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The impact of the Russian Ukrainian war on the EU economy

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Abstract

On February 24, 2022, Russian President Vladimir Putin announced a special military operation against Ukraine, marking Russia's full-scale invasion of Ukraine. The Russian Ukrainian conflict has far-reaching impacts on the regional and global economy, especially in Europe. For a long time, Europe has maintained close economic cooperation with Russia and has been deeply dependent on Russia's energy's exports. After the war, EU passed a series of sanctions against Russia, among them sanctions which limited the exports of oil and natural gas to the European continent, and which resulted in an energy crisis. This thesis investigates the macroeconomic consequences of this crisis on 5 important EU economies which differ in the degree of their dependence on Russian energy resources. More precisely, using macroeconomic data series such as inflation and unemployment we find that based on different dependence on energy, countries received different impact. Most notably, the German economy that had relied heavily on Russia's natural gas exports suffered more significant impacts from the crisis, compared to other countries. The differences we observed and formalized through our econometric analysis, led us to conclude that the energy shock experienced by the European economies during this conflict, is not only an aggregate shock to the Eurozone, but also entails a significant redistributive component across the EU's economies. In line with the wide held view that Germany's economic performance is likely to have deteriorated in relative terms we find a substantial effect of the dependency of this country on Russian energy imports, on its inflation and unemployment rates.

Introduction

The Russia-Ukrainian War had a profound impact on the European economy as well as on the overall global economy. In 2022 immediately following the start of this conflict, energy prices (for oil and natural gas) increased considerably. In the EU, (data from the U.S. Energy Information Administration and IMF suggest that) both crude oil and natural gas prices increased significantly after the war, especially prices for natural gas (see Figures 1 and 2 below). In August 2022, European natural gas prices hit their highest level since 1990, approaching $70 per million cubic meters.

Figure. 1 Crude Oil price: Brent-Europe; Source: U.S. Energy Information Administration

https://fred.stlouisfed.org/series/PNGASEUUSDM#

Figure .2 Global price of Natural gas, EU; Source: International Monetary Fund

https://fred.stlouisfed.org/series/DCOILBRENTEU

A direct consequence of this, is that countries that relied heavily on imports of these resources to fuel industrial production or household consumption (heating) experienced a startling rise in inflation rates, that have been unprecedented since the 1980s. These effects were of course not concentrated only in Europe, where arguably reliance on Russian natural gas has been high (especially in Germany), but they spread across the globe as the shortage of energy (a direct immediate consequence of the sanctions posed on Russia's economy) increased the global prices for these resources which are traded internationally in competitive markets.

In this thesis, we explore how the recent surge of inflation impacted several European economies. More precisely we draw data on inflation, unemployment, output and other variables of interest for 5 EU member states (Ireland, German, Spain, Italy and France) which account for a large share of total production in the EU. These countries have been likely impacted differently by the rise in energy prices. Whereas (it is well known that) Germany's industrial production was highly dependent on Russian energy before the war, Ireland's and Spain's production have been much less reliant. Thus, we may expect heterogeneous responses of these countries' production, inflation and unemployment to the Russian Ukraine war.

To understand why these differences may be important, consider the trade-off facing the EU monetary authority in its response to the shock. If inflation affects differently the economies/ regions of the EU, then the monetary authority will be facing a difficult dilemma: monetary policy could prioritize fighting very high inflation in one region (thus pursuing a more aggressive increase in interest rates) or may be more concerned with mitigating the recession in another region, where inflationary pressures have not been as considerable. It is well understood that a redistributive shock (one that has asymmetric macroeconomic effects across regions or to put differently, worsens macroeconomic conditions in a subset of countries or regions) in a monetary union is impossible to deal with conventional monetary policy. Therefore, studying the inflation/ unemployment outcomes in different regions (the inflation/unemployment tradeoff-the so-called Phillips curve) is an important policy relevant question.

A second reason for which this analysis is topical and important, concerns the performance of the European economies prior to the shock. It is generally well known that countries at the Core of the European continent (specifically Germany in our sample) have been outperforming countries in the periphery (Spain, Italy). One very convincing piece of evidence can be derived from comparing the unemployment rate across these countries. Whereas since the Euro debt crisis of the early and mid-2010s, countries in the periphery have had 2-digit unemployment rates, in the recent German data (right before the war) the unemployment rate was below 4 percent.

Though these regional differences may be partly reflective of differences in labour market policies (e.g. the well-known reforms of the German unemployment benefit system in the mid-2000s) they most definitely reflect the massive concentration of production in Germany at the expense of the industrial base in other countries. Prior to the war, Germany had for many years run a sizable trade surplus vs the rest of the continent, whereas other significant EU economies run trade deficits. Generically, such a disequilibrium is considered unsustainable in the context of a monetary union, where resorting to depreciating one's currency to improve competitiveness, is not feasible (e.g. Krugman 2013). And if part of the relative success of the German economy has been due to its access to cheap Russian natural gas, then the rise in energy prices since 2022, may have partly closed the competitiveness gap.

These two very basic arguments reveal the importance of understanding differential macroeconomic outcomes in the Eurozone. The analysis that we carry out in this thesis identifies the redistributive effects of the recent energy shock using a standard regression framework where the main dependent variables are country specific inflation and unemployment rates. We estimate the differential impact of the energy shock, through its interaction with each country's reliance on oil (a proxy for the dependence of Russian energy imports). Our hypothesis is that countries that have heavily relied on energy imports (in terms of their overall energy mix) ought to have been more exposed to the shock and thus suffered a bigger inflationary pressure and /or a steeper rise in unemployment rates.

As we explain, such a regression analysis is necessary to identify the redistributive components of the shock, precisely because estimating the reaction of inflation and unemployment rates to a shock is likely to confound the effects of other factors such as expectations about inflation or current and future marginal cost conditions that we could not (and generally is difficult to) control directly in a regression framework. Thus, by using the oil dependence as an instrument (e.g. Bartik 1991) our claim is that we can reliably identify the heterogeneous reactions of key macroeconomic aggregates to the energy crisis. As we shall show our estimates suggest a significant heterogeneity in the responses of inflation and unemployment.

The follow content of this thesis is structured as follows. Section 1 is the Literature Review, which introduces the literature we found to help us understand economic impact due to the energy crisis and build analytical models. The second section gives a brief overview of the conflict, which is important to reminder the reader of the key dates and events that leading up to the recent crisis. Next section inspects the data to first discern the energy mix of the 5 countries in our sample and the macroeconomic time series of interest. Section 4 presents the empirical framework and the results we derived from the estimation of the model. A final section concludes the thesis.

1. Literature Review

This work is connected to several strands of literature. First, it contributes to the substantial body of research on the macroeconomics of optimum currency areas. Within this literature, the idea that asymmetric business cycles pose a significant challenge for monetary unions is well established and dates back to the foundational work of Robert Mundell (1961) (see also Eichengreen (1991) and Bayoumi and Eichengreen, (1996) among others). A central concern in such unions is that differing business cycle patterns hinder conventional monetary policy, which cannot simultaneously induce contraction in one region and expansion in another.

Given the nature of the supply-side shock examined in this thesis, the analysis primarily focuses on the efficacy of monetary policy, abstracting from other policy interventions (e.g., adjustments to the tax schedule or government spending levels). In the standard New Keynesian model, an energy shock represents a shock to the Phillips curve (a supply-side shock). Shocks to the supply of goods driven by changes in marginal production costs are generally not the type that fiscal authorities are expected to address, as fiscal policy is less effective in combating such shocks[1].

In the standard textbook framework, supply-side innovations are treated as cost-push shocks to the Phillips curve. This thesis thus also connects to the extensive literature that empirically examines the relationship between inflation and unemployment (e.g, Coibion and., Gorodnychenko, 2015, and references therein). More specifically, it aligns with a subset of this literature focusing on inflation dynamics within monetary unions. These studies often investigate how cross-regional heterogeneity in the inflation-unemployment trade-off complicates centralized monetary policy, echoing concerns raised by Benigno (2004).

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1. One could argue that distortionary taxation might serve as a tool to combat inflation from a cost-push shock, e.g., through a temporary reduction in tax rates. However, implementing temporary tax changes is often challenging, as fiscal instruments tend to be more rigid than monetary ones. Moreover, in the aftermath of COVID-19, the countries in our sample face high debt levels, leaving little room for governments to cut taxes to mitigate inflationary pressures.

It is important to note that our analysis diverges from many empirical applications of the New Keynesian Phillips curve. Our baseline model treats inflation as the dependent variable, with various macroeconomic factors, including unemployment, as explanatory variables. However, we do not necessarily attribute to this equation the structural properties of the New Keynesian Phillips curve. Instead, our primary focus is on identifying the heterogeneous impact of the recent oil price shock on inflation. Additionally, we explore unemployment adjustments by estimating models where the country-level unemployment rate serves as the dependent variable.

Finally, on the methodological front, this thesis employs the shift-share framework (e.g., Bartik 1991) to derive reliable estimates of the energy shock's effects on macroeconomic variables. This methodology places the work within a broader literature that has applied the shift-share framework in various empirical contexts (e.g., Autor Dorn and Hanson 2013).

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2. Background on the conflict and sanctions

In 2014, Russia annexed Crimea and supported the independence movements in Ukraine's Donetsk and Luhansk oblasts. Since then, relations between Russia and the European Union (EU) have rapidly deteriorated. The EU imposed a series of sanctions against Russia; however, these sanctions initially had little impact on trade between the two.

By the end of 2021, tensions between Russia and Ukraine over eastern Ukraine had escalated significantly. On February 24, 2022, President Vladimir Putin authorized the Russian military to conduct what he termed "special operations" in Ukraine, purportedly aimed at "demilitarizing and de-Nazifying Ukraine." This marked the beginning of Russia's full-scale invasion and the intensification of the conflict between Russia and Ukraine.

In response, EU countries strongly condemned Russia's aggression. Alongside providing economic and military assistance to Ukraine, the EU adopted a series of sanctions targeting Russia. Following the invasion, EU leaders convened at a special summit to address the situation and agreed on additional sanctions aimed at Russia's financial sector, energy and transport sectors, dual-use goods, export controls, export financing, visa policies, and specific Russian individuals. These measures also introduced new criteria for further listings.

According to the Council of the European Union (n.d.), the objective of these sanctions is to impose severe consequences on Russia for its actions and to hinder its capacity to continue its aggression. The latest package of sanctions was adopted on December 16, 2024. To date, the EU has implemented a total of 15 sanction packages (European Commission, 2024).

3. The war's impact to energy imports in Europe

As one of the world's largest economies, the European Union (EU) accounted for 15.2% of global gross domestic product (GDP) in purchasing power standards (PPS), according to Eurostat (2024). An article by the European Parliament highlights that industry contributes significantly to the EU economy, accounting for over 20% of its economic output and 80% of exported goods. Furthermore, manufacturing was the EU's largest industrial activity in 2019, representing 84.7% of industrial value added and 90.3% of industrial employment (Eurostat, 2022). These figures underscore the critical role of industry, particularly manufacturing, in the EU's economic framework. Energy, as a key input, is indispensable to industrial production in any economy.

Before the war, the EU produced a significant portion of its own energy but still relied heavily on imports, particularly from Russia. In 2021, Russia supplied over 40% of the EU's gas consumption, 27% of its oil imports, and 46% of its coal imports (European Commission, 2022). The war dramatically altered the EU's energy landscape, triggering an energy crisis in many member states. Following the outbreak of the conflict, the EU took steps to reduce its dependence on Russian energy. While formal sanctions on Russian energy were announced in June 2022, the shift away from Russian imports began earlier.

By the third quarter of 2022, Russian oil accounted for approximately 14.4% of the EU's total oil imports. By the same period in 2023, this figure had dropped significantly to 3.9% (see Figure 3).

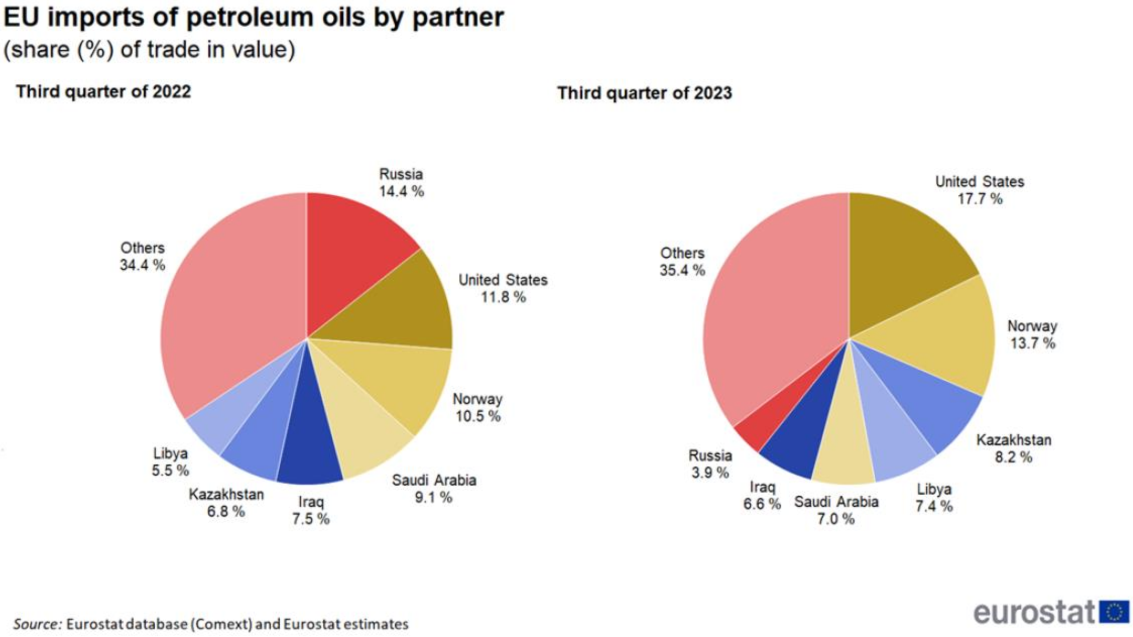
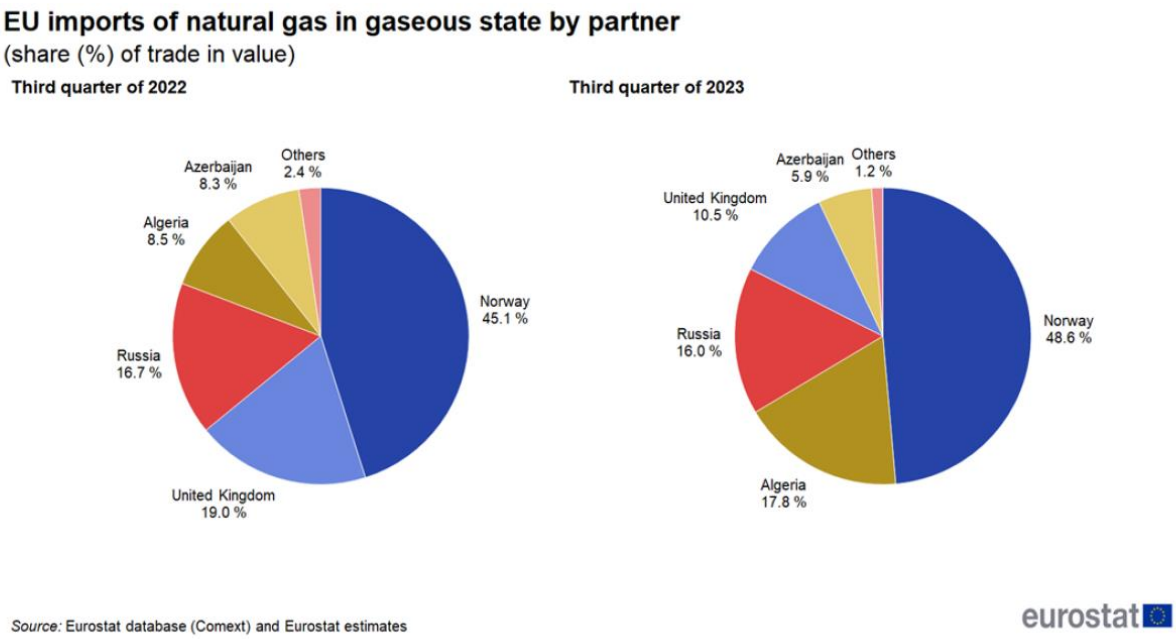


Figure 3 EU imports of crude oil by partner

Notice that, although Russia's natural gas supply to the EU has been greatly reduced since the outbreak of the war and the EU has also begun to reduce its dependence on Russian natural gas, the EU has not yet signed a strict ban on the import of Russian natural gas. EU member states may still import liquefied natural gas from Russia (LNG). According to the EU Commission, by the third quarter of 2023, Russian natural gas accounted for about 16% of the EU's total natural gas imports, a significant decline from the pre-war 45%.



Source: Eurostat

3.1 **A breakdown of energy imports in 5 European countries.**

As discussed, the main focus of this analysis is to detect asymmetric responses of EU member state economies to the energy crisis. A key variable in our subsequent econometric analysis will be an index of the dependency of the 5 countries in our sample on Russian energy imports. We now outline a few facts for each of the countries that demonstrate the depth of this dependency.

Germany

According to Eurostat, in 2021, Germany held the highest share of the EU's value-added in manufacturing, contributing a significant 33.2% to the total. Additionally, Germany led the EU in the electricity, gas, steam, and air conditioning supply sectors, with a notable 27.6% share. These figures underscore Germany's pivotal role in the European economy, often referred to as the "European steam engine" due to its industrial strength and influence.

Germany's industrial sector was heavily reliant on energy imports, a dependency that became particularly pronounced during the geopolitical tensions following the 2022 invasion of Ukraine. Before the war, Russia was Germany's largest supplier of oil, accounting for 34.1% of its imports, followed by the United States (12.5%), Kazakhstan (9.8%), and Norway (9.6%) (Julian Wettengel, March 25, 2022). Beyond oil, Russia also supplied a substantial share of Germany's natural gas and coal, with Germany's reliance on Russian natural gas reaching approximately 60% and coal around 23%. Notably, compared to other major industrialized countries, coal accounted for a relatively modest 17% of Germany's overall energy consumption (IEA, 2023).

Before the war, Germany's overall reliance on Russian fossil fuels was approximately 31%. This dependency brought certain economic advantages, as access to Russian energy helped Germany maintain relatively low gas prices for its industrial sector. Prior to the war, Germany enjoyed the lowest natural gas prices among the five countries in our sample, giving its industries a competitive edge in energy-intensive sectors.

However, this heavy reliance on Russian energy left Germany particularly vulnerable to disruptions once the war began. Following the invasion, Germany faced severe energy supply challenges, which resulted in soaring energy costs. Between February and March 2022, Germany's energy inflation rate surged dramatically from 22.4% to 37.6% and remained above 30% for an extended period, highlighting the profound impact of the energy crisis on its economy.

While the European Union swiftly imposed sanctions on Russian energy imports in response to the invasion, it made special allowances for member states heavily dependent on Russian energy supplies. Germany, being one of these states, continued importing gas from Russia until the Nord Stream pipeline explosion on September 26, 2022 (see Figure 5).

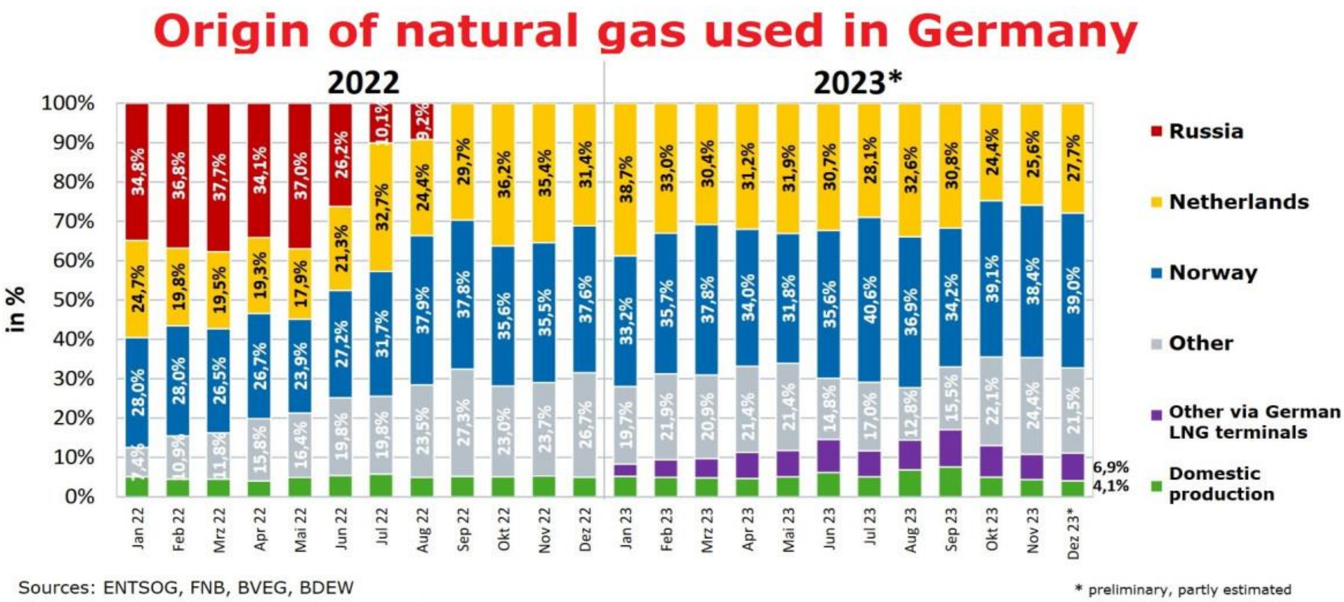


Figure 5. Source of Germany natural gas. Source: BDEW (CLEW translation)

Official data indicates that for the full year 2022, 25.4% of Germany’s crude oil imports came from Russia, making it by far the largest supplier, followed by the United States at 13.7%. However, due to the European Union's embargo and Germany’s commitment to end crude oil imports from Russia, supplies ceased entirely at the turn of 2022/2023.

Data shows that as late as November 2022, approximately 16% of Germany’s crude oil imports still originated from Russia. By January 2023, however, this figure had dropped to nearly zero, with Germany importing only about 3,000 tons of crude oil from Russia. This was a significant reduction compared to December 2022, when imports stood at approximately 1.15 million tonnes.

Italy

Before the war, Italy was the second-largest industrial country in the European Union, with its manufacturing industry ranking second only to Germany. Italy also relied heavily on natural gas imports (Eurostat, 2022), with 41% of its total gas imports coming from Russia in 2021. Additionally, about 23% of the country's electricity generation depended on fossil fuel imports from Russia, marking the second-highest dependency among International Energy Agency (IEA) member countries, after Hungary. In total, Italy's energy dependence on Russia in 2021 was approximately 23%.

After the war, Italy experienced high energy inflation. Between February and March 2022, energy inflation rose from 46.5% to 51.5%. Moreover, the overall inflation level remained persistently high. Since February 2022, Italy's energy inflation has consistently exceeded 40%, peaking at 70% in October 2022.

France

According to Eurostat, in 2021, French manufacturing accounted for about 10% of the EU's total manufacturing output, ranking third after Germany and Italy. Unlike Germany and Italy, France relies heavily on nuclear power, which accounts for around 40% of its energy consumption (IEA, 2021).

Among fossil energy sources, France's reliance on Russian oil, coal, and natural gas in 2021 was 5.7%, 21%, and 24.1%, respectively. However, due to its significant reliance on nuclear power, France's total dependence on Russian fossil fuels was relatively low, accounting for only 6.2% of its energy consumption.

After Russia's invasion of Ukraine, energy inflation in France also rose, but the increase was modest compared to other major EU economies. Energy inflation increased from 22% in February 2022 to 29.8% in March 2022, lower than that of Germany, Spain, and Ireland (Eurostat, n.d.).

France stands out among these five countries for two reasons: its low energy dependence on Russia and its low proportion of imported energy. According to the IEA, only 40% of France's energy is imported. This suggests that France is relatively less vulnerable to energy shocks compared to other countries.

Ireland

In 2021, Ireland was the fourth-largest manufacturing country in the EU. According to the IEA, Ireland relied heavily on Russian coal, with 62% of its coal imports coming from Russia. However, coal accounted for only about 5.5% of Ireland's total energy consumption. Consequently, Ireland’s overall reliance on Russian fossil fuels was low.

After the outbreak of the Russia-Ukraine war, Ireland experienced a sharp rise in energy inflation, which increased from 30% in February 2022 to 43.8% in March 2022.

Spain

According to Eurostat, Spain was the fifth-largest manufacturing country in the EU. Before the war, Spain relied significantly on Russian coal, with 34.8% of its coal imports coming from Russia, while its reliance on Russian natural gas was around 9.5% (IEA, 2021). Spain’s total dependence on Russian fossil fuels was approximately 8.6%.

After the Russian invasion, Spain experienced the highest energy inflation rate among the five largest EU manufacturing economies. Energy inflation rose from 43.7% in February 2022 to 60.3% in March 2022.

However, Spain was the first to see a significant decline in energy inflation. By October 2022, when energy inflation in the other four countries remained high, Spain's rate had dropped to 7.9%, the lowest among the five.

3.2 The energy mix in the five countries.

Figure 6 shows the energy mix in the countries of our sample during 2023. The figure is meant to complement the discussion of the previous paragraph summarizing the composition of inputs (coal, oil, natural gas, nuclear etc) in the EU. With the exception of France, where reliance on nuclear power is considerable, in all of the remaining economies in our sample, a large fraction of the energy mix is accounted for by oil and natural gas consumption.

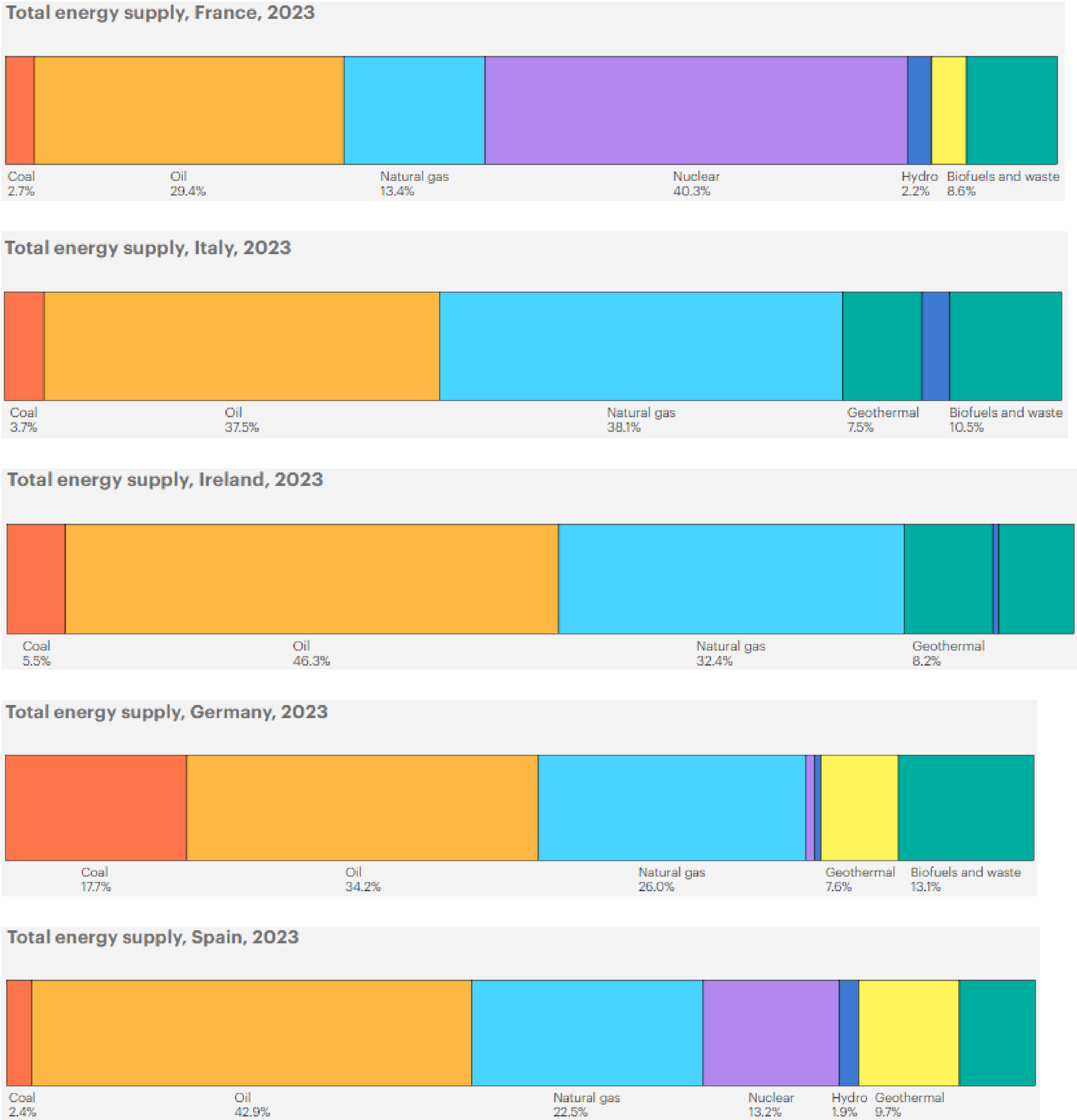


Figure 6: The energy mix. Source: https://www.iea.org/countries/

3.3 Macroeconomic Series: Inflation and Unemployment.

We now briefly present the main macroeconomic variables that we will use in our empirical analysis. Figure 7 shows the country inflation rates. The sample consists of monthly observations of annualized inflation covering the period 2014 to 2024.

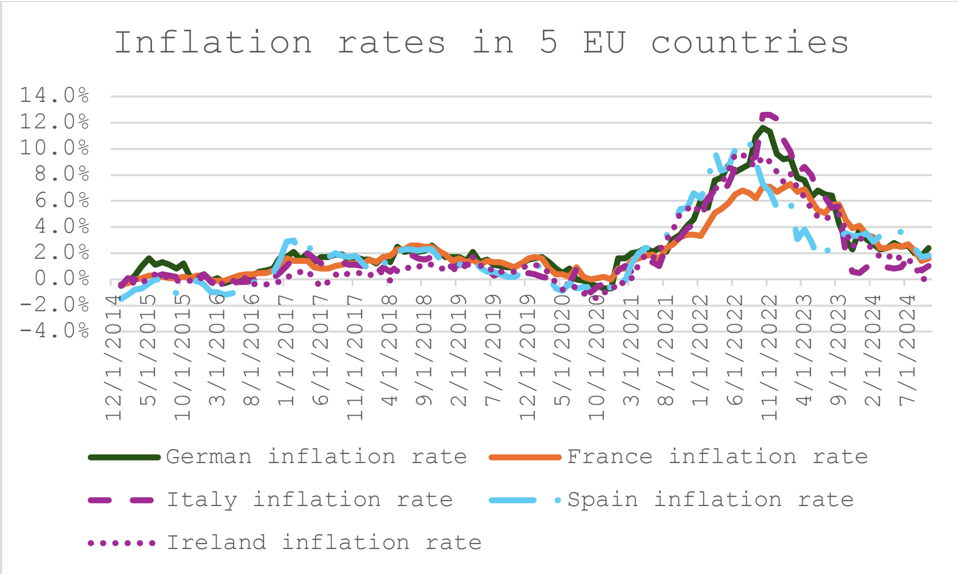


Figure 7: Country specific inflation rates. Source: FRED.

By and large, inflation has been stable from the start of the sample and during the Covid 19 pandemic (until roughly the summer of 2021). As these economies exited the Covid 19 recession, however, we can notice inflation picking up with December 2021 figures being between 4 and 6 percentage points. The higher post Covid inflation rates are widely believed to be a consequence of *supply chain disruptions*. We are mainly interested on the subsequent supply side shock that occurred after February 2022, the date that marks the start of the war between Russia and Ukraine. As can be seen from the Figure during 2022 as well as for the most part of 2023, inflation rates soared, peaking at slightly above 10 percent in Italy, nearly 12 percent in Germany and 7 percent in France. The 'peak months' are not coincident across countries and in general abstracting from the overall (aggregate) trend in inflation, it is quite evident that there is considerable heterogeneity both in terms of the recorded country specific inflation rates, as well as in terms of the adjustment paths followed by inflation after the shock.

It is worth noting that this recent inflationary episode has been quite unique in the EU's economic history. Industrialized countries hadn't experienced such rapid rates of growth of prices since the 1980s. The energy that occurred in 2022 is therefore (at least in terms of its economic impact) quite similar to the oil price shocks of the mid 1970s and 1980s.

Furthermore, note that even though inflation seemed to have risen temporarily (as by late 2023 these rates seemed to be anchored at around 2 percent- a level which is considered as ideal for the ECB) comparing the 2023-2024 numbers with the pre Covid sample indicates that average inflation continued to be higher after the energy crisis. It is well known that the 2010s were a period of inexplicably low inflation rates in the EU and the US. Though the monetary authorities had tried to raise the price level by keeping interest rates permanently low, the failed to do so. Therefore, the slightly higher average inflation at the end of our sample is at odds with what appears to have been average inflation since the financial crisis.

Turning to the unemployment series shown in Figure 8 we can easily spot differences across the countries considered in the sample. Most notably the differences were considerable in the early periods of the sample, with Spain recording unemployment rates higher than 20 percentage points and France Italy and Ireland having unemployment rates higher than 10 percent. For three of these countries (Italy, Spain and Ireland) these high rates of joblessness can be seen as a consequence of the severe economic downturns of the 2010s (the Euro debt crisis). However, partly higher unemployment can be attributed to structural reasons, Spain and Italy have persistently high rates even during the 90s and 2000s. The same applies to France.

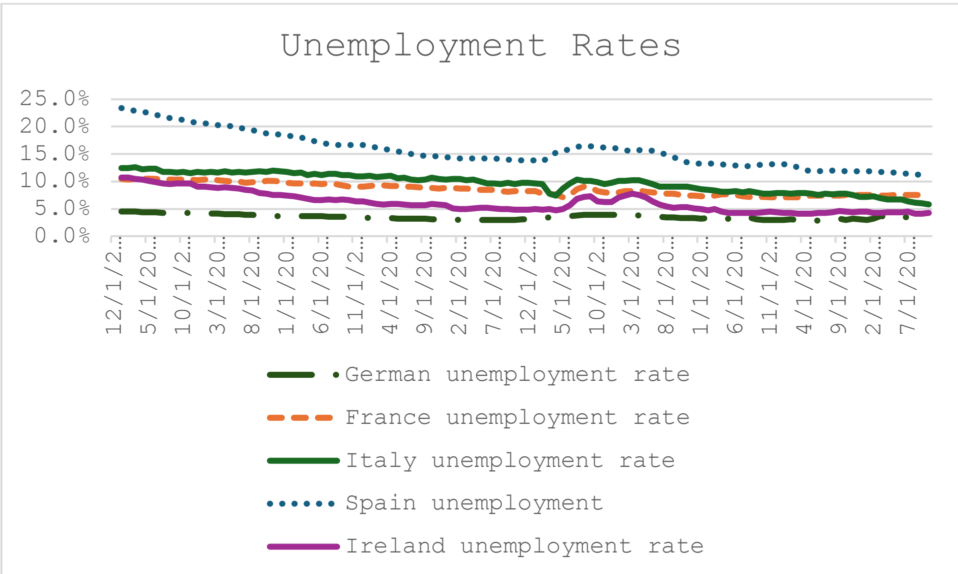


Figure 8: Country specific unemployment rates. Source: FRED.

3.4 The oil reliance index.

The last important variable that we will use in our analysis is shown in Figure 9. It is a variable measuring the dependence of each country's energy mix on imports from Russia. While reliance had been positive through most of the sample period, it stopped abruptly during the war years. This is most evident in the case of Germany, a country which imported more than 20 percent of its oil from Russian before the war and stopped doing so in 2022. The pre war numbers are more modest for the rest of the countries (Spain is the least dependent on Russian imports) but are significant nonetheless.

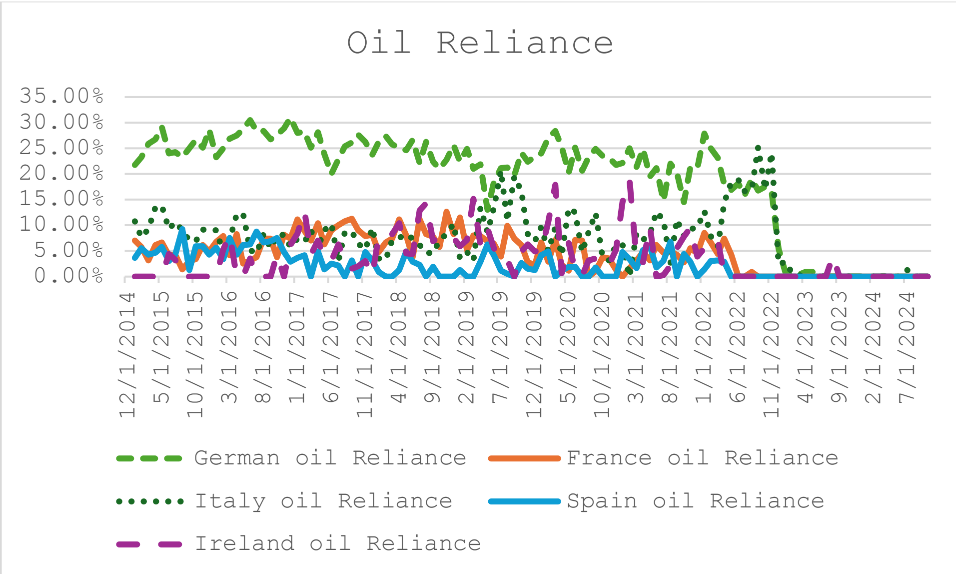


Figure 9: Oil reliance. Fraction of oil imports from Russia.

Oil reliance is an important variable for our analysis, on the basis of which we will attempt to measure the differential impact of the energy shock on the five countries in our sample. As the next paragraph elaborates, we will rely on the interaction between the average reliance on Russian imports and the time series on energy inflation to identify differential effects.

4. Empirical Model and Result analysis.

We now spell our baseline econometric model. It is given by the following regression

$$\boldsymbol{Inflation_{i,t} = \alpha + \beta_1 Unemployment_{i,t} + \beta_2 Energy\ HICP_t + \beta_3 Energy\ HICP_t * AverageReliance + \epsilon_{i,t}}$$

On the left-hand side of this equation, the dependent variable is the rate of country i (France, Italy, etc) in month t. On the right hand side, the independent variables are the unemployment rate (***Unemployment***), the Energy inflation rate (***Energy HICP***$_t$) which is an aggregate variable that is common across countries and the energy inflation interacted with the average reliance index which we measure as each country's average of pre war observations of the variable shown in Figure 9. The term $\epsilon_{i,t}$ is the error term of the regression.

We will estimate this equation using a pooled panel data estimator over the sample period. The coefficients that we are particularly interested in are β_2 and β_3. Note that measures the impact of energy inflation on all countries, that is the average (or aggregate) effect of increasing the ***Energy HICP$_t$*** value by (say) 1 percentage point. On the other hand β_3 is meant to pick up on the differential responses of the 5 countries to a shock in ***Energy HICP$_t$***

The fact that we are measuring this differential impact through the interaction of HIPC with a 'structural' economic variable is an important part of identification. Afterall, one could also look at differential effects by running the following model:

$$Inflation_{i,t} = \alpha + \beta_{1i}Unemployment_{i,t} + \beta_{2i}Energy\ HICP_t + \epsilon_{i,t}$$

For each of the countries in the sample to separately estimate coefficient β_{2i}. However, this estimation will may confound the effect of the energy shock with other effects under plausible misspecifications of the fundamental equation of inflation or due to omitted variables. One (concrete) possibility is the missing inflation expectations in our empirical framework. Note that at its core the above equation describes a Phillips curve that links inflation, unemployment and the cost push shock (energy). But the New Keynesian format of this equation assigns a crucial role to inflation expectations, which are missing variable from our dataset. Since our main interest is in identifying the different shifters – cost push shocks- between the countries, we believe that the interaction variable is a good of way capturing the differences despite not having at our disposal precise data on private inflation expectations.

A second specification of the model aims at partially controlling for these missing variables. Specifically, we will also run the following specification

$$Inflation_{i,t} = \alpha + \beta_1 Unemployment_{i,t} + \beta_2 Energy\ HICP_t + \beta_3 Energy\ HICP_t * AverageReliance + \beta_4 Exhcange_t + \epsilon_{i,t}$$

The variable ***Exhcange$_t$*** is the Euro/dollar exchange rate in month t. To see why this variable could be important, note that since standard theories predict that exchange rates react to inflation, and they react quickly since they are financial variables. Therefore, the exchange rate could be seen as a proxy for the (average) inflation expectations in the Euro area.

Finally, as was previously remarked, the unemployment variable allows us to interpret our empirical model as a Phillips curve. We will present results when $\boldsymbol{Unemployment_{i,t}}$ is the rate of unemployment minus the country average and also results when we detrend unemployment with a country specific quadratic trend. In the latter case we consider that the trend represents the natural rate of unemployment and so the deviation from the trend is the cyclical component. Not detrending the data is however also sensible since as we saw before, following the crisis in the early 2010s several countries experienced persistent increases in unemployment which could also be seen as cyclical. Though not the primary interest here, coefficient $\boldsymbol{\beta_1}$ in these specifications measures the slope of the Phillips curve.

4.1 Results analysis.

The results from the baseline specification of the model are shown in Table 1.

All of the estimated coefficients (Column 1) are statistically significant at the 1 percent level (t statistics are shown in Column 2 of the table). The slope of the Phillips curve is -.4 which is a reasonable value. The point estimate for the $\boldsymbol{\beta_2}$ *(the* ***Energy*** $\boldsymbol{HICP_t}$ *coefficient)* is .132 revealing that energy inflation has a considerable effect on the average inflation rate in the EU. Thus, an increase in *Energy* $HICP_t$ *by* 1 percentage point increases each country's inflation rate by .13 percent.

The point estimate for coefficient $\boldsymbol{\beta_3}$ is 0.168. This is the most crucial finding. It means that an increase *Energy* $HICP_t$ by 1 percent interacted with an oil reliance index of .2 (roughly the average in Germany) will result in an increase of country inflation by 0.032 percent. Though this might not seem much, one has to consider that during the energy crisis, energy inflation was as high as 40 percent. Thus the interaction term contributes a lot to the differences in the inflation rates observed, and we estimate that for the range of the oil reliance index , it contributed at least 1 percentage point higher inflation in Germany than in Ireland (max and min respectively in terms of reliance). We thus found a large effect.

The second set of results corresponds to the empirical model with the Exchange rate variable. This is reported in Table 2. Notice that now we find slightly smaller values for the point estimates (Column 1 of the table), however, they are comparable to the baseline and statistically significant. Thus, our estimates for $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ are 0.12 and 0.1571. The (absolute value of the) slope of the Phillips curve is slightly smaller now, however, this is to be expected when the model includes (a proxy of) inflation expectations.

Table 1.

	Coefficients	**t – stats**
Constant	0.0157	23.3213
Ugap	-0. 4046	-11.1136
HICP	**0.1322**	16. 4966
HIPC*oil	**0.1684**	2.7206

R^2 = 0.6843

Number of observations: 590.

Notes: The table shows the baseline estimates of the model $\boldsymbol{Inflation_{i,t} = \alpha + \beta_1 Unemployment_{i,t} + \beta_2 Energy\ HICP_t + \beta_3 Energy\ HICP_t * AverageReliance + \epsilon_{i,t}}$. Unemployment gap is defined as the deviation of the country unemployment rate from its average over the sample period. T-stats are reported in Column 2 of the table and the point estimates of the coefficients in Column 1.

Table 2 .

	Coefficients	**t – stats**
Constant	0.1643	12.1679
Ugap	-0.3595	-10.7608
HICP	0.1200	16.2629
HIPC*oil	**0.1571**	2.7879
Dollar exchange	-0.1322	-11.0181

R^2 = 0.7381

Number of observations: 590.

Notes: The table shows the estimates of the model $\boldsymbol{Inflation_{i,t} = \alpha + \beta_1 Unemployment_{i,t} + \beta_2 Energy\ HICP_t + \beta_3 Energy\ HICP_t * AverageReliance + \beta_4 Exhcange_t + \epsilon_{i,t}}$ Unemployment gap is defined as the deviation of the country unemployment rate from its average over the sample period. T-stats are reported in Column 2 of the table and the point estimates of the coefficients in Column 1.

Table 3.

	Coefficients	**t – stats**
Constant	0.0149	20.2767
Ugap	-0.1668	-1.5344
HICP	0.1614	19.4367
HIPC*oil	**0.0690**	1.0266

R^2 = 0.6197

Number of observations: 590.

Notes: The table shows the baseline estimates of the model ***Inflation$_{i,t}$ = α + β$_1$Unemployment$_{i,t}$ + β$_2$Energy HICP$_t$ +β$_3$Energy HICP$_t$ *AverageReliance + ϵ$_{i,t}$***. Unemployment gap is defined as the deviation of the country unemployment rate from a quadratic trend fit over the sample period. T-stats are reported in Column 2 of the table and the point estimates of the coefficients in Column 1.

Table 4.

	Coefficients	**t – stats**
Constant	0.1853	12.2780
Ugap	0.1111	1.0936
HICP	0.1454	18.9852
HIPC*oil	**0.0670**	1.0996
Dollar exchange	-0.1516	-11.3035

R^2 = 0.6874

Number of observations: 590.

Notes: The table shows the estimates of the model ***Inflation$_{i,t}$ = α + β$_1$Unemployment$_{i,t}$ + β$_2$Energy HICP$_t$ +β$_3$Energy HICP$_t$ *AverageReliance+ β$_4$Exhcange$_t$ + ϵ$_{i,t}$*** Unemployment gap is defined as the deviation of the country unemployment rate from its average over the sample period. T-stats are reported in Column 2 of the table and the point estimates of the coefficients in Column 1.

We next consider the baseline specification with the alternative measure of the unemployment gap. The results are in Columns 1 and 2 of Table 3. The point estimates of the coefficients ***β$_2$*** and ***β$_3$*** continue being positive. Specifically, we now find ***β$_2$*** is equal to 0.1614 ***β$_3$*** is 0.069. Therefore, using the alternative unemployment gap measure attenuates the importance of the interaction variable. More crucially, however, the estimated coefficient ***β$_3$*** is no longer statistically significant. One cannot reject the hypothesis that the interaction effect is zero.

Though this result may seem discouraging, one has to bear in mind the previous discussion that detrending unemployment may not be appropriate for this set of countries that are in transition from the large shocks experienced in the early 2010s. What is perhaps a sign of this model not being a good specification is that the slope of the Phillips curve is now also insignificant. A second telling sign is that the goodness of fit worsens relative to the baseline model.

Including the exchange rate as a measure of inflation expectations does not improve these metrics. Note that in Table 4, the slope of the Phillips curve is reported to be positive (a very peculiar finding for a tradeoff between inflation and unemployment) and the estimated coefficients β_2 and β_3 are comparable to Table 3.

Finding a positively sloped Phillips curve, suggests that in this specification of the model the relation between inflation and unemployment may not be an accurate depiction of the relation at business cycle frequencies. In the short term, the Phillips curve has to be negatively sloped, however, over a longer horizon shifts in the relation between inflation and unemployment can result in a positive correlation between these variables. Such shifts can originate from changes in inflation expectations or from supply side shocks that perhaps the models reported in Tables 3 and 4 may not be fully able to capture. At its core the difference with the results reported in Tables 1 and 2 could be linked to the different detrending methods used.

For completeness, the appendix plots the two measures of the unemployment gap we used in this section.

5. Conclusion.

The empirical analysis presented in the previous paragraph provides mixed evidence. While the baseline model revealed strong evidence of heterogeneity in inflation rates during the period 2022–2024 based on oil reliance, this result proved sensitive to the definition of the unemployment gap.

Numerous alternative specifications of the Phillips curve have been explored in the empirical literature, highlighting the inherent difficulty in estimating the inflation-unemployment tradeoff. The four models we employed here could, of course, be extended in many ways. Nevertheless, our findings suggest that further investigation of heterogeneous inflation responses to energy shocks is a promising avenue for research. Specifically, we proposed a concrete measure—oil reliance—to capture this heterogeneity. This measure is likely to satisfy exogeneity assumptions, thus enabling unbiased estimates.

Future research could extend our analysis by refining the measure of the unemployment gap, such as by expanding the sample to achieve a more accurate estimate of the natural unemployment rate. It could also allow for additional sources of heterogeneity in the estimated Phillips curves—for example, incorporating varying slope coefficients across countries—to improve the model's fit. Importantly, it would be valuable to examine whether, in the presence of such additional heterogeneity, the interaction term coefficients remain significant.

Before concluding this thesis, we reiterate the importance of understanding heterogeneity in shocks and Phillips curves within the context of the European Monetary Union. This understanding is crucial because the trade-off faced by the EU monetary authority in responding to a cost-push shock becomes more challenging when country-specific inflation and unemployment outcomes diverge. In addition to the standard trade-off of combating inflation at the expense of higher unemployment, the monetary authority faces a dilemma: whether to pursue a more aggressive interest rate increase to address severe inflation in one region or to focus on mitigating a recession in another region where inflationary pressures are less pronounced.

A redistributive shock—one that has asymmetric macroeconomic effects across regions, worsening conditions in only a subset of countries—cannot be effectively addressed through conventional monetary policy in a monetary union. Thus, studying the inflation-unemployment tradeoff (i.e., the Phillips curve) across different regions is a highly policy-relevant question.

The empirical analysis presented in this thesis seeks to contribute to this discussion. Future research could explore additional heterogeneity in Phillips curves, which would have significant implications for monetary policy within a monetary union.

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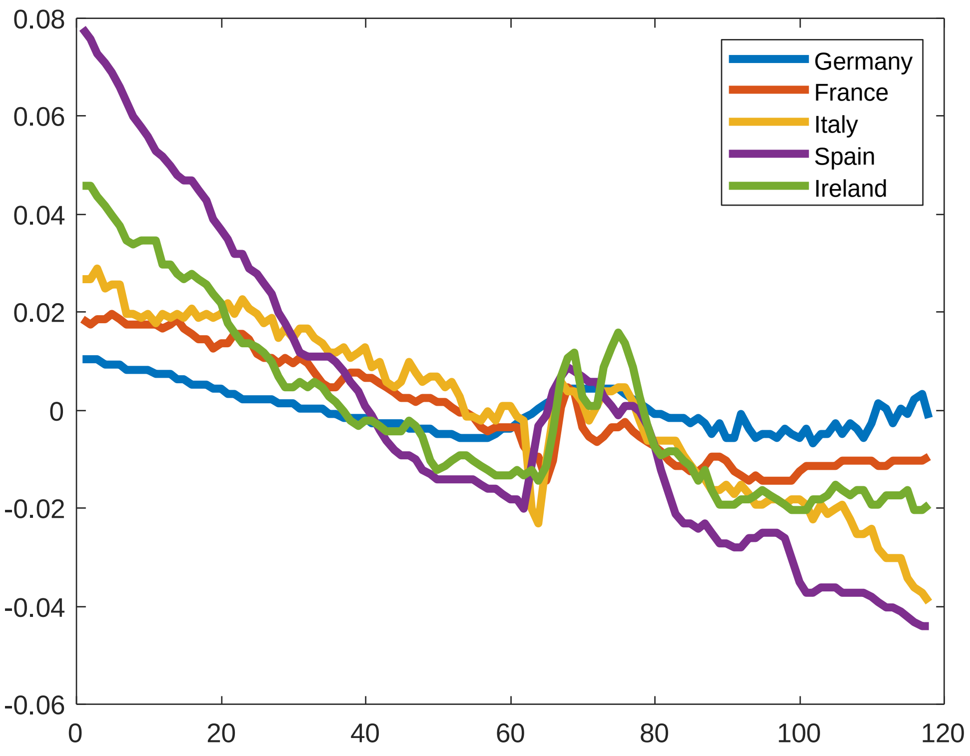

Figure: Unemployment gaps: Deviations from country averages.

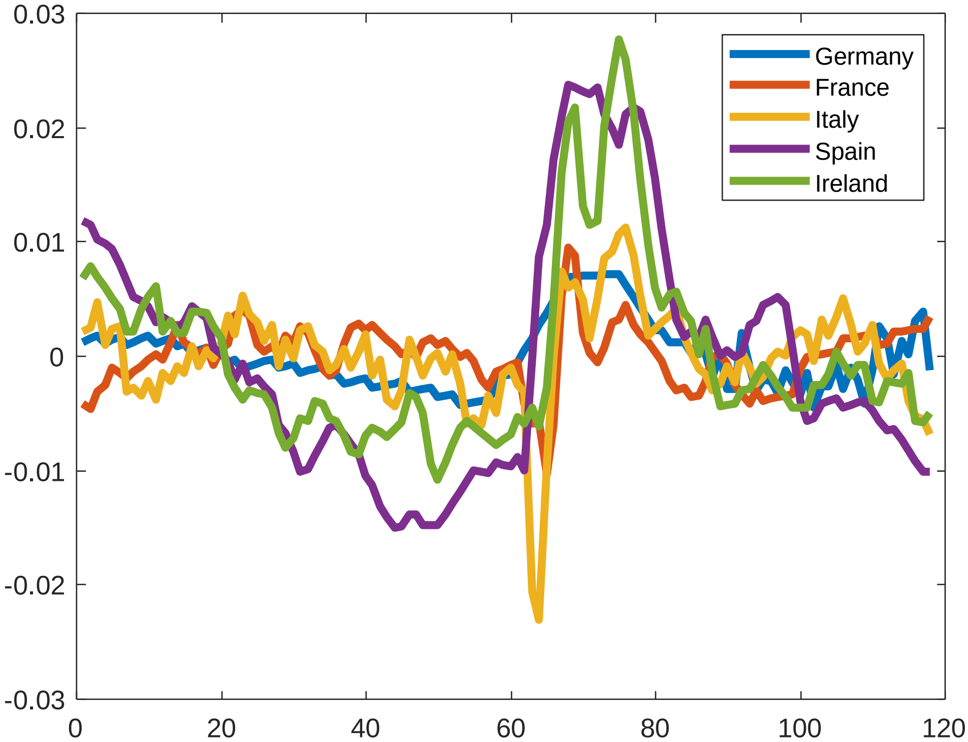

Figure: Unemployment gaps: Deviations from quadratic trends.