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The slope of the euro area price Phillips curve: evidence from regional data

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Abstract

This paper contributes to the literature on the price Phillips curve by exploiting subnational regional data from 11 euro area countries. Beyond controlling for aggregate fluctuations common across euro area regions, our approach accounts for country-specific dynamics, including national inflation expectations, thereby addressing key limitations in previous studies. Our results suggest that the Phillips curve in the euro area is relatively flat, but statistically significant. Furthermore, we provide novel evidence on potential non-linearities in the price Phillips curve and highlight the critical role of properly accounting for country-specific factors such as inflation expectations. These findings provide new insights for the conduct of monetary policy and underscore the value of regional data in euro area macroeconomic analysis.

Keywords: *price Phillips curve, regional data, non-linearity, heterogeneity.*

JEL Classification: E24, E30, E31

Non-Technical Summary

Understanding the relationship between inflation and economic slack—commonly captured by the Phillips curve—is central to the design and implementation of monetary policy. A steeper Phillips curve suggests that inflation responds strongly to changes in economic activity, whereas a flatter curve implies that inflation is less sensitive to such fluctuations, potentially complicating central banks' efforts to steer inflation through interest rate changes.

This paper provides new evidence on the slope of the price Phillips curve in the euro area by drawing on a unique dataset of subnational regional data from 11 euro area countries. The use of regional variation allows to address several econometric challenges that have hindered earlier studies, such as unobserved heterogeneity across regions within countries and common shocks transmitting differently to all euro area regions simultaneously.

One of the key innovations is the careful treatment of national inflation expectations, which have been shown to play a critical role in shaping inflation dynamics but tend to vary across countries. By accounting for these expectations—both explicitly through professional forecasts and implicitly via country-time fixed effects—the analysis provides a more accurate assessment of the underlying relationship between inflation and slack.

The main findings suggest that the Phillips curve in the euro area remains statistically significant, but its slope is relatively flat. This means that changes in economic slack translate into relatively modest movements in inflation. Moreover, the inclusion of national inflation expectations further reduces the estimated sensitivity of inflation to slack, underscoring the importance of expectations in driving inflation outcomes. Compared to recent evidence for the United States, the euro area curve shows a similar degree of flatness.

The study also explores whether the Phillips curve behaves differently depending on the level of slack—a question of growing importance in light of the recent inflation surge. Using threshold models, we find some evidence of nonlinearities, but these are sensitive to the inclusion of inflation expectations in the specification. Once expectations are controlled for, the evidence for a nonlinear Phillips curve in the euro area weakens significantly.

These findings have important implications for monetary policy in the euro area. A flatter Phillips curve suggests that inflation is now more influenced by expectations and supply-side factors than by the cyclical position of the economy. As a result, traditional demand-side policies, such as adjusting interest rates in response to output gaps, may be less effective in stabilising inflation. Instead,

maintaining well-anchored inflation expectations through clear communication, rule-based policy strategies, and credible forward guidance becomes increasingly important.

By highlighting the role of regional data and expectation dynamics, this paper contributes to a better understanding of inflation behaviour in the euro area and provides relevant insights for the design of monetary policy in an environment characterised by muted inflation responsiveness to slack.

1 Introduction

The Phillips curve, Phillips (1958), remains a cornerstone of macroeconomic analysis, providing a framework for understanding the relationship between inflation and economic slack. For economists, the Phillips curve underpins key policy discussions, particularly in the context of monetary policy, as it offers insight into the trade-offs central banks face when pursuing price stability and full employment.

Despite its long history and evolution, there continues to be extensive discussion in the literature about the econometric challenges of pinning down the slope of the Phillips curve, i.e. the coefficient attached to the measure of resource slack. A large coefficient would imply that reducing inflation would be less costly in terms of economic activity compared to a case where the coefficient would be small. For surveys on recent developments in the estimation and identification of the Phillips curve and its slope, see Mavroeidis et al. (2014) and the most recent one by Furlanetto and Lepetit (2024).

An approach developed in recent years to overcome these econometric challenges is to use regional data.[1] The idea is that the potentially larger variability in the data can help for the estimation, while time fixed effects can capture changes common to all regions. This includes for example the common effects from the response of monetary policy to cost-push factors as emphasized by McLeay and Tenreyro (2019) and Fitzgerald et al. (2024) or the common inflation expectations as highlighted by Hazell et al. (2022). Other papers that use state-level or metropolitan-level data for the United States to estimate the price Phillips curve are Kiley (2015), Hooper et al. (2020), Cerrato and Gitti (2022), Smith et al. (2023), Gitti (2024) and Beaudry et al. (2025).[2]

For the euro area, the literature is less extensive and has sometimes relied on country-level data as a proxy for a *region*. This is the case for Eser et al. (2020), Smith et al. (2023) and Florio et al. (2025).[3]

Our paper is the first to estimate the slope of the price Phillips curve using subnational regional data from 11 euro area countries. This approach enables us to account not only for time-invariant country or regional characteristics, through country or region fixed effects, and also for aggregate fluctuations common to all euro area regions, via time fixed effects. Notably, this allows us to capture the

[1]Notwithstanding these advancements, econometric challenges remain even with regional data as noted by Canova (2024).

[2]The last two papers use labour market tightness as the measure of slack, whereas the earlier studies rely on the unemployment rate or the unemployment gap as the primary indicator of economic slack.

[3]Only Levy (2019) used subnational regional data at NUTS-2 level to estimate the slope of a wage Phillips curve for European countries.

common component of inflation expectations across euro area regions, which have been shown to be important in shaping the Phillips curve in the United States (Hazell et al., 2022).

However, in the euro area context, inflation expectations tend to also vary considerably across jurisdictions, particularly in the short to medium run. Our analysis accounts for these national inflation expectations either explicitly, by considering country-specific professional one-year ahead inflation forecasts or implicitly, through the use of country-time fixed effects. This last approach also allows to control for any country-specific inflation expectations (households, firms' managers or professional forecasters) but also for the heterogeneous transmission of monetary policy across euro area countries and for variations in fiscal policies at the national level, among other factors. To the best of our knowledge, we are the first to exploit this methodological advantage to address a highly relevant question regarding euro area inflation dynamics.

Our baseline results suggest an alive and relatively steep price Phillips curve in the euro area when we control for region- or country time-invariant characteristics. While the slope of the Phillips curve remains statistically significant, it flattens when we account for time-varying fluctuations, which includes common inflation expectations across euro area regions.

When we explicitly control for national inflation expectations, as in McLeay and Tenreyro (2019), the sensitivity of regional inflation to regional labor market slack is further reduced by a factor of two compared to our specification that includes only region fixed effects.[4] Furthermore, while our estimate of the slope remains statistically significant, it approaches zero when we apply country-time fixed effects. Despite being close to zero, this final point estimate is in line with estimated or calibrated structural coefficients of New Keynesian models. Our baseline results remain robust when using an instrumental variable strategy to address regional confounders, following the approach of Hazell et al. (2022) and Gitti (2024).

Beyond the slope, the functional form of the Phillips curve has been subject to an extensive debate in the literature. The central question on whether the Phillips curve is better approximated by a linear or a nonlinear relationship has also been at the forefront of recent policy discussions in the wake of the inflation surge after 2020, both in the United States and in the euro area (Kugler, 2025; Lane, 2024; Schnabel, 2025).[5] Does the Phillips curve feature a kink or a threshold effect when

[4]The flattening is confirmed when estimating the slope separately for each country controlling for region fixed effects, similar to Schuffels et al. (2024) who rely on country-level data, and when accounting for time-varying factors such as national inflation expectations.

[5]According to Lane (2024), the evidence of a state-dependent increase in the frequency of price adjustments over the course of 2022, can be interpreted as some combinations of a shift up in the

the labour market is particularly tight? The implications of assuming linearity are straightforward: an additional percentage point change in economic slack has the same effect on inflation regardless of the prevailing level of slack.[6] However, if the relationship is nonlinear, the inflationary impact of slack may vary with the business cycle phase, which has important implications for monetary policy. Empirical evidence for the United States is mixed. Using unemployment as the measure of slack in the price Phillips curve, several studies identify non-linearities, such as Nalewaik (2016), Hooper et al. (2020) and Cerrato and Gitti (2022), while others find only mild convexity or fail to find strong evidence of nonlinear effects (Babb and Detmeister, 2017; Hazell et al., 2022; Murphy, 2017).[7]

For the euro area, the existing evidence for a nonlinear Phillips curve remains limited (Eser et al., 2020; Moretti et al., 2019; Musso et al., 2007; Smith et al., 2023). We address this question by leveraging our large cross-sectional dataset at the regional level to estimate a threshold model to formally test for nonlinearity in the price Phillips curve. Overall, the evidence supporting nonlinearity in the euro area price Phillips curve would very much depend on the control variables integrated in the specification. In particular, the presence of short-term national inflation expectations in the specification would weaken the case for a nonlinear Phillips curve in the euro area.[8]

On the policy front, a flat Phillips curve poses challenges for the conduct of monetary policy by reducing the effectiveness of interest rates adjustments in steering inflation via the demand channel. When the relationship between economic slack and inflation weakens, inflation expectations and supply-side shocks become more dominant drivers of inflation dynamics. Lenza et al. (2025) and Beaudry et al. (2025) empirically find support for nonlinearities manifesting more intensively through the expectation channel, as a shift in the Phillips curve, and less via the demand channel, i.e., a change in the slope of the Phillips curve. Consequently, central banks would need to increasingly rely on anchoring expectations through clear policy rules, the systematic component of monetary policy, and communica-

curve and an increase in the slope of the Phillips Curve.

[6]From a theoretical perspective, Karadi et al. (2024) provide micro-foundations for a nonlinear Phillips curve whereby the sensitivity of inflation to activity increases after large shocks due to an endogenous rise in the frequency of price changes.

[7]Recent research has increasingly adopted the vacancy-to-unemployment ratio as an alternative measure of labour market slack. Again, some authors find evidence of nonlinearities (Benigno and Eggertsson, 2023; Gitti, 2024), while others do not (Beaudry et al., 2025). There is also a debate on whether the vacancy-to-unemployment ratio is appropriate to measure labor market slack in periods of high inflation (Afrouzi et al., 2024).

[8]Blanchard and Bernanke (2023) find using a structural model that the post-2020 increase in nominal wages, and hence inflation, in the United States was largely explained by higher short-term inflation expectations. Similar evidence has been found for the euro area (Arce et al., 2024).

tion strategies rather than focusing only on traditional demand-side policies. According to Blanchard et al. (2015), in such an environment, if inflation exhibits weak responsiveness to economic conditions, central banks may be inclined to delay policy adjustments, under the assumption that inflationary pressures are transitory. However, if inflation expectations become unanchored, either persistently rising above or falling below central's bank target, this could necessitate abrupt policy interventions. For an extensive discussion of the implications for monetary policy of a flat Phillips curve, see for example Del Negro et al. (2020) and Beaudry et al. (2024) among many others.

The paper is structured as follows. Section 2 delves into the data description and some stylized facts. Section 3 describes our baseline specification and presents results. Section 4 studies the nonlinearity of the Phillips curve. Finally, Section 5 documents a range of robustness checks, and Section 6 concludes.

2 Data collection and stylized facts

2.1 Data collection

We exploit disaggregated economic data for the euro area at the regional level from the European Commission's ARDECO database. Regions follow Eurostat's Nomenclature of Territorial Units for Statistics (NUTS) classification, which subdivides European countries into four levels, generally mirroring their territorial administrative division.[9] The highest level (NUTS-0) corresponds to the nation-state, while the lower levels (NUTS-1 to NUTS-3) further divide national territories into more specific regional units of similar population size (see the example of Italy in Figure A1 in Annex).[10] As a result, the number of NUTS-2 regions varies by country, ranging from 38 regions in Germany to a single region in Cyprus or Luxembourg (see Figure A2 in Annex). Our study relies on NUTS-2 data, which offers the most granular breakdown available for our analysis.

The Phillips curve traditionally relates current inflation to inflation expectations and to a measure of economic slack, either related to output or unemployment. Our analysis considers the unemployment rate, that is available at the NUTS-2 level for all euro area regions. In contrast, regional consumer price indices (CPI) are only available for a limited number of euro area countries, specifically Italy, Germany, and Spain.[11] Instead, we use the GDP deflator as our measure of prices.[12] While the CPI reflects the prices of a basket of goods and services, including imported goods, the GDP deflator measures the prices of goods and services produced domestically. Although conceptually distinct, the GDP deflator has historically shown a close relationship at the national level with the CPI that excludes energy and food prices (see Figure A3a in Annex). This strong correlation is also observable at the regional level between the regional GDP deflator and the regional CPI to which we subtract energy and food at the *national* level. The correlation is particularly pronounced for Italy and Germany, and somewhat less so for Spain (Figures A3b-A3d in Annex).[13]

[9] For example, the NUTS-2 regions correspond to the *Regioni* in Italy, to the *Lands* in Austria and to the *Periféries* in Greece.

[10] The population size for a typical NUTS-2 region varies between 800'000 and 3'000'000 inhabitants.

[11] CPI are available at NUTS-2 level for Italy from 2016 and for Spain from 2002. CPI for Germany is available only at the NUTS-1 level from 1995.

[12] Specifically, we calculate the regional GDP deflator as the ratio between regional GDP at current market prices and regional GDP at constant prices. The GDP deflator has been used as a measure of euro area prices in previous studies, see for instance Del Negro et al. (2020).

[13] CPI excluding food and energy is not available at the regional level. We calculate a measure of regional inflation excluding food and energy by subtracting the difference between *regional* inflation, measured by the CPI, and *national* energy and food inflation.

Furthermore, we use professional forecasters' inflation expectations from Consensus Economics as our measure of inflation expectations.[14] Professional inflation forecasts are available for 11 euro area countries at the monthly frequency since 1999.[15] We take our annual country-specific inflation expectations as the one-year-ahead inflation expectation collected each January, and averaged across professional forecasters.[16]

Our final sample consists of 168 NUTS-2 regions for 11 euro area countries at annual frequency from 1999 to 2023.[17]

2.2 Stylized facts

Table 1 presents summary statistics on inflation and on the unemployment rate at both regional and national levels. The first three columns display statistics (mean, 10th, and 90th percentiles) across regions and countries in the euro area over the 1999-2023 period. On average, regional and national figures are similar, with inflation around 2.0% and unemployment at approximately 8.3%. However, regional data exhibit a wider distribution, particularly for the unemployment rate. The standard deviation of regional unemployment is higher than for national unemployment and the difference between the 90th and 10th percentiles is around 12.3 percentage points, compared to 10.0 percentage points for national unemployment. In contrast, the disparity in inflation distributions is somewhat less pronounced, with similar standard deviations and less differences between the 90th and 10th percentiles at the regional and national levels, at approximately 4.0 and 3.6 percentage points respectively.

The last column of Table 1 shows the coefficient of variation (CV), calculated as the ratio of the standard deviation to the mean. The CV at the regional level is computed for each individual country and captures the dispersion of inflation and unemployment *within* each country. By contrast, the CV at national level is computed using country-level data and reflects inflation and unemployment variability *across*

[14] The European Commission's Business and Consumer Survey provides quantitative inflation expectations for households, but only for the euro area aggregate. Household inflation expectations at the country level are available in the European Central Bank's Consumer Expectations Survey, but only since 2020.

[15] Country-level inflation expectations are available for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.

[16] In January of each year, professional forecasters have comprehensive information on price developments from the previous year, enabling them to make informed predictions for the upcoming year. We also collect the January two-year-ahead inflation expectations.

[17] We follow the literature in excluding NUTS-2 regions of the French overseas territories of Guadeloupe, Martinique, French Guiana, La Réunion and Mayotte, along with the Portuguese autonomous regions of the Azores and Madeira and the Spanish autonomous cities of Ceuta and Melilla (Becker et al., 2010).

Table 1: Summary statistics

Level	P10	Average	P90	Std. Dev.	CV
Regional level					
Inflation	0.30	2.00	4.26	1.91	0.95
Unemployment rate	3.22	8.26	15.53	5.10	0.62
Country level					
Inflation	0.45	1.96	4.04	1.57	0.80
Unemployment rate	3.65	8.39	13.66	4.28	0.51

Note: This table reports the summary statistics for 11 euro area countries on the percentage change in the GDP deflator and the unemployment rate, both at NUTS-2 level and at country (NUTS-0) level, on average over the 1999-2023 period. The coefficient of variation (CV) at the regional level is computed as the ratio of the standard deviation to the mean of all NUTS-2 units within each country, while at the country level, it is calculated as the ratio of the standard deviation to the mean across the 11 euro area countries. Data are at annual frequency and figures are expressed in percentages.

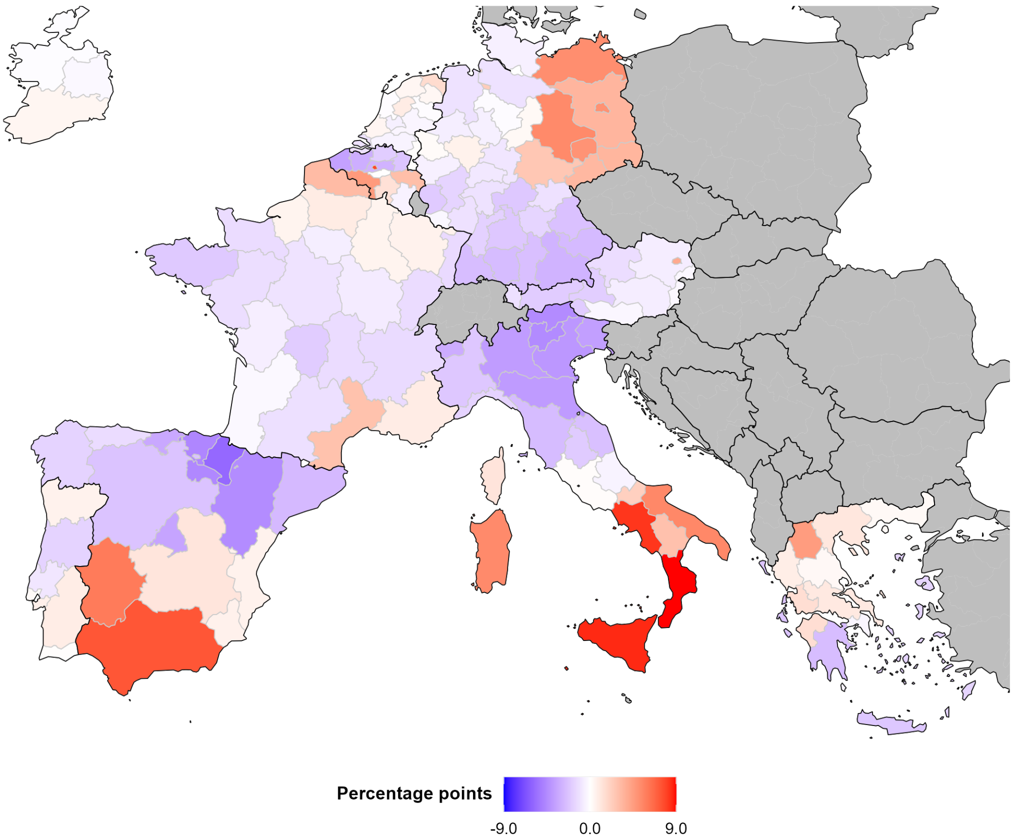
euro area countries. On average, the within-country dispersion for both inflation and unemployment is comparable to the dispersion observed between euro area countries, therefore indicating substantial regional disparities within countries.

We graphically illustrate the regional dispersion of unemployment within euro area countries by depicting the difference between *regional* and *national* unemployment on average over the 1999-2023 period. Figure 1 highlights substantial heterogeneity in regional business cycles: the average difference between regional unemployment rates and national unemployment rates varies between -5.9 and 9.0 percentage points. It also points to large differences in unemployment dispersion across euro area countries. Unemployment rates were significantly higher in Southern Italian regions, as well as in Eastern Germany and Southern Spain, compared to the rest of their respective countries.[18] While these regional disparities have persisted, the overall dispersion across local labor markets has evolved over time (see Figure A4 in Annex). In Germany, for instance, the range between the minimum and maximum unemployment decreased from 15.9 percentage points in 2000 to 3.4 percentage points in 2023. Conversely, the range remained broadly stable in Italy (16.0 percentage points) and Spain (13.8 percentage points).

In comparison, the regional inflation dispersion was overall relatively less pronounced, with inflation differentials ranging between -0.2 to 0.8 percentage points. Yet, as with unemployment rates, this heterogeneity is not uniform across countries (see Figure A5 in Annex). For example, certain regions in Eastern Germany,

[18] As an example, the unemployment rate in Sicily was on average 8.5 percentage points higher than the national unemployment rate over the 1999-2023 period.

Figure 1: Within-country unemployment dispersion



Note: This figure shows the within-country dispersion for 10 euro area countries, averaged over the 1999-2023 period. The within-country dispersion is measured as the difference between regional and national unemployment rates. Finland is not shown for readability. Figures are expressed in percentage points.

the northeast of France, and central Spain have experienced relatively higher inflation rates than other regions within their respective countries. In contrast, inflation rates have been more uniform across regions in Italy and Austria.

3 Baseline estimation

3.1 Baseline framework

We first estimate a price Phillips curve equation for the euro area with the following general form over the 1999-2023 period

$$\pi_{i,t} = \psi u_{i,t} + \delta \mathbf{X}_{c,i,t} + \varepsilon_{i,t} \tag{1}$$

where the dependent variable $\pi_{i,t}$ represents inflation in region i at time t. Our main variable of interest is the unemployment rate $u_{i,t}$, whose parameter ψ represents the slope of the price Phillips curve. Our first empirical strategy to identify ψ relies on a set of fixed effects included in $\mathbf{X}_{c,i,t}$ that varies at regional, country (with subscript c), and time level (Fitzgerald et al., 2024; Hazell et al., 2022; McLeay and Tenreyro, 2019). Standard errors are clustered at the NUTS-2 level.

Our first specification includes country fixed effects to account for time-invariant characteristics that are common across all regions within a given country. Notably, this approach helps to control for persistent differences in the national natural rate of unemployment (McLeay and Tenreyro, 2019). However, regional unemployment rates tend to be structurally different even within euro area countries. For example, regions that had relatively high unemployment rates in 1999 compared to the national average have tended to keep these elevated rates throughout our sample period (see Figure A6 in Annex). To address these structural disparities, we alternatively include region fixed effects, which account for both time-invariant country characteristics and time-invariant regional characteristics.[19]

The slope estimate may still be subject to bias due to the presence of aggregate cost-push shocks or the endogenous policy responses they may trigger, such as monetary or fiscal interventions. To address this potential endogeneity, our second specification adds time fixed effects to control for aggregate fluctuations that are common across all euro area regions (Fitzgerald et al., 2024; McLeay and Tenreyro, 2019). Importantly, these time fixed effects also absorb variation stemming from common long-run inflation expectations (Hazell et al., 2022). Specifically, we estimate the following equation

$$\pi_{i,t} = \psi u_{i,t} + \delta_i + \eta_t + \varepsilon_{i,t} \tag{2}$$

[19] Since all regions belong to their respective countries throughout the sample under consideration, the inclusion of region fixed effects absorbs any time-invariant country-level characteristics. The region fixed effects help to control for persistent differences in regional natural unemployment rates.

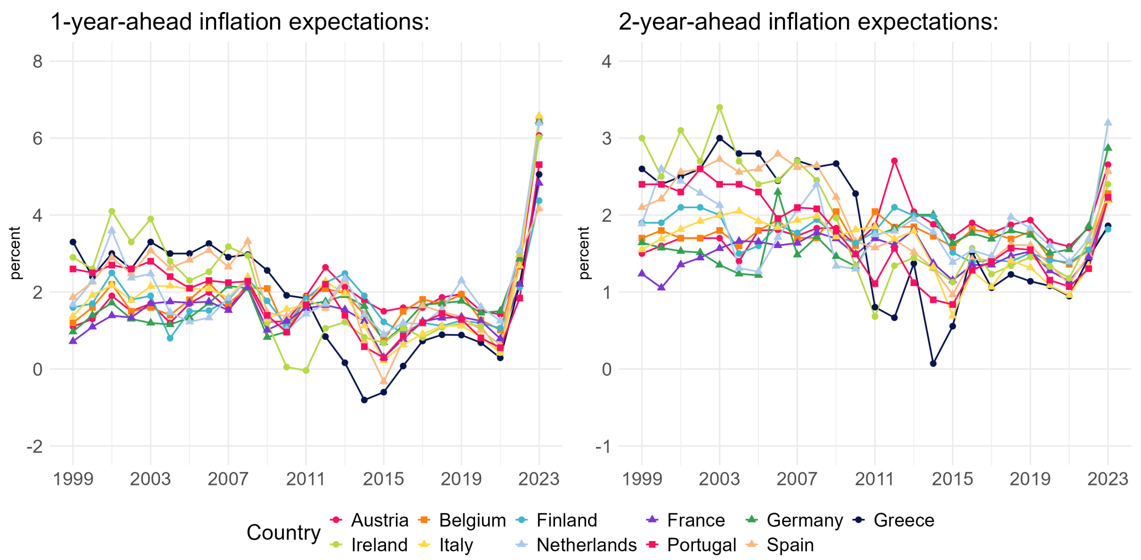
where δ_i is a set of region fixed effects and η_t are time fixed effects.

However, recent surveys highlight substantial cross-country variations in inflation expectations within the euro area, reflecting the diverse inflation dynamics among its member countries. For example, professional forecasters tend to have heterogeneous short-term inflation expectations across euro area countries (Figure 2).[20] Consequently, while time fixed effects may capture common long-run trends in inflation expectations, they are unlikely to account for country-specific variation in the short to medium term. To address this issue, we incorporate the one-year-ahead inflation expectations of professional forecasters from Consensus Forecasts, which are available at the country level over our time sample.[21] Therefore, our third specification takes the form

$$\pi_{i,t} = \psi u_{i,t} + \gamma \mathbb{E}_t[\pi_{c,t+1}^{Consensus}] + \delta_i + \eta_t + \varepsilon_{i,t} \tag{3}$$

where $\mathbb{E}_t[\pi_{c,t+1}^{Consensus}]$ is the one-year-ahead inflation expectations for country c at time t.

Figure 2: Inflation expectations in euro area countries



Note: The figures represent the one-year-ahead and two-year-ahead inflation expectations for 11 euro area countries, averaged across professional forecasters.

But inflation expectations of other agents, such as consumers or firms, may also play an important role in shaping inflation and these expectations might not necessarily be in line with professional forecasts (see Coibion et al. (2018) for a liter-

[20] Baumann et al. (2024) also find that firms' short- to medium-term inflation expectations are shaped by national economic conditions.

[21] We apply the same inflation expectations to all regions of a given country over time.

ature review).[22] Unfortunately, quantitative inflation expectations of households or firms' managers are not available for euro area countries over a sufficiently long time period.[23] To capture them, we exploit the richness of our regional panel dataset and incorporate country-time fixed effects, which control for any country-specific time-varying fluctuations, including country-level inflation expectations.

Therefore, our final empirical specification is

$$\pi_{i,t} = \psi u_{i,t} + \delta_i + \gamma_{c,t} + \varepsilon_{c,i,t} \tag{4}$$

where $\pi_{i,t}$ and $u_{i,t}$ correspond to inflation and unemployment, respectively, in region i at time t, while δ_i is a set of region fixed effects and $\gamma_{c,t}$ a set of country-time fixed effects.

The country-time fixed effects have also the advantage to control for other country-specific disturbances that are not captured by time fixed effects. For instance, oil price shocks can have heterogeneous effects across euro area countries, due to differences in their energy mix or reliance on energy intensive sectors. Moreover, while the European Central Bank (ECB) sets a uniform interest rates across all member countries, there is substantial evidence that the transmission of monetary policy is heterogeneous among euro area economies (Ciccarelli et al., 2014; Ciccarelli and Rebucci, 2006; Georgiadis, 2015; Mandler et al., 2022). Consequently, the monetary policy response to aggregate cost-push shocks may have asymmetric effects across countries, which are only partially accounted for by the inclusion of time fixed effects. Similarly, although euro area countries are constrained by supranational fiscal rules, fiscal policy remains largely under national jurisdiction and tends to vary significantly across countries in response to shocks.[24]

While the inclusion of country-time fixed effects improves the identification of the slope of the price Phillips curve by capturing these effects, it also changes the interpretation of the ψ-coefficient in equation 4. The coefficient ψ now reflects the extent to which regional inflation responds to deviations in regional unemployment relative to other regions within the same country at a given point in time. In this setup, all national-level (aggregate) variation that is common across regions within a country in a given year is effectively removed. As a result, the estimated

[22]Evidence for the United States shows that consumer forecasts appear to fit the Phillips curve better than professional forecasts, both before the Great Recession and after (Coibion and Gorodnichenko, 2015).

[23]The ECB Consumer Expectation Survey has been reporting since 2020 that one- and three-year-ahead household inflation expectations differ markedly across euro area countries, particularly in the short term (see Figure A7 in Annex).

[24]The cyclicality of fiscal policy varied considerably across euro area countries between 1995 and 2021. For instance, discretionary fiscal policies were on average countercyclical in Germany and Belgium, and procyclical in Spain (Heimberger, 2023).

ψ-coefficient does not capture the effect of national unemployment on inflation, but rather the differential effect of regional unemployment—that is, how inflation in a specific region moves relative to other regions in the same country and period, in response to region-specific changes in unemployment. In this sense, the coefficient isolates regional idiosyncratic shocks and their pass-through to inflation. It implicitly assumes that regions have the capacity to influence their own unemployment rates independently—through local labour market conditions—allowing for the identification of truly regional Phillips curve dynamics.

3.2 Baseline results

Table 2 presents the results of our baseline regression using country, region or time fixed effects. Across all specifications, the estimated slope of the price Phillips curve (ψ) is statistically significant and displays the expected negative sign.

Table 2: Price Phillips curve

	Dependent variable: Regional Inflation (%)				
	Pooled	Country	Country + Time	Region	Region + Time
	(1)	(2)	(3)	(4)	(5)
ψ	-0.10^{***}	-0.16^{***}	-0.10^{***}	-0.28^{***}	-0.19^{***}
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Country FE	✗	✓	✓	✗	✗
Region FE	✗	✗	✗	✓	✓
Time FE	✗	✗	✓	✗	✓
Observations	3,968	3,968	3,968	3,968	3,968
Adjusted R^2	0.07	0.13	0.51	0.19	0.53

Note: This table reports the estimates of ψ over the 1999-2023 period using different sets of fixed effects. Specification (1) estimates equation 1 by pooled ordinary least squares (OLS). Specification (2) and (3) estimate 1 by using country and time fixed effects. Specifications (4) and (5) estimate equation 2 by using region and time fixed effects. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

The first column reports the pooled OLS estimate, which suggests a relatively flat price Phillips curve, with a slope of -0.10. The second and third columns present the estimates when including country fixed effects and time fixed effects. Controlling for time-invariant country-specific characteristics steepens the slope to -0.16 (Column 2). However, when time fixed effects are included to account for aggregate fluctuations common to all euro area regions, the slope flattens to -0.10 (Column 3). This results indicates that such aggregate dynamics reduce the responsiveness of inflation to economic slack. Compared to Eser et al. (2020), who estimate the Phillips curve using cross-country variation and include both country and time fixed effects, our regional-level estimates yield a slope approximately ten times steeper, highlighting the additional information gained from within-country regional variation.

The fourth column presents the estimate when including region fixed effects solely. Accounting for time-invariant, region-specific characteristics results in a nearly twofold increase in the coefficient's magnitude relative to the specification with only country fixed effects, highlighting the importance of controlling for regional differences in our sample. In the fifth column, we include both region and time fixed effects. This specification is the most comparable to those used in prior studies for the United States. Compared with Hazell et al. (2022), who use U.S. state-level data, our estimates suggest a slope roughly twice as large in the post-1990 period.[25]

Table 3 presents results under different specifications that account for national inflation expectations.[26] In the first two columns, we control for expectations explicitly in addition to region and country fixed effects, while the third column does so implicitly through the inclusion of country-time fixed effects. When national inflation expectations are included alongside time and either country or region fixed effects, they are positive and highly statistically significant. Their inclusion noticeably reduces the estimated slope of the price Phillips curve, although the slope coefficient remains strongly significant. Specifically, the slope flattens from -0.10 to -0.05 when using country fixed effects (Column 1), and from -0.19 to -0.12 when accounting for region fixed effects (Column 2).

The inclusion of country-time fixed effects, which captures not only national inflation expectations but also broader country-specific time-varying factors, flattens further the slope. Without region fixed effects, the ψ-coefficient becomes insignificant and close to 0 (Column 3). However, even with a reduced estimated coefficient of -0.02, ψ remains highly statistically significant when including region fixed effects (Column 4), which further underscores the need to control for time-invariant structural characteristics across regions.

The relatively flat price Phillips curve is also evident when estimating our baseline specification for each euro area country.[27] While the results obtained using re-

[25] Slope coefficient comparisons are difficult to make since estimates depend on the Phillips curve specification, the frequency of the data and the horizon of inflation expectations among many other factors.

[26] These specifications are close to McLeay and Tenreyro (2019), who use U.S. state-level data and control for time fixed effects and regional inflation expectations.

[27] Specifically, we estimate our baseline equation for Austria, Belgium, France, Germany, Greece, Italy, the Netherlands, Portugal, and Spain. Our specification is given by: $\pi_{i,t} = \psi^c u_{i,t} +$

Table 3: Price Phillips curve controlling for national inflation expectations

	Dependent variable: Regional Inflation (%)			
	Country + Time	Region + Time	Country-Time	Region + Country-Time
	(1)	(2)	(3)	(4)
ψ	-0.05^{***}	-0.12^{***}	-0.002	-0.02^{**}
	(0.01)	(0.01)	(0.002)	(0.01)
γ	0.94^{***}	0.73^{***}		
	(0.05)	(0.06)		
Country FE	✓	✗	✗	✗
Region FE	✗	✓	✗	✓
Time FE	✓	✓	✗	✗
Country-Time FE	✗	✗	✓	✓
Inflation expectations	✓	✓	✗	✗
Observations	3,968	3,968	3,968	3.968
Adjusted R^2	0.56	0.56	0.73	0.72

Note: This table reports the estimates of the coefficients associated with the unemployment rate, ψ, and the coefficient associated with the one-year-ahead inflation expectations, γ, over the 1999-2023 period, using different sets of fixed effects. Specification (1) estimates equation 3 using country and time fixed effects, while specification (2) relies on region and time fixed effects. Specification (3) relies on country-fixed effects solely, while specification (4) estimates equation 4, using both region and country-fixed effects. Standard errors clustered at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

gion fixed effects suggest substantial cross-country heterogeneity in the estimated Phillips curve slopes, ranging from -0.06 for Austria to -0.79 for the Netherlands (see Tables A1-A3 in Annex), a notable flattening of the Phillips curve re-emerges once national inflation expectations are included in the estimations.[28] As an example, the ψ-coefficient remains negative and statistically significant in Germany but changes from -0.24 to -0.15, while it changes from -0.31 to -0.09 in Greece and from -0.28 to -0.18 in Spain.

Overall, these results highlight the importance of controlling not only for long-term inflation expectations through time fixed effects, but also for country-specific inflation expectations when estimating the Phillips curve in the euro area.

$+\gamma^c \mathbb{E}_t[\pi_{c,t+1}^{Consensus}] + \delta^c \mathbf{X}_{i,t} + \varepsilon_{i,t}$, where ψ^c captures the country-specific slope of the Phillips curve.

[28] These findings are consistent with the results of Schuffels et al. (2024) using country-level data, whose Phillips curve estimates range between -0.16 and -0.41.

3.3 Instrumental variable approach

Although the inclusion of different sets of fixed effects mitigates potential bias arising from unobserved cost-push shocks, regional inflation may still be influenced by idiosyncratic regional cost-push shocks, which could bias the estimates of ψ. In addition, recent evidence also suggests that monetary policy transmits not only across countries, but also across regions (de Groot et al., 2023). As a result, the monetary policy response to an aggregate cost-push shock could also affect the regions of a given country differently, and this effect would not be captured by the country-time fixed effects. Finally, suppose a region experiences a relatively higher inflation rate driven by increased wage growth. This situation may prompt households to relocate to regions offering higher wages, consequently boosting the labor supply in those areas. As a result, the estimates of ψ may be biased due to inter-regional labor mobility.

To address these concerns, our first approach is to instrument the current unemployment rate using its one-year lag. This approach has been used by Hazell et al. (2022) and assumes that, under rational expectations, lagged unemployment will be uncorrelated with the expectation error. Our second identification strategy employs a shift-share instrument, similar to Bartik (1991), that captures productivity shocks in tradable sectors. Unobserved cost-push shocks at national or supranational level may affect inflation heterogeneously across regions due to structural differences in their sectoral composition. For instance, a productivity shock in the Spanish industrial sector would lead to lower unemployment, higher wages, and ultimately, increased price levels in Spain. However, this effect would be more pronounced in regions such as Navarra, La Rioja and the Basque Country, where industrial activity is concentrated, compared to Madrid, which is more service-oriented. As a result, the instrument captures *demand-driven* variations in regional unemployment rates that are exogenous to unobserved regional cost-push shocks. This methodological approach is consistent with previous applications for the United States by Hazell et al. (2022), Cerrato and Gitti (2022), and Gitti (2024).[29]

The instrument is constructed as the inner product between *regional* employment shares across individual tradable sectors and the corresponding *national* employment growth in those sectors. For the *shares*, we collect data on sectoral employment at the regional level for 19 NACE Rev. 2 manufacturing sectors using

[29] Shift-share instruments have been employed in many fields of economics, ranging from immigration to international trade, see for instance Autor et al. (2013), Blanchard and Katz (1992) or Card (2001). McLeay and Tenreyro (2019) adopted a related approach by using identified demand shocks from government spending to estimate the slope of the regional Phillips curve in the United States.

Eurostat's Structural Business Statistics.[30] For the *shifts*, we source employment at the national level for the same sectors using the Eurostat's National Accounts. Formally, our instrument is defined as:

$$z_{i,t} = \sum_{j} \bar{S}_{i,j} \times \Delta_{3Y} \log E_{c,j,t} \tag{5}$$

where $S_{i,j,\tau}$ represents the employment share of sector j in region i, averaged over time. The shifters, $\Delta_{3Y} \log E_{c,j,t}$, correspond to the three-year percentage change in national employment of tradable sector j in year t, as in Hazell et al. (2022).

We instrument the unemployment rate in the different specifications of our baseline equation (equations 1-4), either by the one-year lagged unemployment rate or by our shift-share instrument. To verify the relevance of our instruments, we report in Table 4 the first-stage regression where the dependent variable is $u_{i,t}$ and the main explanatory variable is either $u_{i,t-1}$ or $z_{i,t}$, whose associated coefficient is denoted by θ, controlling for different sets of fixed effects.[31]

The first-stage regression results indicate that the lagged unemployment rate is a strong instrument, as evidenced by the consistently negative and statistically significant estimates of θ. The F-statistics exceed conventional thresholds for weak instrument, thereby confirming the relevance of our instrument. In constrast, the instrument $z_{c,i,t}$ is relevant across all specifications, except when country-time fixed effects are included, suggesting that controlling for national variations may already address endogeneity concerns arising from potential regional confounders.

The second-stage regression results continue to provide evidence of an "alive" price Phillips curve in the euro area when instrumenting with lagged unemployment: the coefficient ψ remains negative and strongly statistically significant. The ψ-coefficients remain very close to our baseline estimates. The results when instrumenting with the shift-share instrument suggest a steeper price Phillips curve when using region and time fixed effects, which indicates that the instrumental variable approach corrects for some bias. When country-fixed effects are employed, the IV estimate of the slope of the price Phillips curve is no longer statistically significant from zero.[32]

[30] NACE (*Nomenclature statistique des activités économiques dans la Communauté européenne*) is the statistical classification of economic activities in the European Union. The sector correspond to various manufacturing industries at the 2-digit level (e.g. manufacture of paper and paper products, basic metals, rubber and plastic products, etc.). The Eurostat Structural Business Statistics database has information on sectoral employment at the regional level from 2008 to 2023.

[31] The results are robust when we further control for the relative price of intermediate inputs and labor productivity shocks in the non-tradable sector as in Cerrato and Gitti (2022) and Gitti (2024) (see Section 5).

[32] The coefficient ψ also exhibit the "wrong" sign but the results should be interpreted with caution given the lack of the relevance of the shift-share instrument in the first-stage regression.

Table 4: Two-Stage Least Squares Results

	Dependent variable: Regional inflation (Second Stage)			
	Region (1)	Region + Time (2)	Region + Time + Infl. Exp. (3)	Region + Country-Time (4)
Panel A. Lagged unemployment rate				
I Stage				
θ	0.85***	0.84***	0.77***	0.62***
	(0.04)	(0.04)	(0.06)	(0.10)
II Stage				
ψ	−0.28***	−0.19***	−0.11***	−0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
F-statistic (I Stage)	539.2	391.7	178.1	35.5
Adjusted R^2 (II Stage)	0.20	0.54	0.55	0.72
Observations	3,808	3,808	3,808	3,808
Panel B. Bartik instrument				
I Stage				
θ	−0.24***	−0.27***	−0.20***	−0.04
	(0.02)	(0.02)	(0.02)	(0.05)
II Stage				
ψ	−0.46***	−0.35***	−0.34***	0.35
	(0.04)	(0.03)	(0.04)	(1.12)
F-statistic (I Stage)	250.3	193.3	120.0	0.63
Adjusted R^2 (II Stage)	0.10	0.47	0.47	0.63
Observations	3,960	3,960	3,960	3,960
Specifications				
Region FE	✓	✓	✓	✓
Time FE	✗	✓	✓	✗
Country–Time FE	✗	✗	✗	✓
Inflation expectations	✗	✗	✓	✗

Note: This table shows the IV estimations of the baseline specification, where the unemployment rate is instrumented by lagged unemployment rate (Panel A) and by the shift-share instrument (Panel B). The table reports the estimates of θ from the first-stage regression and the estimates of ψ from the second-stage regression (equations 1-4). The shift-share instrument is constructed using country-sector employment growth rates. Specification (1) includes region fixed effects. Specifications (2) includes region and time fixed effects, and specification (3) further controls for inflation expectations. Specification (4) includes a set of region and country-time fixed effects. Inflation expectations coefficients are omitted for readability. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

4 Nonlinearity of the price Phillips curve

The inflation surge following 2020, combined with historically low unemployment levels, prompted economists to reconsider the idea of a nonlinear Phillips curve, particularly in the United States. Benigno and Eggertsson (2023), for instance, show that the price Phillips curve may become strongly nonlinear when the vacancy-to-unemployment ratio exceeds one. This finding is supported by

Gitti (2024), who uses subnational U.S. data and the same measure of labor market tightness. However, signs of nonlinearities in the Phillips curve were already present before the pandemic, even when using the more traditional unemployment rate as slack variable (Babb and Detmeister, 2017; Hooper et al., 2020). In contrast, Beaudry et al. (2025) argue that these apparent nonlinearities may stem from insufficient control for inflation expectations. Once expectations are properly accounted for, they find that the U.S. Phillips curve appears linear, even at high-levels of labour market tightness.[33]

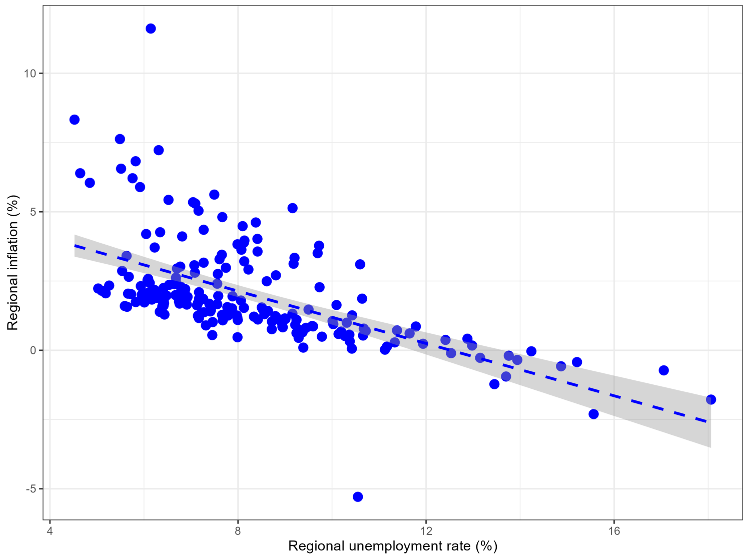
For the euro area, the evidence is similarly mixed. Several studies find little support for a nonlinear price Phillips curve (Eser et al., 2020; Moretti et al., 2019; Musso et al., 2007), or suggest that any nonlinearity is more likely to be driven by inflation expectations (Lenza et al., 2025). More recently, Smith et al. (2023) report evidence of a steeper slope under tight labor market conditions. Importantly, these studies rely on country-level or aggregate euro area data, and do not exploit regional-level data information, which may offer additional insights into the functional form of the Phillips curve.

We explore this question by leveraging our extensive cross-sectional dataset at the regional level for the euro area. To obtain a visual sense of a potential nonlinear relationship between inflation and unemployment, we begin by plotting in Figure 3a the raw data, both for inflation and unemployment, grouped by bins of unemployment. The visual analysis indicates a relatively linear slope for unemployment rates exceeding 9 percent. However, noticeable upward shifts in inflation can be observed for lower unemployment rates, suggesting the possibility of nonlinearity in the Phillips curve slope. Panel 3b displays the binned residuals of inflation and unemployment derived from our baseline regressions, after accounting for region and time fixed effects, and controlling for national inflation expectations. In contrast, the figure does not provide clear evidence of nonlinearity in the price Phillips curve for the euro area, indicating that the observed shifts in inflation are significantly mitigated when inflation expectations are taken into account.

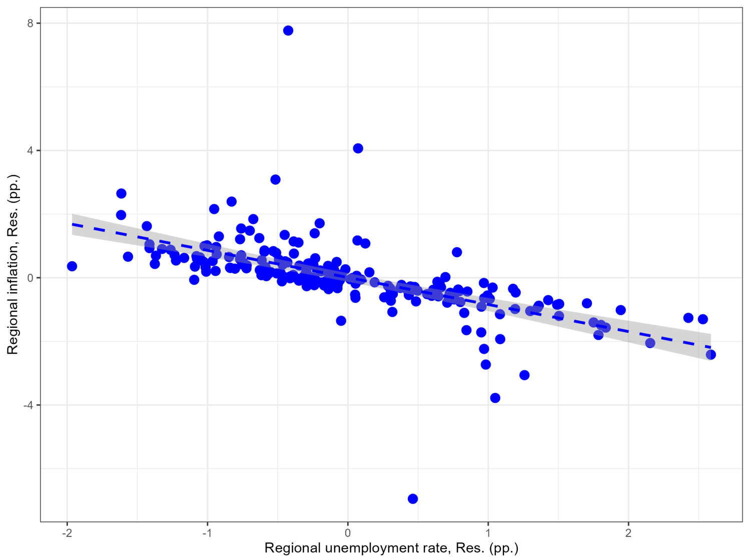
[33] Afrouzi et al. (2024) also find that unexpected inflation can lead workers to engage in job-to-job transitions, leading to a rise in aggregate vacancies relative to unemployment during inflationary periods.

Figure 3: Estimates of ψ controlling for fixed effects

(a) Without fixed effects



(b) With fixed effects and inflation expectations



Note: These figures provide a graphical representation of ψ from our baseline specifications. Figure 3a plots the raw inflation and raw unemployment data, grouped by 200 bins of unemployment. Figure 3b plots the residualized inflation and unemployment against region and time fixed effects, and controlling for national inflation expectations. The dashed lines represent the best linear fit for both specifications, and the associated confidence intervals are shown by the grey areas.

Therefore, we formally test for nonlinearity in the price Phillips curve by estimating the following threshold model:

$$\pi_{i,t} = \psi_0 + \psi_1 u_{i,t} + \psi_2 u_{i,t} \times D_{i,t} + \psi_3 D_{i,t} + \gamma \mathbb{E}_t[\pi_{c,t+1}^{Consensus}] + \delta \mathbf{X}_{c,i,t} + \varepsilon_{i,t} \quad (6)$$

where $D_{i,t}$ is a dummy variable that takes 1 if the regional unemployment rate, $u_{i,t}$, is above the 25th percentile of the regional unemployment rates over time within that specific country.[34] Therefore, we apply varying thresholds across euro area countries to account for structural differences in national unemployment rates.[35] Consequently, ψ_1 indicates the slope of the price Phillips curve when unemployment is below the first quartile of its country distribution, and the intercept is ψ_0. When the regional unemployment rate is above the first quartile, the slope is $\psi_1 + \psi_2$ and the intercept is $\psi_0 + \psi_3$.

Table 5: Nonlinearities in the Price Phillips curve

	Dependent variable: Regional Inflation (%)			
	Region	Region + Time	Region + Time + Infl. Exp.	Region + Country-Time
	(1)	(2)	(3)	(4)
ψ_1	-0.32^{***}	-0.24^{***}	-0.15^{***}	-0.03
	(0.04)	(0.03)	(0.03)	(0.02)
ψ_2	0.09^{***}	0.07^{***}	0.04^{*}	0.01
	(0.03)	(0.02)	(0.02)	(0.02)
Region Fixed Effect	✓	✓	✓	✓
Time Fixed Effect	✗	✓	✓	✗
Country-Time Fixed Effect	✗	✗	✗	✓
Inflation expectations	✗	✗	✓	✗
Observations	3,968	3,968	3,968	3,968
Adjusted R^2	0.23	0.54	0.56	0.72

Note: This table reports the estimates of ψ_1 and ψ_2 of equation 6 respectively over the 1999-2023 period. The constants are not reported for readability. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

The results reported in Table 5 suggest the presence of nonlinearity when controlling for region fixed effects (Column 1). Notably, the estimated slope is -0.32 for regional unemployment rates below the 25th percentile of their respective country distributions, flattening to -0.23 at higher levels of unemployment. The presence of time fixed effects attenuates the nonlinearity of the curve, resulting in slope estimates of -0.24 for low unemployment rates and -0.17 for high unemployment rates (Column 2). The steepness of the slope for lower unemployment rates is further reduced when we account for national inflation expectations (Column 3). The ψ_1-coefficient is now estimated at -0.15 and the coefficient of the interaction term, ψ_2, remains statistically significant but only at the 10 percent level, resulting in a slope of -0.11 for high unemployment rates. Finally, both coefficients ψ_1 and ψ_2 become

[34] The results are robust using different thresholds, namely the 10th percentile and the median (see Section 5).

[35] Specifically, the thresholds are as follows: Austria (3.4%), Belgium (4.2%), Germany (3.4%), Greece (9.3%), Spain (9.5%), Finland (7.2%), France (6.8%), Ireland (4.3%), Italy (4.9%), the Netherlands (3.3%), and Portugal (5.9%).

insignificant in both models when we control for country-specific aggregate fluctuations.[36]

The open question was whether the observed nonlinearity in the slope of the price Phillips curve reflects improper control for inflation expectations, as suggested by Beaudry et al. (2025). Our results provide some support for this interpretation: incorporating inflation expectations, in our case from professional forecasters, not only affects the estimated slope of the Phillips curve but also diminishes the empirical evidence for nonlinearity. Furthermore, the estimated nonlinearity effectively disappears when we control for time-varying country specific factors, which notably control for any inflation expectation.[37]

[36]We also explore the nonlinearity of the Phillips curve using a quadratic model and a cubic model following Ball et al. (2022) and Beaudry et al. (2025) and the results point to similar conclusions (see Section 5).

[37]Beaudry et al. (2025) suggest to control for inflation expectations of households and firms as alternatives, but they are not available for the euro area.

5 Robustness checks

We test the robustness of our results by first estimating our baseline equation across various country samples. We begin with the four largest euro area economies, (Germany, France, Italy, and Spain) each of which includes at least 17 regions, thereby ensuring a large cross-sectional variation when incorporating country-time fixed effects. The results show that the slope of the price Phillips curve remains broadly consistent with our baseline findings (see Table A4). Notably, the estimated ψ-coefficient is statistically significant at -0.18 when controlling for region and time fixed effects, and flattens to -0.12 when further controlling for national inflation expectations. The coefficient remains similar to our baseline results when we include country-time fixed effects. The findings remain robust when the Netherlands is added to the sample, and consistent estimates when we consider a sample of euro area countries excluding the five largest economies, although the slope estimate becomes insignificant with the presence of country-fixed effects.

Second, we estimate our baseline equations by using alternative measure of regional inflation. As regional Consumer Price Index (CPI) data are available over a sufficiently long period only for Germany (since 1998 at the NUTS-1 level) and Spain (since 2002 at the NUTS-2 level), we re-estimate the country-specific price Phillips curves using regional CPI inflation instead of the GDP deflator for these two countries.[38] The results suggest a flatter, but still statistically significant, Phillips curve for both countries when controlling for region fixed effects: the slope is estimated at -0.13 across German regions (compared to -0.24 when using the GDP deflator) and at -0.13 across Spanish regions (compared to -0.28) (see Table A5). Importantly, the inclusion of national inflation expectations leads to a further flattening of the price Phillips curve, consistent with our baseline results.[39]

Professional forecasters have access to comprehensive information regarding price dynamics from the previous year when they formulate their inflation expectations for the upcoming year in January. Consequently, we re-estimate our baseline equations using 2-year ahead national inflation expectations, which are fully forecasted. The results are virtually unchanged (as shown in Table A6).

As stated by Cerrato and Gitti (2022) and Gitti (2024), productivity shocks in the tradable sector might lower the price of tradable goods across regions, which could in turn also lower the price of non-tradables. To control for the direct incidence of a change in tradable prices on non-tradable prices, we follow Cerrato and Gitti (2022) and Gitti (2024) and include the relative price of intermediate inputs

[38] Regional CPI for Italian regions is only available since 2016.

[39] Quantitatively, the Phillips curve estimates are at -0.04 for Germany and -0.07 for Spain.

to the GDP deflator in our IV specification. Furthermore, regional unemployment rates might be affected by productivity shocks in the non-tradable sector. If regional productivity shocks in the tradable sector correlate with the variation in unemployment rates captured by our instrument, then our estimate of ψ would be biased. We therefore control for labor productivity growth in the construction and service sector. The results shown in Table A7 are close to our benchmark IV results, especially when using country-time fixed effects.

Fourth, our baseline results do not provide evidence of significant nonlinearity in the price Phillips curve when estimated using a threshold model where the kink is set by the 25th percentile of regional unemployment rates within the country distribution. We assess the robustness of this result by shifting the threshold to the median. As shown in Table A8 changing the threshold makes any evidence of nonlinearities even less pronounced in both our preferred specifications. This result robust to even finer threshold as shown in Table A9 where we consider the first decile as threshold.

Fifth, in the spirit of Beaudry et al. (2025), we check whether results on nonlinearity are preserved when using a more flexible model, more precisely a quadratic relation between inflation and unemployment.[40] Table A10 reveals only limited evidence of curvature in the price Phillips curve, reinforcing the adequacy of the linear specification. The results are also preserved using a cubic model (see Table A11).[41]

Finally, the inclusion of country-time fixed effects in our baseline equation improves the identification of the slope of the price Phillips curve but may come at the cost of absorbing a substantial portion of the data variation, particularly in countries with a relatively small number of regions, which could lead to overfitting of the regression model. To assess this issue, we first demean regional unemployment $u_{i,t}$ by its time-invariant regional mean $\bar{u}_i$, and subsequently by its country-time mean, $\bar{u}_{c,t}$. We repeat the same procedure for regional inflation, and then plot the relationship between the demeaned unemployment and demeaned inflation series. As shown in Figure A8 in the Annex, we continue to observe meaningful variation in the data even after controlling for region and country-time fixed effects. This visual evidence is corroborated by a comparison of the variance in the data before and after demeaning. While the variance, especially for inflation, is reduced relative to the raw data, it remains substantial, indicating that the inclusion of fixed effects does not eliminate all informative variation in the dataset.

[40]Specifically, our quadratic model takes the form $\pi_{i,t} = \psi_1 u_{i,t} + \psi_2 u_{i,t}^2 + \delta \mathbf{X}_{i,c,t} + \varepsilon_{i,t}$.

[41]The cubic model takes the form $\pi_{i,t} = \psi_1 u_{i,t} + \psi_2 u_{i,t}^2 + \psi_3 u_{i,t}^3 + \delta \mathbf{X}_{i,c,t} + \varepsilon_{i,t}$.

6 Conclusion

We estimate the price Phillips curve for the euro area by leveraging regional variation and introducing a novel identification strategy that controls for potential confounders at the regional, national, and euro area levels. Our findings confirm that the price Phillips curve remains empirically relevant but is characterized by a flat and a quasi linear slope, once controlling for national inflation expectations.

This implies that the central bank faces greater challenges in counteracting inflationary pressures through the demand channel. In other words, in the presence of a flatter Phillips curve, monetary policy becomes less effective in steering inflation via unsystematic interventions, regardless of the nature of the shock—whether supply- or demand-driven. As a result, stabilising prices in response to temporary fluctuations becomes more difficult.

The most effective way for monetary policy to regain control over inflation is not through isolated or discretionary policy interventions, but through a systematic and forward-looking adjustment of the policy stance in response to evolving economic conditions. In an environment characterised by a flatter Phillips curve and heightened structural uncertainty, the effectiveness of traditional demand-side channels may be diminished. This reinforces the importance of a state-contingent and proportionate monetary policy framework, underpinned by clear communication and a credible commitment to the medium-term inflation objective. By enhancing the anchoring of inflation expectations, such an approach strengthens the transmission of monetary policy and supports price stability over the medium term.

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A Annex

A.1 Additional tables

Table A1: Price Phillips curve for Austria, Belgium and France

	Dependent variable: Regional Inflation (%)					
	Austria		Belgium		France	
	Region	Region + Infl. Exp.	Region	Region + Infl. Exp.	Region	Region + Infl. Exp.
	(1)	(2)	(3)	(4)	(5)	(6)
ψ	-0.06	0.15^{***}	-0.44^{***}	-0.29^{***}	-0.31^{***}	-0.13^{*}
	(0.14)	(0.04)	(0.08)	(0.07)	(0.11)	(0.06)
γ		1.22^{***}		0.63^{***}		1.01^{***}
		(0.08)		(0.05)		(0.04)
Region Fixed Effect	✓	✓	✓	✓	✓	✓
Inflation expectations	✗	✓	✗	✓	✗	✓
Observations	225	225	275	275	550	550
Adjusted R^2	0.01	0.50	0.15	0.32	0.18	0.57

Note: This table reports the estimates of ψ over the 1999-2023 period using different sets of fixed effects for Austria, Belgium and France. Columns (1), (3) and (5) show the estimates of ψ when estimating equation 1 for each country separately when using region fixed effects. Columns (2), (4) and (6) show the estimates of equation 1 when using region fixed effects and controlling for national inflation expectations.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A2: Price Phillips curve for Germany, Greece and Italy

	Dependent variable: Regional Inflation (%)					
	Germany		Greece		Italy	
	Region	Region + Infl. Exp.	Region	Region + Infl. Exp.	Region	Region + Infl. Exp.
	(1)	(2)	(3)	(4)	(5)	(6)
ψ	-0.24^{***}	-0.15^{***}	-0.31^{***}	-0.09^{***}	-0.14^{**}	-0.05
	(0.02)	(0.01)	(0.03)	(0.03)	(0.06)	(0.03)
γ		0.89^{***}		0.92^{***}		0.80^{***}
		(0.03)		(0.15)		(0.04)
Region Fixed Effect	✓	✓	✓	✓	✓	✓
Inflation expectations	✗	✓	✗	✓	✗	✓
Observations	950	950	325	325	518	518
Adjusted R^2	0.21	0.54	0.26	0.33	0.09	0.52

Note: This table reports the estimates of ψ over the 1999-2023 period using different sets of fixed effects for Germany, Greece and Italy. Columns (1), (3) and (5) show the estimates of ψ when estimating equation 1 for each country separately when using region fixed effects. Columns (2), (4) and (6) show the estimates of equation 1 when using region fixed effects and controlling for national inflation expectations.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A3: Price Phillips curve for the Netherlands, Portugal and Spain

	Dependent variable: Regional Inflation (%)					
	Netherlands		Portugal		Spain	
	Region	Region + Infl. Exp.	Region	Region + Infl. Exp.	Region	Region + Infl. Exp.
	(1)	(2)	(3)	(4)	(5)	(6)
ψ	-0.79^{***}	-0.35^{***}	-0.29^{***}	-0.19^{***}	-0.28^{***}	-0.18^{***}
	(0.07)	(0.05)	(0.03)	(0.02)	(0.01)	(0.01)
γ		1.31^{***}		0.81^{***}		0.85^{***}
		(0.10)		(0.04)		(0.05)
Region Fixed Effect	✓	✓	✓	✓	✓	✓
Inflation expectations	✗	✓	✗	✓	✗	✓
Observations	325	325	200	200	425	425
Adjusted R^2	0.18	0.42	0.33	0.52	0.51	0.63

Note: This table reports the estimates of ψ over the 1999-2023 period using different sets of fixed effects for the Netherlands, Portugal and Spain. Columns (1), (3) and (5) show the estimates of ψ when estimating equation 1 for each country separately when using region fixed effects. Columns (2), (4) and (6) show the estimates of equation 1 when using region fixed effects and controlling for national inflation expectations.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A4: Subsample Results

	EA4	EA5	Excl. EA5
ψ (Region FE)	-0.25^{***}	-0.26^{***}	-0.31^{***}
	(0.019)	(0.020)	(0.021)
ψ (Region FE + Time FE)	-0.18^{***}	-0.18^{***}	-0.24^{***}
	(0.016)	(0.015)	(0.019)
ψ (Region FE + Time FE + Infl. Exp.)	-0.12^{***}	-0.12^{***}	-0.11^{***}
	(0.015)	(0.014)	(0.019)
ψ (Region FE + Country–Time FE)	-0.02^{*}	-0.02^{*}	-0.01
	(0.008)	(0.008)	(0.025)
Adjusted R^2 (Region FE)	0.280	0.236	0.214
Adjusted R^2 (Region FE + Time FE)	0.703	0.628	0.473
Adjusted R^2 (Region FE + Time FE + Infl. Exp.)	0.731	0.653	0.497
Adjusted R^2 (Region FE + Country–Time FE)	0.848	0.769	0.729
Observations	2,443	2,768	1,200
Minimum number of regions	17	14	3

Note: EA4 includes the four largest euro area economies, namely Germany, France, Italy, and Spain. EA5 adds Netherlands to the EA4 sample. The sample excluding EA5 comprises all euro area countries in our dataset excluding the five largest euro area economies. The ψ coefficients represent the estimated slope of the price Phillips curve depending on different sets of fixed effects. Clustered standard errors at the NUTS-2 level are reported in parentheses. * / ** / *** indicate 10% / 5% / 1% significance level.

Table A5: Price Phillips curve using CPI

	Dependent variable: Regional Inflation (%)	
	Region	Region + Infl. Exp.
	(1)	(2)
Germany		
ψ	-0.13^{***}	-0.04^{***}
	(0.01)	(0.01)
γ		1.08^{***}
		(0.02)
Spain		
ψ	-0.13^{***}	-0.07^{***}
	(0.01)	(0.005)
γ		0.54^{***}
		(0.02)
Region FE	✓	✓
Inflation Expectations	✗	✓
Observations (*Germany*)	372	372
Observations (*Spain*)	336	336
Adjusted R^2 (*Germany*)	0.06	0.58
Adjusted R^2 (*Spain*)	0.25	0.37

Note: This table reports the estimates of ψ over the 1998-2023 period for Germany using NUTS-1 level regions and over the 2002-2023 period for Spain using NUTS-2 level regions. Specification (1) reports estimates for equation 1, while specification (2) reports estimates for equation 3. Standard errors clustered at the NUTS-1 level for Germany and at the NUTS-2 level for Spain are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A6: Price Phillips curve controlling for national two-year-ahead inflation expectations

	Dependent variable: Regional Inflation (%)	
	Country + Time	Region + Time
	(1)	(2)
ψ	-0.04^{***}	-0.11^{***}
	(0.01)	(0.01)
γ	1.34^{***}	1.01^{***}
	(0.08)	(0.11)
Country FE	✓	✗
Region FE	✗	✓
Time FE	✓	✓
Inflation expectations	✓	✓
Observations	3,968	3,968
Adjusted R^2	0.56	0.55

Note: This table reports the estimates of the coefficients associated with the unemployment rate, ψ, and the coefficient associated with the two-year-ahead inflation expectations, γ, over the 1999-2023 period, using different sets of fixed effects. Specification (1) estimates equation 3 using country and time fixed effects, while specification (2) relies on region and time fixed effects. Standard errors clustered at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A7: Two-Stage Least Squares Results (Robustness)

	Dependent variable: Regional inflation (Second Stage)			
	Region (1)	Region + Time (2)	Region + Time + Infl. Exp. (3)	Region + Country-Time (4)
Stage I				
θ	-0.23^{***}	-0.27^{***}	-0.21^{***}	-0.05
	(0.02)	(0.02)	(0.02)	(0.05)
Stage II				
ψ	-0.42^{***}	-0.34^{***}	-0.35^{***}	0.36
	(0.04)	(0.04)	(0.04)	(0.98)
Region FE	✓	✓	✓	✓
Time FE	✗	✓	✓	✗
Country–Time FE	✗	✗	✗	✓
Inflation expectations	✗	✗	✓	✗
F-statistic (Stage I)	242.06	158.00	117.67	0.96
Adjusted R^2 (Stage II)	0.21	0.49	0.48	0.62
Observations	3,802	3,802	3,802	3,802

Note: This table shows the IV estimation of the baseline specification, where the unemployment rate is instrumented by the shift-share instrument. The table reports the estimates of θ from the first-stage regression and the estimates of ψ from the second-stage regression (equations 1-4). The shift-share instrument is constructed using country-sector employment growth rates. Specification (1) includes region fixed effects. Specifications (2) includes region and time fixed effects, and specification (3) further controls for inflation expectations. Specification (4) includes a set of region and country-time fixed effects. Following Cerrato and Gitti (2022) and Gitti (2024), we include the relative price of intermediate inputs to the GDP deflator and labor productivity growth in the construction and service sector in our IV specification. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A8: Threshold model when the threshold is set by the median

	Dependent variable: Regional Inflation (%)			
	Region (1)	Region + Time (2)	Region + Time + Infl. Exp. (3)	Region + Country-Time (4)
ψ_1	-0.28^{***}	-0.20^{***}	-0.12^{***}	0.01
	(0.03)	(0.03)	(0.02)	(0.02)
ψ_2	0.08^{***}	0.04^{**}	0.02	-0.03
	(0.02)	(0.02)	(0.01)	(0.02)
Region FE	✓	✓	✓	✓
Time FE	✗	✓	✓	✗
Country-Time FE	✗	✗	✗	✓
Inflation expectations	✗	✗	✓	✗
Observations	3,968	3,968	3,968	3,968
Adjusted R^2	0.22	0.54	0.56	0.72

Note: This table reports the estimates of ψ_1 and ψ_2 of equation 6 respectively over the 1999-2023 period. ψ_1 captures the slope of the price Phillips curve when the regional unemployment rate is below the median of its country distribution, while $\psi_1 + \psi_2$ when it is above. The constants are not reported for readability. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A9: Threshold model when the threshold is set by the first decile

	Dependent variable: Regional Inflation (%)			
	Region	Region + Time	Region + Time + + Infl. Exp.	Region + Country-Time
	(1)	(2)	(3)	(4)
ψ_1	-0.44^{***}	-0.25^{***}	-0.16^{***}	-0.03
	(0.06)	(0.05)	(0.04)	(0.04)
ψ_2	0.18^{***}	0.07	0.05	0.02
	(0.06)	(0.05)	(0.04)	(0.03)
Region FE	✓	✓	✓	✓
Time FE	✗	✓	✓	✗
Country-Time FE	✗	✗	✗	✓
Inflation expectations	✗	✗	✓	✗
Observations	3,968	3,968	3,968	3,968
Adjusted R^2	0.21	0.53	0.56	0.72

Note: This table reports the estimates of ψ_1 and ψ_2 of equation 6 respectively over the 1999-2023 period. ψ_1 captures the slope of the price Phillips curve when the regional unemployment rate is below the first decile of its country distribution, while $\psi_1 + \psi_2$ when it is above. The constants are not reported for readability. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

Table A10: Nonlinearity of the Phillips curve using a quadratic model

	Dependent variable: Regional Inflation (%)			
	Region	Region + Time	Region + Time + Infl. Exp.	Region + Country-Time
	(1)	(2)	(3)	(4)
ψ_1	-0.14^{***}	-0.51^{***}	-0.21^{***}	-0.06
	(0.03)	(0.11)	(0.03)	(0.04)
ψ_2	0.002^{*}	0.01^{***}	0.003^{***}	0.001
	(0.001)	(0.003)	(0.001)	(0.001)
Region FE	✓	✓	✓	✓
Time FE	✗	✓	✓	✗
Country-Time FE	✗	✗	✗	✓
Inflation Expectations	✗	✗	✗	✗
Observations	3,968	3,968	3,968	3,968
Adjusted R^2	0.07	0.22	0.56	0.72

Note: This table reports the estimates of the slope of the price Phillips curve using a quadratic model for the 1999-2023 period. Specifically, the model takes the form $\pi_{i,t} = \psi_1 u_{i,t} + \psi_2 u_{i,t}^2 + \delta \mathbf{X}_{i,c,t} + \varepsilon_{i,t}$. Specification (1) estimates the model using region fixed effects, specification (2) uses region and time fixed effects. Specification (3) estimates the model controlling for inflation expectations and including region and time fixed effects. Specification (4) estimates the quadratic by including a set of region and country-time fixed effects. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

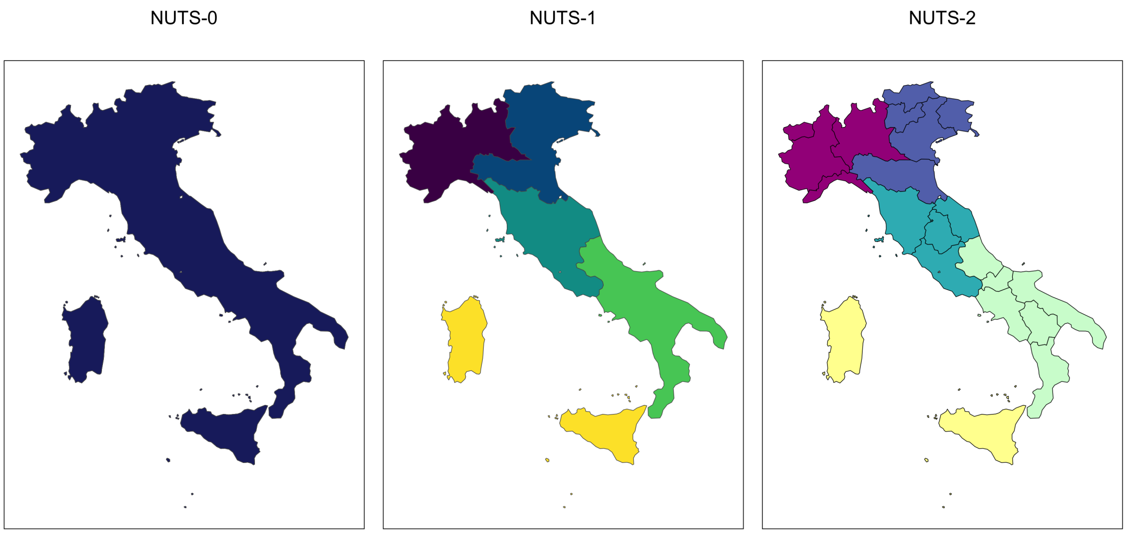
Table A11: Nonlinearity of the Phillips curve using a cubic model

	Dependent variable: Regional Inflation (%)			
	Region	Region + Time	Region + Time + Infl. Exp.	Region + Country-Time
	(1)	(2)	(3)	(4)
ψ_1	-0.16^{**}	-0.58^{**}	-0.23^{***}	-0.06
	(0.07)	(0.21)	(0.06)	(0.04)
ψ_2	0.003	0.01	0.005	0.001
	(0.01)	(0.01)	(0.004)	(0.002)
ψ_3	-0.0000	-0.0001	-0.0000	0.0000
	(0.0001)	(0.0002)	(0.0001)	(0.0000)
Region FE	✓	✓	✓	✓
Time FE	✗	✓	✓	✗
Country-Time FE	✗	✗	✗	✓
Inflation expectations	✗	✗	✓	✗
Observations	3,968	3,968	3,968	3,968
Adjusted R^2	0.07	0.22	0.56	0.72

Note: This table reports the estimates of the slope of the price Phillips curve using a cubic model for the 1999-2023 period. Specifically, the model takes the form $\pi_{i,t} = \psi_1 u_{i,t} + \psi_2 u_{i,t}^2 + \psi_3 u_{i,t}^3 + \delta \mathbf{X}_{i,c,t} + \varepsilon_{i,t}$. Specification (1) estimates the model using region fixed effects, specification (2) uses region and time fixed effects. Specification (3) estimates the model controlling for inflation expectations and including region and time fixed effects. Specification (4) estimates the cubic by including a set of region and country-time fixed effects. Clustered standard errors at the NUTS-2 level are reported in parentheses.
* / ** / *** indicate 10% / 5% / 1% significance level.

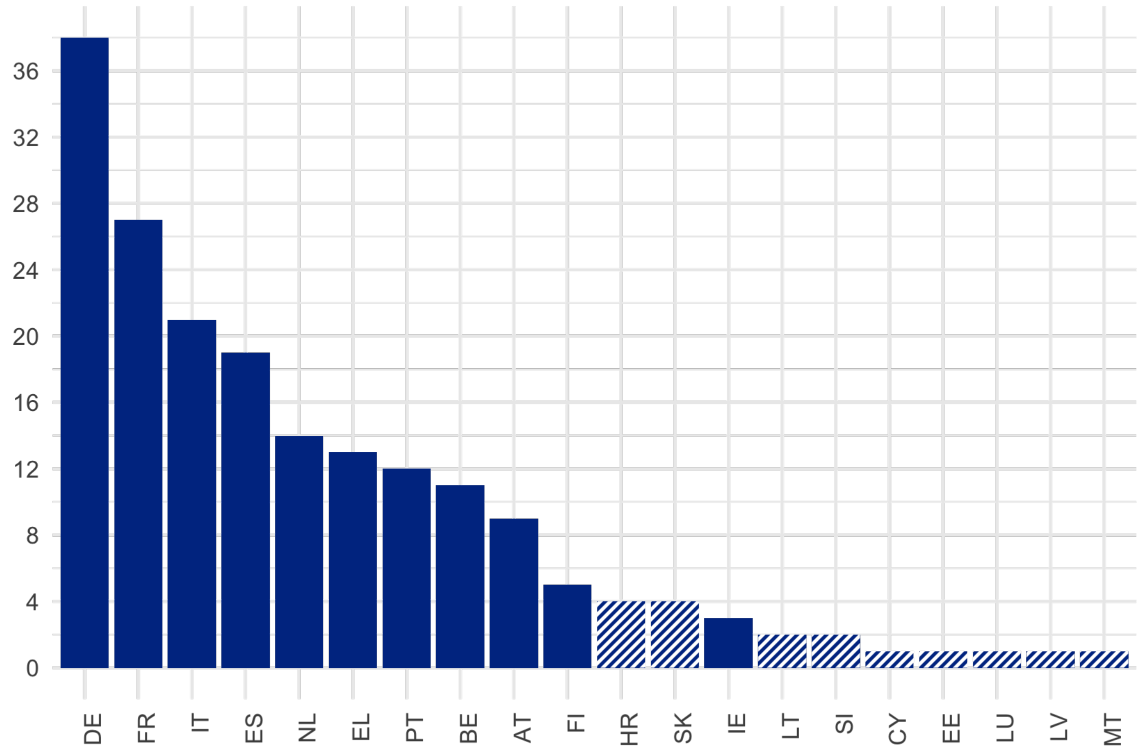
A.2 Additional figures

Figure A1: Dividing the Italian national territory into regions



Note: This figure shows the Italian regions at the NUTS-0 (country-level), NUTS-1, and NUTS-2 levels.

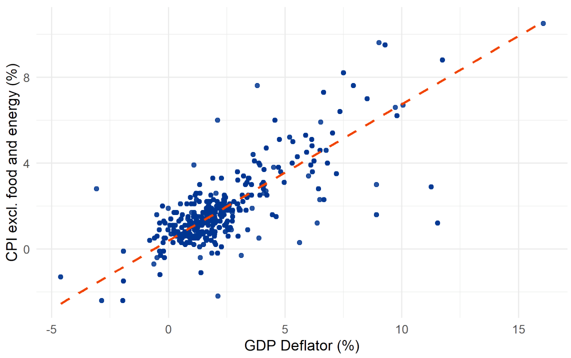
Figure A2: Number of NUTS-2 regions for each euro area country



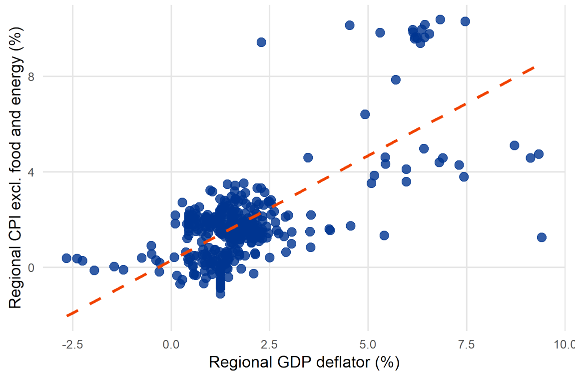
Note: The figure shows the number of NUTS-2 regions for each euro area country. Solid blue bars represent the 11 countries used in our analysis; stripped bars represent the remaining euro area countries.

Figure A3: The GDP deflator is closely related to core inflation

(a) National level



(b) Regional level for Germany



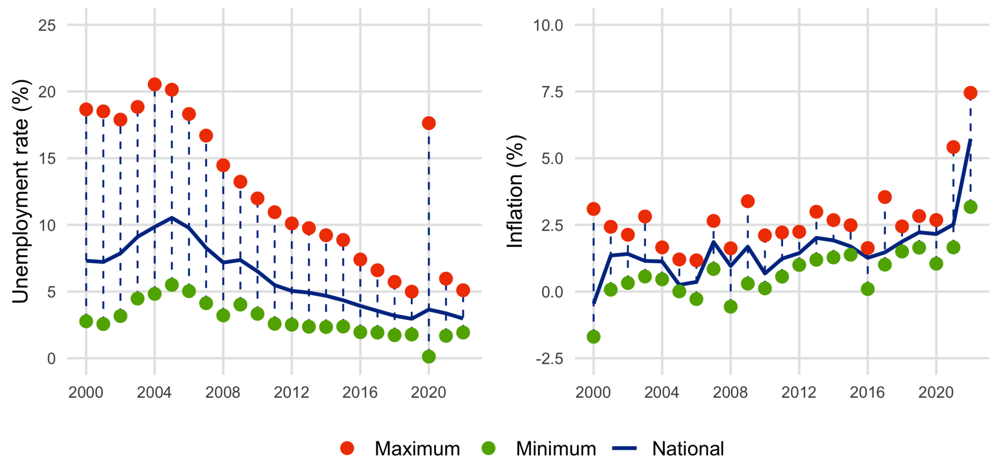
(c) Regional level for Italy

(d) Regional level for Spain

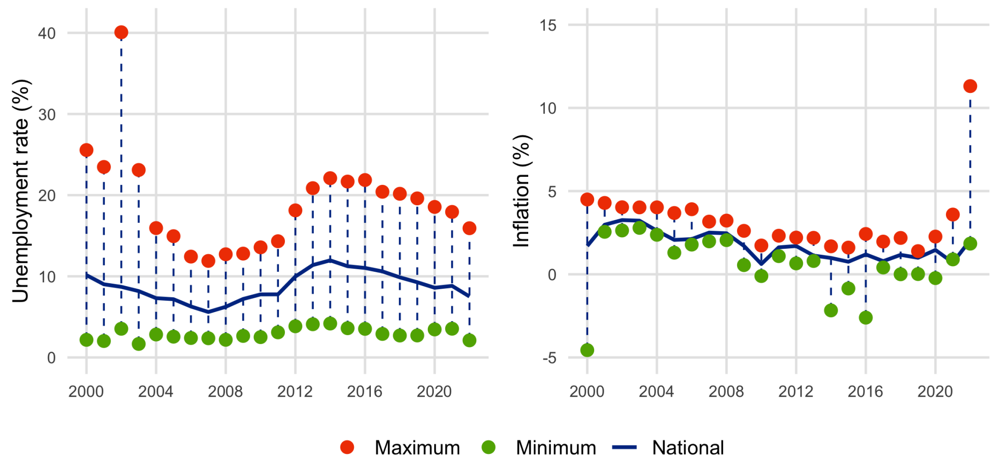
Note: These figures show the correlation between the percentage change of the GDP deflator and the percentage change of the CPI excluding energy and food. Figure A3a depicts the correlation at national level between the HICP index excluding food and energy (HICPX) and the GDP deflator for all euro area countries. Figures A3b-A3d show the correlation at regional level for Germany (NUTS-1 level), Italy and Spain (both NUTS-2 level) between the regional GDP deflator and regional CPI to which national-level energy and food prices are subtracted. Data as of 1998 for Germany, 2016 for Italy and 2002 for Spain.

Figure A4: Regional heterogeneity in unemployment rate and inflation

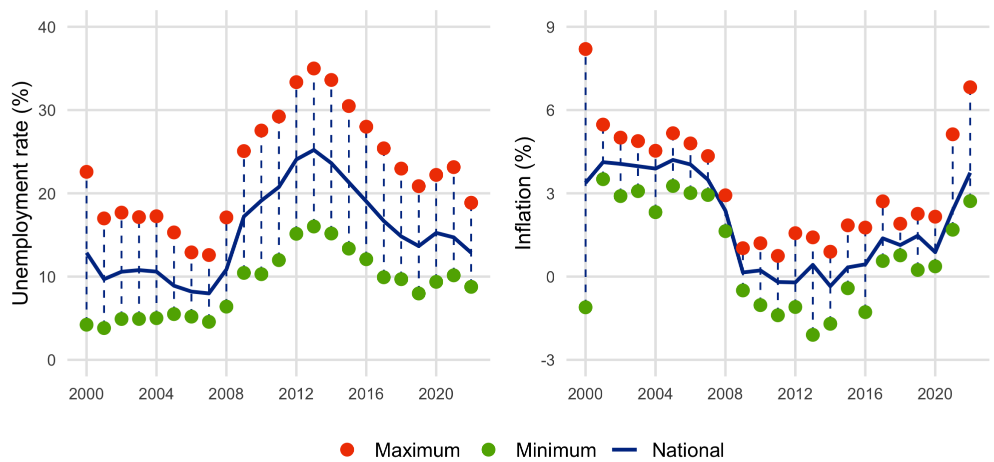
(a) Germany



(b) Italy

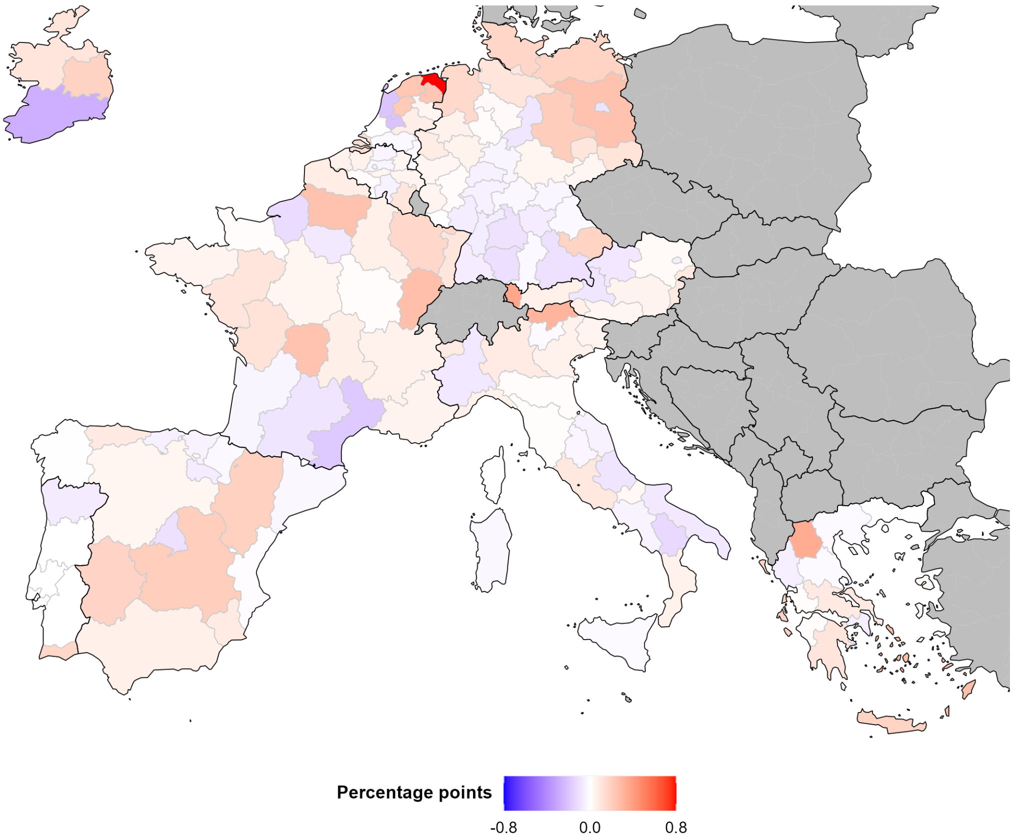


(c) Spain



Note: The figures display the national values along with the regional maximum and minimum values for unemployment rates and inflation for Germany, Italy and Spain.

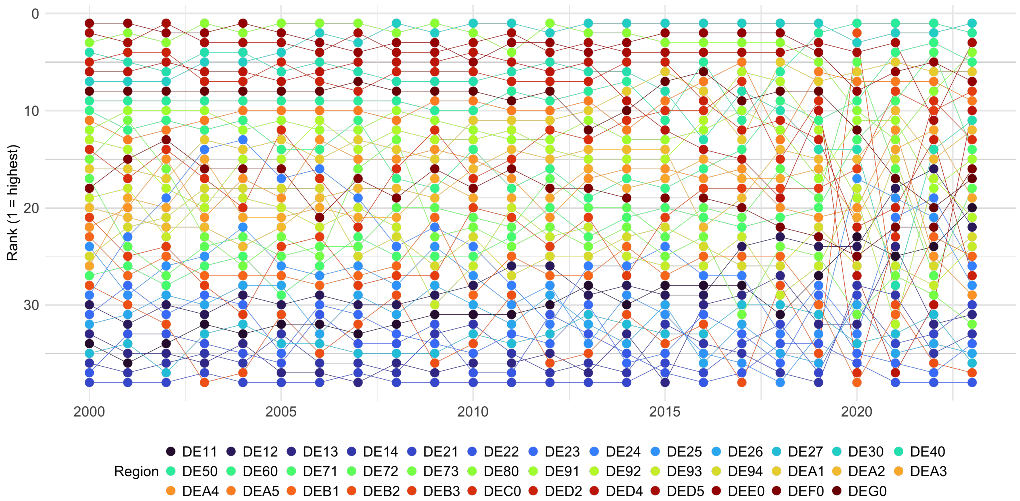
Figure A5: Within-country inflation dispersion



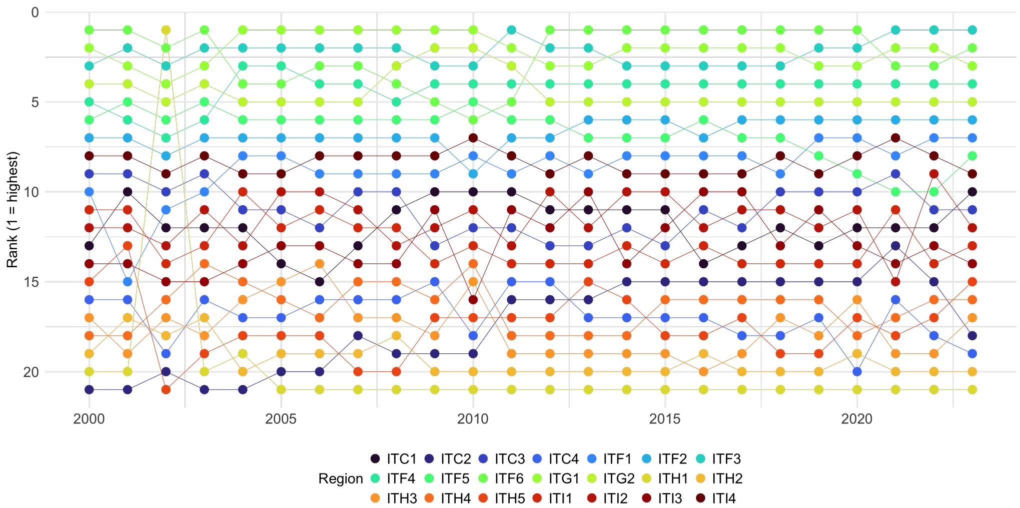
Note: This figure shows the within-country dispersion for 10 euro area countries, averaged over the 1999-2023 period. The within-country dispersion is measured as the difference between regional and national inflation. Finland is not shown for readability. Figures are expressed in percentage points.

Figure A6: Regional rankings of unemployment rates

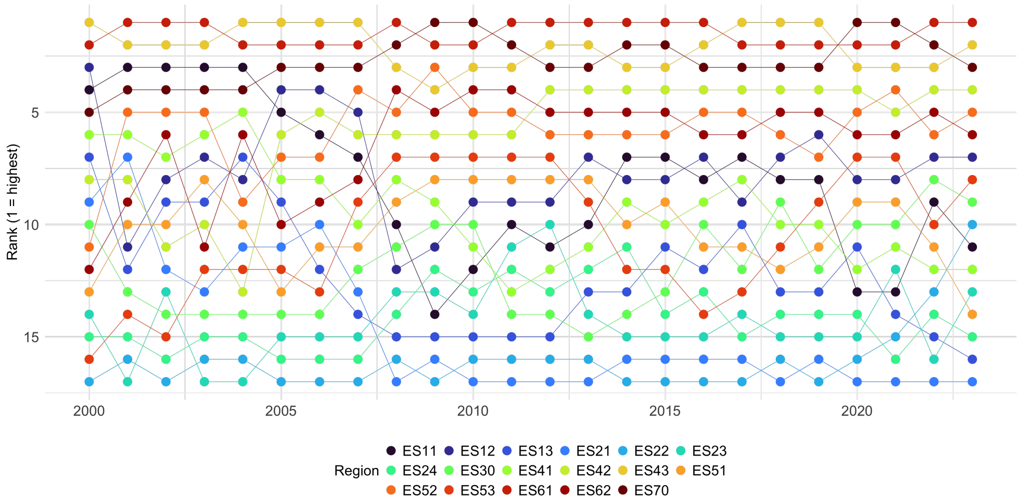
(a) Germany



(b) Italy

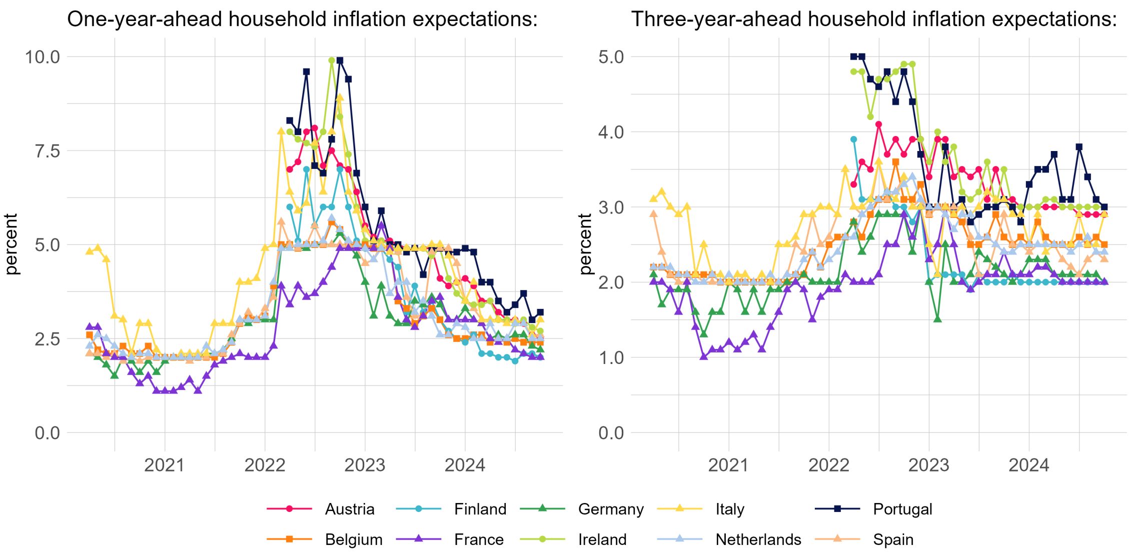


(c) Spain



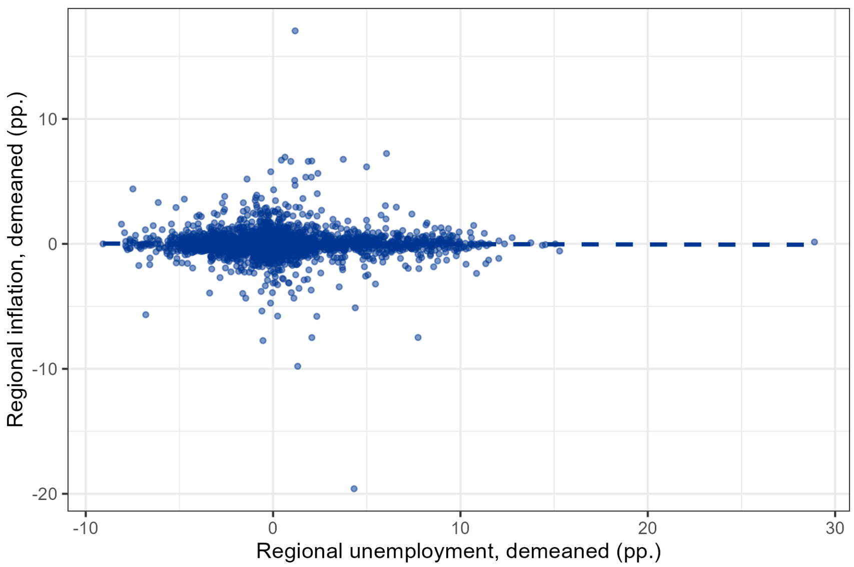
Note: The figures show regional rankings of unemployment rates for Germany, Italy, and Spain.

Figure A7: Household inflation expectations in euro area countries



Note: The figures show the median household inflation expectations one and three years ahead across euro area countries, based on data from the ECB Consumer Expectations Survey. Greece is not shown for readability. For further details on the ECB Consumers Expectations Survey, see Bańkowska et al. (2021) and Georgarakos and Kenny (2022).

Figure A8: Regional inflation and regional unemployment rate in deviation from their country-time mean



Variable	Before Fixed Effects	After Fixed Effects
Regional Inflation Variance	3.64	0.93
Regional Unemployment Rate Variance	26.0	9.54

Note: The scatter plot shows the relation between regional inflation and regional unemployment, where both variables are taken in difference from their time-invariant mean and from their country-time mean. The table shows the variance of both regional inflation and regional unemployment rate before and after taking the difference from their time-invariant mean and from their country-time mean.

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