post-pandemic observations given the chosen lag structure. Hence, the benchmark analysis reported in the chapter uses estimation results obtained with pre-pandemic data.

The coefficient estimates have the expected signs and are in line with the literature. On average, a 1 percentage point increase in unemployment above its HP trend is associated with a decline in wage inflation of 1 percentage points in AE and 1.9 percentage points in CESEE. Lagged wage growth and expected inflation are both significant drivers of wage growth, while the coefficient on inflation expectation is smaller in CESEE compared to AE, pointing to a more backward-looking wage formation in CESEE (see also Chapter 2 of October 2022 *World Economic Outlook*). Wage growth in CESEE is also more sensitive to import price growth and productivity growth.

Annex Table 2.2.1. Wage Phillips Curve Panel Estimation Result

	(1) AE	(2) AE	(3) AE	(4) CESEE	(5) CESEE	(6) CESEE
Lagged wage inflation	0.0635	0.302***	0.308***	0.357*	0.394*	0.413*
(Sum of coefficients)	(0.125)	(0.106)	(0.104)	(0.153)	(0.173)	(0.168)
Inflation expectations	0.936***	0.698***	0.692***	0.643***	0.606***	0.587***
	(0.125)	(0.106)	(0.104)	(0.153)	(0.173)	(0.168)
Wage catch-up	-0.318***	-0.234***	-0.233***	-0.503***	-0.573***	-0.581***
	(0.060)	(0.057)	(0.055)	(0.115)	(0.146)	(0.143)
Unemployment gap	-1.211***	-0.998***	-0.976***	-1.600***	-1.850***	-1.801***
	(0.287)	(0.246)	(0.245)	(0.371)	(0.421)	(0.416)
Labor productivity growth	0.527***	0.370***	0.373***	0.757***	0.807***	0.807***
	(0.082)	(0.066)	(0.066)	(0.054)	(0.059)	(0.059)
Imported price growth	0.023	0.017	0.017	0.125***	0.088***	0.080**
	(0.021)	(0.019)	(0.019)	(0.029)	(0.034)	(0.032)
Observations	1,531	1,337	1,351	905	762	773
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Coef. Const.	Yes	Yes	Yes	Yes	Yes	Yes
Sample Period	Full	Pre-Covid	Drop Covid	Full	Pre-Covid	Drop Covid
Memorandum:						
Wage growth - Lag 1	-0.250***	-0.236***	-0.230***	-0.076*	-0.050	-0.046
	(0.059)	(0.044)	(0.044)	(0.042)	(0.049)	(0.048)
Wage growth - Lag 2	-0.066*	-0.023	-0.024	0.148***	0.155***	0.162***
	(0.039)	(0.043)	(0.042)	(0.042)	(0.048)	(0.047)
Wage growth - Lag 3	0.078***	0.093***	0.093***	0.060	0.053	0.056
	(0.028)	(0.034)	(0.033)	(0.050)	(0.057)	(0.056)
Wage growth - Lag 4	0.061**	0.048	0.055	-0.007	-0.040	-0.037
	(0.031)	(0.043)	(0.043)	(0.057)	(0.066)	(0.065)
Wage growth - Lag 5	0.044	0.080*	0.084*	0.045	0.060	0.063
	(0.032)	(0.043)	(0.043)	(0.037)	(0.042)	(0.041)
Wage growth - Lag 6	0.120***	0.197***	0.199***	0.116***	0.134***	0.141***
	(0.032)	(0.048)	(0.048)	(0.037)	(0.042)	(0.042)
Wage growth - Lag 7	0.087***	0.184***	0.177***	0.064	0.053	0.050
	(0.029)	(0.038)	(0.038)	(0.042)	(0.047)	(0.046)
Wage growth - Lag 8	-0.010	-0.040	-0.047	0.007	0.028	0.023
	(0.025)	(0.038)	(0.036)	(0.051)	(0.061)	(0.060)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Sources: IMF staff estimates.
Note: Unbalanced panel data for 15 AE (excl. CESEE) and 11 CESEE countries. “Full sample” is estimated with 1991Q1-2023Q2 data, “pre-Covid” is estimated with 1991Q1-2020Q1 data, and "drop Covid” is estimated with 1991Q1-2023Q2 data excluding 2020Q2-2021Q1 observations. The sum of coefficients on lagged wage growth and expected inflation rates are constrained to be one. Standard errors, reported in parentheses, are corrected for heteroscedasticity and autocorrelations. All regressions include country fixed effects.

2.2.3 Contribution to Wage Dynamics

Considering the persistence of the wage growth, contributions to wage growth are simulated in a dynamic way, attributing fluctuations in past wage growth to movements in the independent variables. Specifically, the contribution of independent variables x to wage dynamics in country i at time t, $C_{i,t}^{x}$, is calculated by:

$$C_{i,t}^{x} = \hat{\beta}_{t}^{x} x_{i,t} + \hat{\beta}_{11} C_{i,t-1}^{x} + \cdots + \hat{\beta}_{18} C_{i,t-8}^{x}, \qquad (5)$$

where $\hat{\beta}_{t}^{x}$ is the corresponding coefficient on variable x obtained from country-by-country wage Phillips curve regressions, and $\hat{\beta}_1$ is the coefficient on lagged wage growth. The country specific coefficients are used to compute the contribution from each regressor to wage growth in each quarter.

Figure 2.5 in Chapter 2 shows the cross-country average contributions of each factor to wage growth. “Other” includes country fixed effects and residuals.

2.3 Passthrough to Inflation

The link from wage growth to inflation is first analyzed with a panel vector autoregression (PVAR) model, drawing on the specification used in Chapter 2 of the 2019 *Regional Economic Outlook: Europe*. It estimates a four variable PVAR, comprising import price inflation, nominal wage growth adjusted for trend productivity growth, core inflation, and unemployment gap. Using the described order, the Cholesky identification of shocks assumes that wage growth affects inflation immediately, while it takes at least a quarter for wages to respond to inflation and the unemployment rate. Shocks to import prices are allowed to affect wages, inflation, and unemployment contemporaneously.

The PVAR model used in the analysis is represented as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ \alpha_0^{21} & 1 & 0 & 0 \\ \alpha_0^{31} & \alpha_0^{32} & 1 & 0 \\ \alpha_0^{41} & \alpha_0^{42} & \alpha_0^{43} & 1 \end{bmatrix} \begin{bmatrix} \Delta p_{it}^{m} \\ \Delta \widetilde{w}_{it} \\ \Delta p_{it} \\ u_{it} \end{bmatrix} = \sum_{l=1}^{L} \begin{bmatrix} \alpha_l^{11} & \alpha_l^{12} & \alpha_l^{13} & \alpha_l^{14} \\ \alpha_l^{21} & \alpha_l^{22} & \alpha_l^{23} & \alpha_l^{24} \\ \alpha_l^{31} & \alpha_l^{32} & \alpha_l^{33} & \alpha_l^{34} \\ \alpha_l^{41} & \alpha_l^{42} & \alpha_l^{43} & \alpha_l^{44} \end{bmatrix} \begin{bmatrix} \Delta p_{it-l}^{m} \\ \Delta \widetilde{w}_{it-l} \\ \Delta p_{it-l} \\ u_{it-l} \end{bmatrix} + FE_i + e_{it}, \qquad (6)$$

where Δp_{it}^{m} is import price inflation, $\Delta \widetilde{w}_{it}$ is nominal wage growth adjusted for trend productivity growth, Δp_{it} is core inflation. All are measured in year-on-year changes. u_{it} is the unemployment gap. FE represents a set of country fixed effects, and e_{it} is a vector of structural shocks that are assumed to be uncorrelated with one another. The lag length L is set at four. The model is estimated for an unbalanced panel of 29 countries from 1991Q1 through 2023Q1.

The estimation accounts for the (temporary) structural change during the pandemic. The pandemic caused a major, temporary, break for a few quarters following 2020Q2. As discussed in the first section, many countries in Europe used short-time work schemes and subsidized labor costs when the pandemic started, which caused a major disconnect between wages (per hour) from standard wage drivers. Through subsidies, wages were kept nominally, broadly unchanged while hours collapsed due to social distancing measures. Firms responded to the lockdown-related drop in demand with temporarily lowering prices. As economies reopened, wages per hour fell back to previous levels but prices started to increase as lockdown-related supply constraints were met with catch-up demand. In fact, observations since 2020Q2 materially influence PVAR estimates, including the impulse response functions (IRF). Annex Figure 2.3.1 shows that the reaction of inflation to wage shocks changes materially compared to the results based on pre-pandemic data (estimated using the data until 2020Q1).

Following Lenza and Primiceri (2021), the following IPVAR estimations drop observations around the pandemic (2020Q2-2021Q2) to take care of the large volatility while making use of post-pandemic observations once the shocks recede. Results on the interaction terms discussed next are robust to dropping the entire post-Covid period.

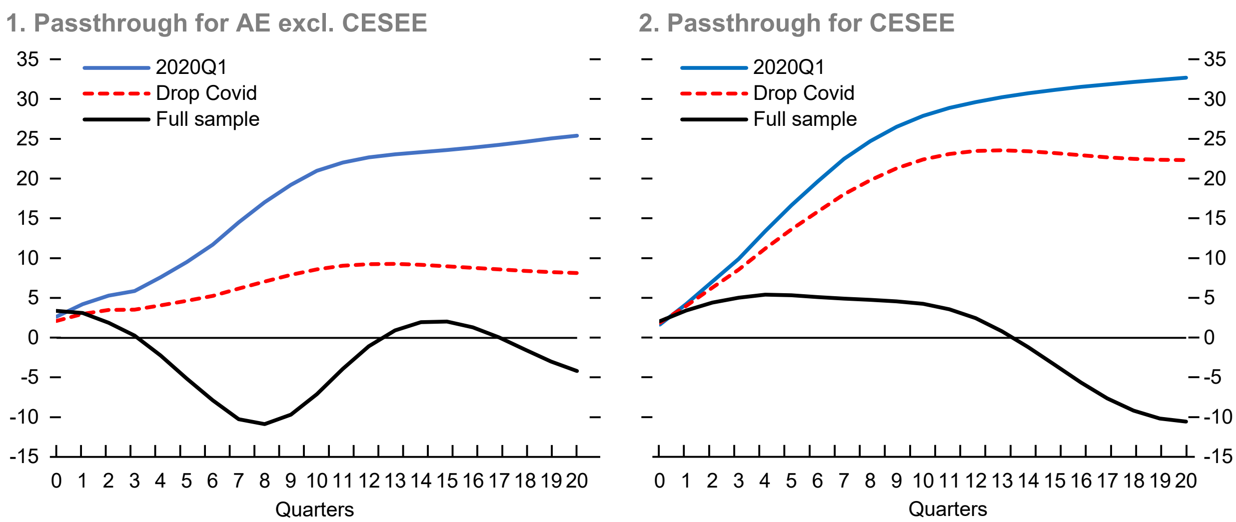
To explore specific factors that affect the strength of passthrough from wages to inflation, interaction terms are introduced using the interacted-PVAR (IPVAR) model. This model can be represented in a similar way as the PVAR, with the coefficient matrix having a time-varying and country-specific structure. In particular, coefficients in equation (6) are modified to:

$$\alpha_{l,it}^{jk} = \theta_{1,l}^{jk} + \theta_{2,l}^{jk} factor_{it}, \qquad (7)$$

where $factor_{it}$ refers to a time-varying country characteristic assumed to have an impact on the passthrough.

Several cyclical and structural factors are explored as factors that could affect the extent of wage passthrough to inflation. The analysis considers each interaction term separately. The factors related to cyclical conditions are used with two lags to avoid potential endogeneity issues. Cyclical factors include the output gap, firm profitability, the monetary policy stance, and the inflation regime. Profitability is defined as non-financial corporations' profit per unit of output. The monetary stance is measured by the extent of tightening reflected in the change in the real interest rate. The inflation regime is defined relative to the country specific historical inflation average, assigning the value of 1 if inflation is above, and the value of zero if inflation is below the average. In addition, two structural dimensions are considered: central bank transparency, and inflation expectations anchor. Central bank transparency is an index with score ranging from 0 to a maximum of 15, measured by analyzing political, economic, procedural, policy and operation transparency (see Dincer and others, 2022). Inflation expectation anchor is the average of three 3-year ahead inflation expectations measures: root mean squared deviation between the expectation and inflation target, dispersion of expectation, and standard deviation of expectation over time (Bems and others, 2021).

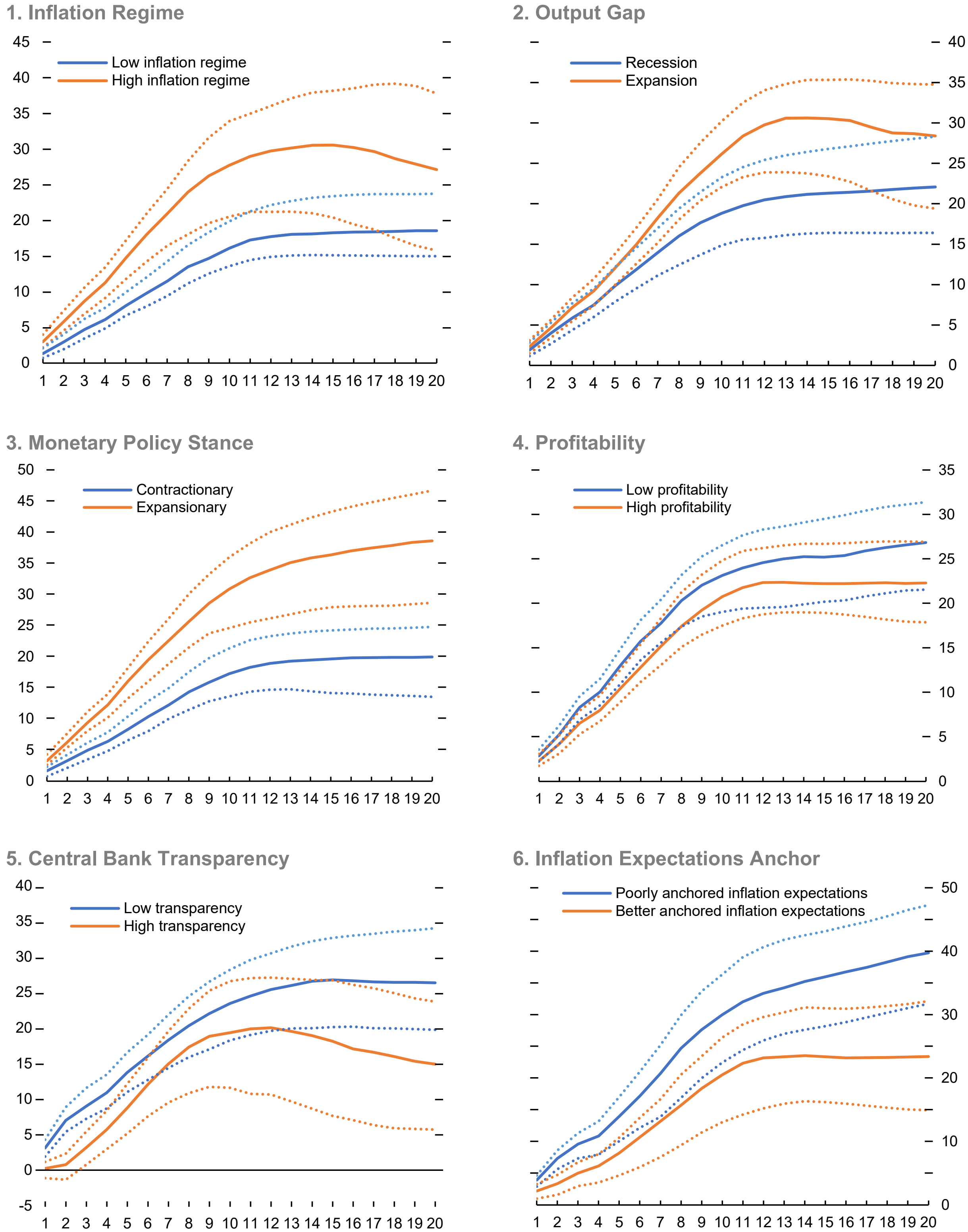
Annex Figure 2.3.1. Passthrough from wage shocks to inflation, by sample periods
(Percent)



Source: IMF staff calculations.

Note: Passthrough ratios of a wage shock to core inflation across time horizon (in quarters). "Full sample" line is estimated with 1995Q1-2023Q1 data, "Drop Covid" line is estimated with 1995Q1-2023Q1 data excluding 2020Q2-2021Q2 observations, and "2020Q1" line is estimated with 1995Q1-2020Q1 data.

Figure 2.3.2. Passthrough of a Wage Shock to Inflation
(Y axis: Percent, X axis: Quarter)



Source: IMF staff calculations.
Notes: Estimates for a sample of 27 European countries over 1995:Q1-2023:Q1. Each panel shows passthrough ratios of a wage shock to core inflation. Dotted lines represent two standard deviation confidence bands. The following variables are used to define regimes: inflation relative to country-specific average inflation in panel 1; output gaps (2 quarter lagged) in panel 2; changes in real interests (2 quarter lagged) in panel 3; profit per unit of output in panel 4; central bank transparency in panel 5; and inflation expectation anchoring in panel 6. Values outside of cross-country inter-quartile ranges are used to define high/low regimes.

Using the estimated IPVAR models, impulse responses of wage growth and inflation from one standard deviation wage shock are computed for the individual interaction terms taking high and low values, respectively. The responses are analyzed using the passthrough ratio which quantifies the relationship between cumulative change in prices and the cumulative change in wages after the wage shock (Figure 2.3.2). The passthrough ratio reveals that wage shocks take effect gradually peaking or plateauing near 12 quarters after the initial shock, consistent with the simple PVAR results (Figure 2.3.1). The IPVAR analysis suggests additionally that the strength of passthrough varies with cyclical and structural conditions. Specifically, inflation responds more to wage growth during high inflation regimes (see also BIS 2022 and Chapter 2 of the October 2023 *World Economic Outlook*), when firms' profits are low, macroeconomic policy is expansionary, and policy frameworks and targets are less-well anchored.

2.4 Wage and inflation projections

2.4.1 Baseline projections

Wage and core inflation forecasts for the 2023-2026 period presented in Figures 10 and 11 in Chapter 2 are produced by jointly simulating four equations. The equations for (1) long-run real wages, (2) the short-run wage Phillips curve, (3) a headline inflation-wage equation (needed for equation 1), and (4) a core inflation-wage equation. The first two equations are described above (section 2.2). Inflation-wage equations relate inflation to respective lagged values, current and past values of wage growth, import price inflation and domestic slack. The specification extends a Phillips curve for inflation by explicitly including wage as a cost factor (see Bernanke and Blanchard, 2023). In addition, by including the current value and four lags of wage growth, the specification assumes that wages respond to other variables with a lag, while wage growth affects inflation, making the system of equations analogous to the VAR model discussed above.

As a preliminary step, projections of the key determinants of wage and inflation are prepared. Auxiliary models are used to project inflation expectations and labor productivity. Country-specific two-year-ahead inflation expectations are projected by their historical relationships with the inflation target and inflation expectations in the last five quarters. GVA-based labor productivity paths are obtained from their historical relationships with GDP-based labor productivity, which is calculated with projections for hours worked (using unemployment rates and time trends) and GDP and unemployment rate projections for the October 2023 *World Economic Outlook*. The analysis also uses the country-specific import price index projections from the October 2023 *World Economic Outlook*. Finally, unemployment gaps are projected to linearly close by 2026Q1.

In the second step, the four equations are estimated by country using pre-pandemic data. The specifications for long-run and short-run wage equations are as described in equations (3) and (4) in Section 2.2. The panel regression counterpart for price Phillips curves for headline and core inflation can be described as follows:

$$\Delta p_{i.t} = \alpha_i + \sum_{l=1}^{4} \beta_{1l}\, \Delta p_{i,t-l} + \beta_2 E_t\left(\Delta p_{i,t+1}\right) + \sum_{l=0}^{4} \beta_{3l}\, \Delta w_{i,t-l} + \sum_{l=1}^{4} \beta_{4l}\, \Delta p_{i.t}^{m} + \varepsilon_{i,t}, \qquad (8)$$

$$\Delta p_{i.t}^{core} = \alpha_i + \sum_{l=1}^{4} \beta_{1l}\, \Delta p_{i.t-l}^{core} + \beta_2 E_t\left(\Delta p_{i,t+1}\right) + \beta_3 u_{i,t} + \sum_{l=0}^{4} \beta_{4l}\, \Delta w_{i,t-l} + \sum_{l=1}^{4} \beta_{5l}\, \Delta p_{i.t}^{m} + \varepsilon_{i,t}. \quad (9)$$

where Δp and Δp^{core} are the quarter-over-quarter annualized headline and core inflation, respectively; α_i reflects a country-specific constant, $E(\Delta p)$ refers to two-year-ahead inflation expectations; u is unemployment gaps from HP trends, Δw is the quarter-over-quarter annualized wage growth, and Δp^m refers to import price growth, respectively, for country i and quarter t.

The panel estimation results for headline and core inflation Phillips Curves are presented in Annex Table 2.4.1. Columns 1-3 report the results for headline inflation, and columns 4-6 report the results for core inflation. The regressions pool all countries in our data and use pre-pandemic data. The sum of coefficients on lagged inflation and expected inflation rates are constrained to be one. The benchmark specification (column 1 for headline inflation and column 5 for core inflation) includes four lags for inflation, wage growth, and import price growth, while unemployment gaps are included only in core inflation Phillips curve due to their statistical insignificance in headline inflation Phillips curve. Labor productivity is not statistically significant in both equations and discarded.

The country-specific forecasts are generated recursively and take into account gradual dissipation of “residuals” in the wage equation. As shown in Figure 2.5 in Chapter 2, wages in selected CESEE countries have grown faster than implied by the wage Phillips curve, leaving large residuals in recent periods. The baseline projections for wage growth assume that the residual estimated in 2023Q2 gradually decays through a first-order autoregressive process with autocorrelation coefficient of 0.5.[1] Starting in 2023Q3, wage growth is forecast based on actual lagged wage growth and other exogenous variables. It feeds into headline and core inflation projections for 2023Q3, and projected headline inflation in turn helps determine the real wage gap based on the long-run wage equation. In the following quarter (2023Q4), wage growth is further projected by using actual and forecasted wage growth as lagged wage growth, the forecasted real wage gap as the wage catch-up term, and other exogenous variable. The process continues recursively until the end of projection period (2026Q4). Figure 2.10 and Figure 2.11 report aggregated wage growth and core inflation across countries using purchasing-power-parity GDP weights.

2.4.2 Scenario analysis

Two alternative scenarios are considered. Under the benign scenario, the “residual” for 2023Q2 from the short-run wage equation vanishes immediately and wage growth is projected as fitted values of the equation in the forecast period. The adverse scenario entails two assumptions: (1) unemployment gaps in 2023Q2 are calculated by holding the natural unemployment rate at the 2019Q4 level and are projected to linearly close by 2026Q1; (2) the coefficients on lagged wages in the short-run wage equations are increased by one standard deviation, and the coefficient on the inflation expectations are reduced by the same amount. If, in a specific country, the sum of recalibrated coefficients on lagged wages exceeds one, the coefficient on inflation expectations is set to zero and the coefficients on lagged wages are rescaled to add up to one.

[1] This parameter is set based on the estimated autoregressive model on the residuals for the pre-COVID period.

Annex Table 2.4.1. Inflation Phillips Curve Panel Estimation Result

	(1) Headline	(2) Headline	(3) Headline	(4) Core	(5) Core	(6) Core
Lagged inflation	0.401***	0.4***	0.4***	0.464***	0.452***	0.451***
(Sum of coefficients)	(0.042)	(0.020)	(0.018)	(0.026)	(0.015)	(0.015)
Inflation expectations	0.599***	0.600***	0.600***	0.536***	0.548***	0.549***
	(0.042)	(0.042)	(0.042)	(0.044)	(0.043)	(0.044)
Wage growth	0.0843***	0.0795***	0.0792***	0.0707***	0.0567***	0.0565***
(Sum of coefficients)	(0.027)	(0.030)	(0.030)	(0.009)	(0.027)	(0.027)
Imported price growth	0.052***	0.0527***	0.0525***	0.0393***	0.0386***	0.038***
(Sum of coefficients)	(0.018)	(0.042)	(0.019)	(0.014)	(0.009)	(0.009)
Unemployment gap		-0.063	-0.061		-0.135***	-0.127***
		(0.062)	(0.064)		(0.045)	(0.045)
Labor productivity			-0.003			-0.010
			(0.009)			(0.008)
Observations	2,121	2,121	2,121	2,075	2,075	2,075
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Coef. Const.	Yes	Yes	Yes	Yes	Yes	Yes
Sample Period	Pre Covid	Pre Covid	Pre Covid	Pre Covid	Pre Covid	Pre Covid
Memorandum:						
Implied long run elasticity	0.141***	0.133***	0.132***	0.132***	0.104***	0.103***
	(0.018)	(0.018)	(0.042)	(0.044)	(0.043)	(0.044)
Inflation - Lag 1	0.289***	0.285***	0.285***	0.343***	0.331***	0.331***
	(0.049)	(0.049)	(0.049)	(0.044)	(0.043)	(0.043)
Inflation - Lag 2	0.112***	0.110**	0.110**	0.120***	0.113***	0.112***
	(0.042)	(0.043)	(0.043)	(0.036)	(0.035)	(0.035)
Inflation - Lag 3	0.104***	0.104***	0.104***	0.078*	0.076*	0.076*
	(0.036)	(0.036)	(0.036)	(0.042)	(0.042)	(0.042)
Inflation - Lag 4	-0.103***	-0.099***	-0.099***	-0.077**	-0.068*	-0.068*
	(0.030)	(0.031)	(0.031)	(0.036)	(0.036)	(0.036)
Wage growth - Lag 0	0.016**	0.015**	0.016*	0.016**	0.014**	0.018**
	(0.008)	(0.008)	(0.009)	(0.007)	(0.007)	(0.008)
Wage growth - Lag 1	0.023***	0.022**	0.021**	0.025***	0.021***	0.020***
	(0.009)	(0.009)	(0.009)	(0.006)	(0.006)	(0.006)
Wage growth - Lag 2	0.017*	0.016*	0.015*	0.019***	0.015**	0.015**
	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)
Wage growth - Lag 3	0.027**	0.025**	0.025**	0.015**	0.012*	0.012*
	(0.012)	(0.012)	(0.012)	(0.006)	(0.006)	(0.006)
Wage growth - Lag 4	0.018**	0.017*	0.017**	0.012	0.009	0.009
	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)
Imported price - Lag 1	0.043***	0.043***	0.043***	0.018***	0.018***	0.018***
	(0.016)	(0.016)	(0.016)	(0.006)	(0.006)	(0.006)
Imported price - Lag 2	0.016**	0.016**	0.016**	0.014***	0.014***	0.013***
	(0.008)	(0.008)	(0.008)	(0.005)	(0.005)	(0.005)
Imported price - Lag 3	0.003	0.003	0.003	0.005	0.005	0.005
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Imported price - Lag 4	-0.010	-0.010	-0.010	0.002	0.001	0.001
	(0.007)	(0.007)	(0.007)	(0.005)	(0.005)	(0.005)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Sources: IMF staff estimates.

Note: Unbalanced panel data for 15 AE (excl. CESEE) and 11 CESEE countries for 1991Q1-2020Q1 data. The sum of coefficients on lagged inflation and expected inflation rates are constrained to be one. Standard errors, reported in parentheses, are corrected for heteroscedasticity and autocorrelations. All regressions include country fixed effects. The long-run elasticity refers to that of inflation to wage growth.

References

Bank for International Settlements, 2022. “Inflation: A Look under the Hood.”, BIS Annual Economic Report, 26 June.

Bems, Rudolfs, Francesca Caselli, Francesco Grigoli, and Bertrand Gruss. 2021. “Expectations’ Anchoring and Inflation Persistence.” Journal of International Economics 132.

Bernanke, Ben, and Olivier Blanchard, 2023. “What Caused the U.S. Pandemic-Era Inflation?” Hutchins Center Working Paper 86.

Dincer, Eichengreen, and Geraats, 2022. “Trends in Monetary Policy Transparency: Further Updates.” International Journal for Central Banking 72nd Issue.

Engle, Robert F, and C. W. J. Granger, 1987. “Co-Integration and Error Correction: Representation, Estimation, and Testing.” Econometrica 55 (2): 251-276.

Lenza, Michele, and Giorgio E. Primiceri, 2022. “How to Estimate a Vector Autoregression after March 2020.” Journal of Applied Econometrics 37:688-699.

Pedroni, Peter, 1999, “Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors.” Oxford Bulletin of Economics and Statistics, 61: 653-670.