Core Strength: International Evidence on the Impact of Energy Prices on Core Inflation*

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February 15, 2024

Abstract

In the post-pandemic period, there was substantial cross-country heterogeneity in energy prices faced by consumers, due to variation in countries' energy mix, as well as variation in government energy subsidy policies. The main contribution of this paper is to exploit this country-level variation to show that countries with higher domestic energy prices faced higher subsequent core inflation. Core inflation rises gradually after an energy shock, for a little over a year, before falling back to the pre-shock rate of inflation. We argue that, in the aftermath of large energy price shocks, core inflation is not a reliable measure of underlying or persistent inflation, and should be adjusted for the predicted, country-specific, energy cost pass-through. Focusing more narrowly on services inflation rather than core inflation does not solve the problem, as services inflation responds similarly, in both magnitude and duration, to energy price shocks.

Keywords: OECD, cross-country, core inflation, energy, monetary policy

JEL Codes: E30, Q43

*This research was carried out while I was a visiting Research Fellow at the London School of Economics. I am grateful for the LSE's hospitality. I thank Silvana Tenreyro, Greg Thwaites and Rodrigo Guimaraes, and seminar participants at the LSE, London Business School, King's College, Bank of England and the Resolution Foundation for helpful comments.

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Introduction

Inflation rose sharply across a large number of countries in 2021-2022, and central banks tightened monetary policy. Energy prices made large direct contribution to inflation, as oil prices recovered in the post-pandemic re-opening of the world economy, and natural gas prices spiked after Russia's invasion of Ukraine.

This paper analyses the indirect impact of energy prices on inflation, i.e.the impact of higher energy prices on the prices of non-energy goods and services.

We quantify this effect by exploiting the fact that there was substantial cross-country heterogeneity in the energy price increases faced by consumers. We show that countries that faced bigger energy price increases experienced stronger increases in core inflation (inflation excluding energy and food) and services inflation.

A positive impact of energy prices on core inflation is consistent with previous work such as Conflitti and Luciani (2019), Baba and J. Lee (2022), Gertler and Gagliardone (2023) and Guerrieri et al. (2023). This paper's main contributions relative to previous work on this subject are three-fold. First, previous work focused on the impact of oil prices, using a single global oil price. Instead, we use country-specific energy prices. In particular, we use energy prices faced by households, which are affected not just by oil prices but also natural gas prices, as well as by government tax and subsidy policies. Second, we consider not just core inflation but also services inflation. Third, we use data that includes the post-pandemic period.

The effect of energy prices on core inflation and services inflation is highly relevant for monetary policy. Core inflation and services inflation are often put forward by policymakers as a better guide to monetary policy, especially after big supply shocks such as energy shocks. For example, chairman of the Federal Reserve Powell (2023) stated: "But food and energy prices are influenced by global factors that remain volatile, and can provide a misleading signal of where inflation is headed. [...] I will focus on core PCE inflation, which omits the food and energy components." Many central banks publish forecasts of core inflation alongside forecasts of headline inflation, illustrating its importance in their deliberations.

But our analysis suggests that core inflation should be interpreted with great care after large energy price shocks: core inflation and services inflation rise gradually for a period of just over a year following an energy shock, before falling back gradually. In the aftermath of large energy price shocks, core inflation and services inflation are not reliable measures of underlying or persistent inflation. They should be adjusted for the predicted, country-specific, energy cost pass-through.

The paper is organised as follows. Section 1 reviews the relevant literature, section 2 describes the data, section 3 presents the results, section 4 discusses policy implications, and section 5 concludes.

1 Related Literature

Several strands of literature provide the context for this paper. There is a literature on what measure of inflation the central bank should target, or use as a guide to policy. Wynne (2008) provides an overview of the key conceptual issues and related literature. Bryan and Cecchetti (1994) examine the properties of a range of measures of core inflation and argue that desirable properties are that they should have a high correlation with money growth and be a good predictor of future inflation. They argue that weighted median inflation best satisfies these criteria. Aoki (2001) shows in a theoretical framework that when not all prices are sticky, the central bank should optimally target inflation in the sticky prices only. Mankiw and Reis (2003) propose in a theoretical framework that the price index a central bank should stabilise depends on a range of factors, not only the sluggishness of price adjustment but also cyclical sensitivity of the sector, the size of the sector and the magnitude of sectoral shocks. Taking the model to the data, they argue that this means the central bank should put substantial weight on nominal wages. Reis and Watson (2010) propose an empirical method using dynamic factor analysis to isolate what they call "pure inflation", and index of equiproportional changes in all inflation rates, to distinguish it from relative price changes. A closely related strand of literature focuses more on finding empirical measures of core inflation that aim to strip out noise and forecast headline inflation well. Examples are Cecchetti (1997), Cristadoro et al. (2005) and Stock and Watson (2007).

Several papers directly investigate the empirical impact of energy prices on core inflation, which is also the question we address. Conflitti and Luciani (2019) examine the oil price impact on disaggregated price indices in the US and euro area, to distinguish direct effects on a particular sector from whole economy effects. Using a VAR, they find that the impact of oil prices on core inflation is small and only borderline significant, but persistent. Baba and J. Lee (2022) use a multi-country panel and local projections to identify the effect of oil prices primarily on wages, and also show results for core inflation. Their focus is on how this effect has changed over time, and how it varies with structural factors such as central bank independence and unionisation. They find a significant and gradual effect over many quarters of energy prices on core inflation, even in their more recent subsample. Guerrieri et al. (2023) use identified oil price shocks, using the identification of Kanzig (2021), and estimate separate VARs for the US and the euro area to identify the impact of oil price shocks on a range of variables, including core inflation. They find a gradual and persistent effect of oil shocks on core inflation, with differing dynamics across the two regions. The impact in the US is faster and shorter-lived than the impact in the euro area. Gertler and Gagliardone (2023) also estimate a VAR for the US with the same identified oil shocks, and use that to calibrate a quantitative New Keynesian model. The peak impact of a 1% oil price shock on core inflation in Guerrieri et al. (2023) and Gertler and Gagliardone (2023) is similar to the estimates in Baba and J. Lee (2022), around $0.03 - 0.04\%$, while the estimates in Conflitti and Luciani (2019) are smaller, at around 0.007%. The timing of the peak impact varies greatly across the studies, ranging from a few months to several years.

2 Data

We use monthly data on inflation from the OECD Main Economic Indicators, accessed via Haver Analytics. For energy prices we use the energy component of the consumer price index, which consists largely of the price of car fuel and the energy price of home heating and home cooking. For core inflation we use the OECD calculated consumer price index for All Items Excluding Food and Energy. And we cross-check the analysis with an even narrower measure of consumer price inflation, namely services inflation. For the US, we calculate services inflation excluding energy services. For other countries, services inflation already excludes energy.

There are 38 OECD member countries. We drop Australia and New Zealand, which only publish quarterly inflation data. We also drop Turkey, which is an extreme outlier in inflation terms. Cumulative core inflation since the pandemic ranges from 0% to 30% in the sample, while the value for Turkey is 200%, more than six times the next highest value. We add Croatia, Cyprus and Malta to the sample to have the complete set of euro area countries.

The energy prices faced by consumers vary widely across the countries in the sample. In part this is due to variation in the energy mix that countries use, combined with the fact that the dynamics of natural gas prices diverged greatly from the dynamics of oil prices as a result of the reduction in Russian pipeline supply in the context of the invasion of Ukraine. The divergence between oil and gas prices is shown in figure 1.

A second reason for the cross-country variation in energy prices faced by households is the variation in government tax and subsidy policies. Several countries implemented price caps, either at the wholesale or retail level, of varying generosity and duration. For example, Scaravatti et al. (2021) show that EU national governments implemented policies with a cost ranging from $0.5\% - 6.8\%$ of national GDP to shield households and firms from the energy crisis.

As a result of the variation across countries of both the energy mix and the government tax and subsidy policies, there was substantial variation across countries in the energy prices that households experienced. Figure 2 shows the cumulative four year log change in consumer energy prices by country, ending in May 2023.

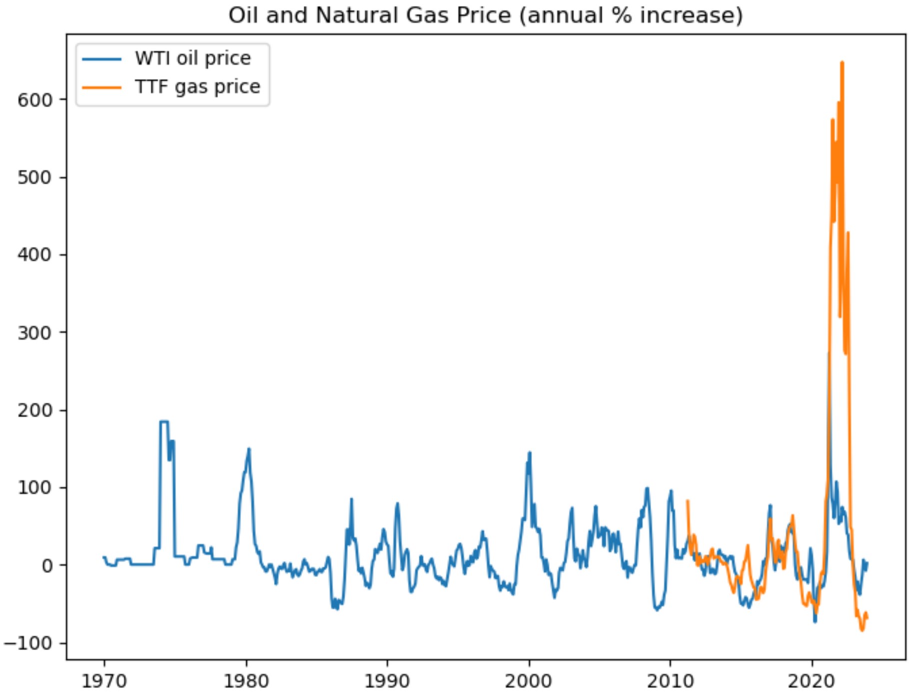

Figure 1: Oil and Natural Gas Price

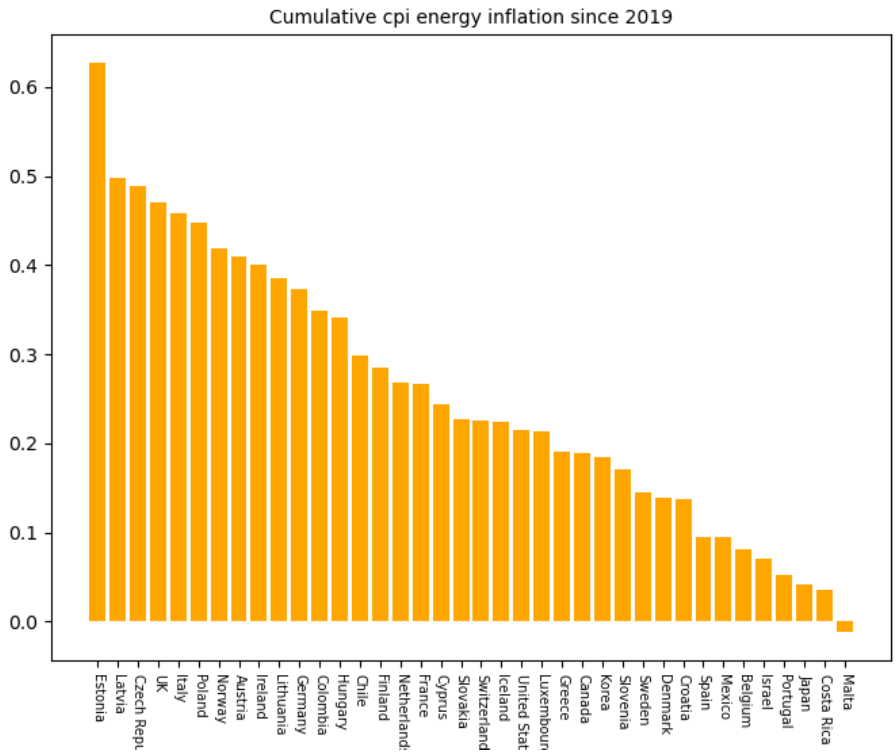

Figure 2: Cumulative Post-pandemic Energy Inflation

3 Impact of Energy Prices on Core and Services Inflation

We use two different methods to analyse the impact of energy price changes on core inflation and services inflation. First, we run simple cross-country regressions using cumulative inflation over a period of interest. This gives a sense of the long-run impact. Second, we use panel data local projections to gain further insights into the dynamic path of the impact.

3.1 Cross-country regression

A first approach to investigate the impact of energy price changes on core inflation is to run a simple cross-country regression on cumulative inflation rates. The question is simply: did countries with higher post-pandemic energy price inflation also experience higher post-pandemic core inflation? Figure 3 suggests the answer is yes.

We use the four-year cumulative inflation rate (measured in log differences) for household energy prices and core inflation, which captures the period since the pandemic. Our sample ends in May 2023 so we use the four-year inflation rate starting May 2019. In principle one could start in February 2020 to coincide more precisely with the start of the pandemic. However, since the data are not seasonally adjusted this would add some seasonal cross-country noise in what is already a small dataset. We therefore chose cumulative inflation rates that start and end in the same month of the year.

Table 1 shows the full regression results, with a highly significant coefficient on energy prices. The first regression is the simple bivariate one illustrated in figure 3. The second regression adds four-year pre-pandemic core inflation as an additional regressor. This is to allow for the possibility that some countries have permanently higher inflation, affecting both core and energy components, which might create a correlation between energy and core inflation that is not causal. The regression result suggests that this effect, if it is present at all, is small. Adding lagged core inflation slightly reduces the estimate of the impact of energy prices on core inflation from 0.22 to 0.18, but it remains

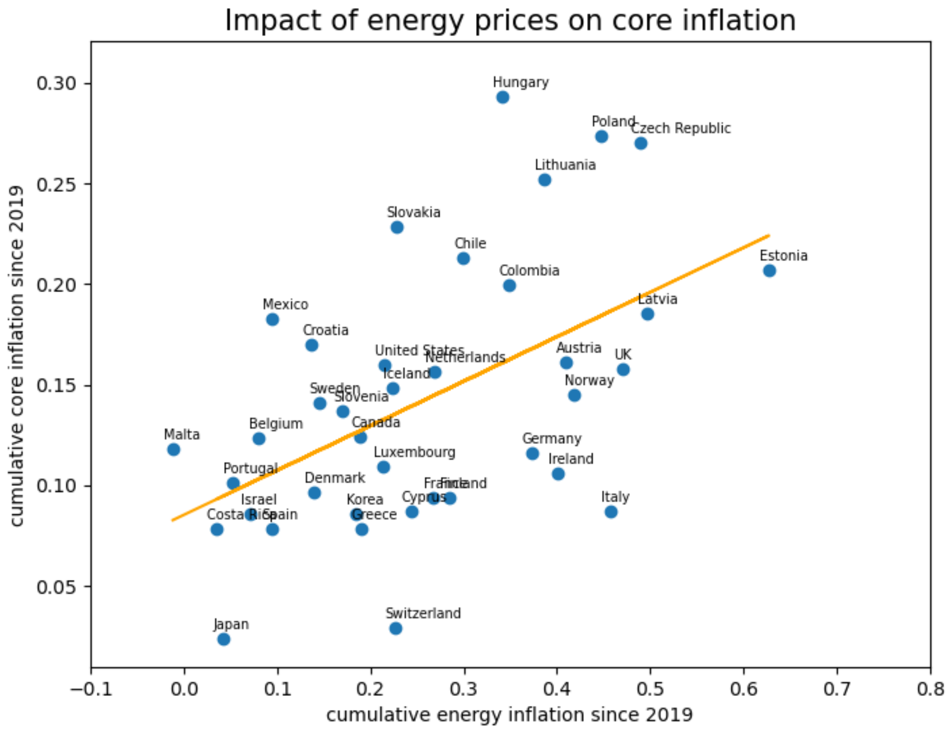

Figure 3: Cross-country variation in energy prices and core inflation

highly significant with a p-value of less than 1% and the difference between the two estimates is not significantly different from zero. Energy price inflation and pre-pandemic core inflation together explain half of the cross-country variation in post-pandemic core inflation ($adj.R^2 = 0.506$). Because these are coefficients on domestic energy prices rather than on oil prices, they are not directly comparable to the $0.03 - 0.04$ estimates in the literature cited in section 1. However, one simple cross-check can be made by regressing changes in aggregate OECD consumer energy prices on changes in oil prices, which gives a coefficient of 0.21. Multiplying this by our estimated impact of 0.18 suggests a peak impact of oil prices on core inflation of 0.04 in our model, similar to the estimates for the US and euro area in Guerrieri et al. (2023) and estimates for the US in Gertler and Gagliardone (2023).

Table 1: Cross-country regression results

	(1)	(2)	(3)	(4)
dependent variable	*core*	*core*	*svs*	*svs*
energy	0.2214*** (0.060)	0.1795*** (0.050)	0.2595*** (0.072)	0.1545** (0.062)
core (pre-pand)	-	1.0847*** (0.247)	-	-
svs (pre-pand)	-	-	-	1.1044*** (0.236)
c	0.0852*** (0.018)	0.0365* (0.018)	0.0838*** (0.022)	0.0210 (0.022)
Obs	38	38	38	38
adj.R^2	0.254	0.506	0.244	0.522

Notes: Dependent variable is the four year log change, ending in May 2023, of the core and services price index respectively. Regressors are energy (four year log change, ending May 2023, of consumer energy price index) and pre-pandemic core and services (four year log change ending in May 2019 of core and services price index respectively). Standard errors in parantheses, with ***, **, * denoting statistical significance at the 1%, 5% and 10% levels respectively.

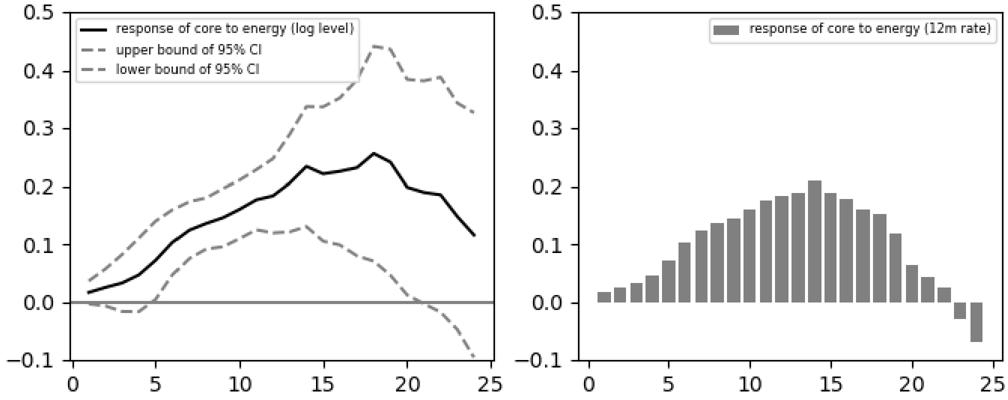

Figure 4: Local projections: energy impact on core prices

3.2 Local Projections: Core Inflation

So far we have not exploited the time-series dimension of the data. One can think of the cross-country analysis as giving a sense of the long-run level impact of energy prices on core prices. Since the short-run dynamics are highly relevant, we now turn to a local projections approach to quantify the dynamics. This has the additional advantage of greatly expanding the dataset, from $N = 38$ to $N = 38, T = 101$ so $N \times T = 3838$. The sample starts in January 2015 and ends in May 2023. For details on local projections methodology, see Jordà (2005), Montiel Olea and Plagborg-Møller (2021) and Jordà (2023).

We run the following panel regression:

$$\Delta p^{core}_{i,t+h} = c + \alpha_i + \beta_h \Delta p^{ener}_{i,t} + \sum_{n=1}^{lags} \gamma_n \Delta p^{ener}_{i,t-n} + \sum_{n=1}^{lags} \delta_n \Delta p^{core}_{i,t-n} + \sum_{n=0}^{lags} \kappa_n u_{i,t-n} + \epsilon_{it} \quad (1)$$

The dependent variable is the long-difference in the log price level at various projection horizons h so that $\Delta p^{core}_{t+h} = p^{core}_{t+h} - p^{core}_t$. Right-hand side variables are simple one-period differences in the log energy and log core price price levels, as well as current and lagged values of the unemployment rate.

The sequence of estimated values for β_h will trace out the impact of a unit log energy price change on the log core price level at various horizons h, shown in figure 4.

The dynamic impact of higher energy prices on core builds up gradually. After a unit shock in energy prices, the core price level rises gradually to a peak of 0.26 over a period of 18 months. The increase is estimated with reasonable precision: the 95% confidence interval is well away from zero after 5 months. As the horizons extends, the impact on core prices becomes insignificantly different from zero only after 20 months. One can also calculate the implied 12-month inflation rate from cumulative price level impact: 12-month core inflation rises gradually after an energy shock, with a peak impact of 0.21 after 14 months, before falling back to zero. This is shown in the right hand panel of figure 4.

3.3 Local Projections: Services Inflation

We also investigate whether energy prices affect services inflation, rather than core inflation. In the post-pandemic period, several central banks have promoted services inflation as an even better measure of underlying inflation than core inflation, in part due to the fact that core goods price inflation was significantly affected by global supply chain problems, which may make services inflation a cleaner measure of underlying inflationary pressures. Examples include Federal Reserve chairman Powell (2022) "Thus, [core services inflation other than housing] may be the most important category for understanding the future evolution of core inflation. Because wages make up the largest cost in delivering these services, the labor market holds the key to understanding inflation in this category." For the Bank of England, see *Minutes of the Monetary Policy Committee Meeting* (2023) "The MPC would continue to monitor closely indications of *persistent* inflationary pressures, including the tightness of labour market conditions and the behaviour of wage growth and services inflation."

Table 1 shows the regression results for services in the final two columns. Switching to services inflation from core inflation makes little difference to the results. Energy prices have a large and significant impact on services prices as well, with an estimated coefficient of 0.15. That is only slightly smaller than, and not significantly different from, the estimated coefficient of 0.18 for for the impact on core inflation.

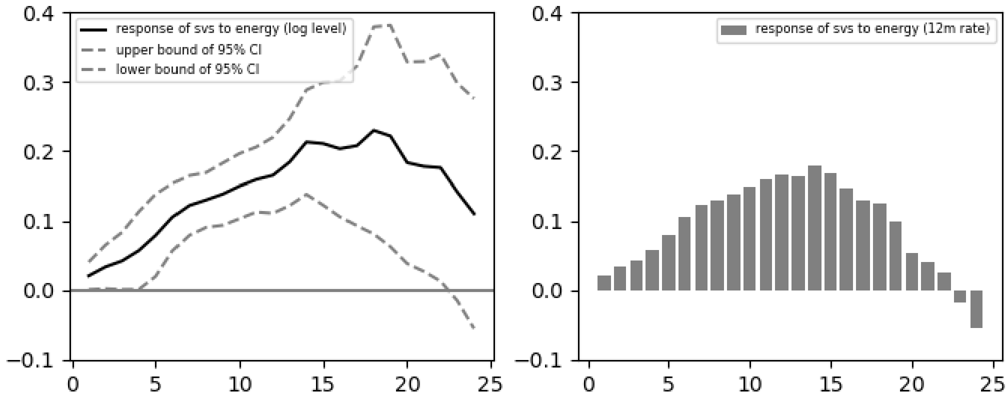

Figure 5: Local projections: energy impact on services prices

It is worth emphasising that the sectors covered by the services component of the CPI are not materially less energy intensive than the sectors covered by the (non-energy) goods component of the CPI, so there is no a priori reason to expect a very different response to energy price changes. Using the UK as an example (see *The energy intensity of the Consumer Prices Index: 2022* (2023)), the mean energy intensity of the services sector based on the input-output tables is 2%, while the mean energy intensity of the non-energy goods sector is 1.4%. The energy intensity of services is particularly high for transport services, but even excluding transport services, the energy intensity of the remaining services is 1.4%, equal to that of non-energy goods. The energy intensity of the entire CPI-based consumption basket of goods and services is much higher at 6.6%, but that is largely accounted for by the direct consumption of energy goods.

Turning to the results for the panel data local projections for services leads to a similar conclusion, namely that services respond quantitatively similarly to energy price changes as core inflation as whole. The dynamic impact of energy prices on services inflation, shown in figure 5, is similar in magnitude and duration to the impact of energy prices on core inflation. The peak level impact on services prices is 0.24 at a horizon of 18 months. The peak services inflation is 0.18 at a horizon of 14 months, before falling back to zero. Focusing on services inflation after an energy shock therefore does not provide a better read of underlying or persistent inflationary forces than focusing on core inflation.

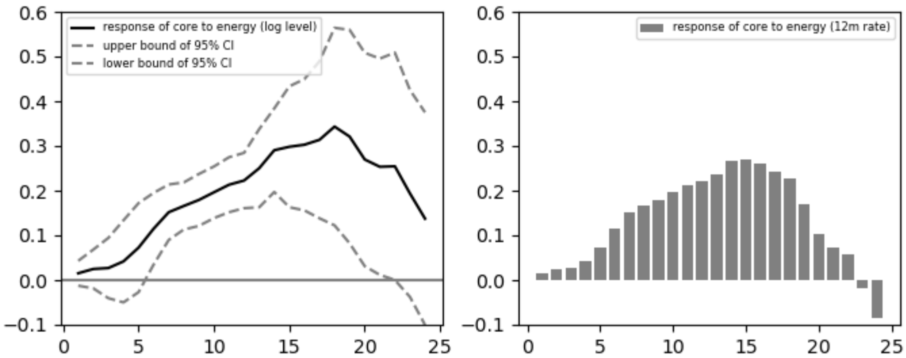

Figure 6: Local projections: energy impact on core prices (euro area sample only)

3.4 Controlling for Endogeneity to Monetary Policy

One concern that needs to be addressed is whether the monetary policy response could be driving these results. For example, excessively loose monetary policy could drive both higher consumer energy prices (which include exchange rate and domestic distribution cost effects) and higher core inflation, but in that case there would be no causality from energy prices to core inflation. To check whether this endogeneity is affecting the results, we restrict the sample to the 20 euro area countries only. This ensures monetary policy is the same across all countries, and cannot be driving the cross-country relationship between energy prices and core inflation. As shown in figure 6, the results still hold in the restricted sample: energy prices boost core inflation gradually, over a period of just over year. If anything, the effect is slightly larger in the euro area, with a peak impact from a unit energy price shock on 12-month core inflation of 0.27 after 15 months.

4 Historical Contribution of Energy Prices and Policy Implications

Having estimated the vector of local projections coefficients β_h, we can also estimate the historical contribution of energy price changes to core inflation for each country. Following Gorodnichenko and B. Lee (2020), the contribution of energy price changes to the log

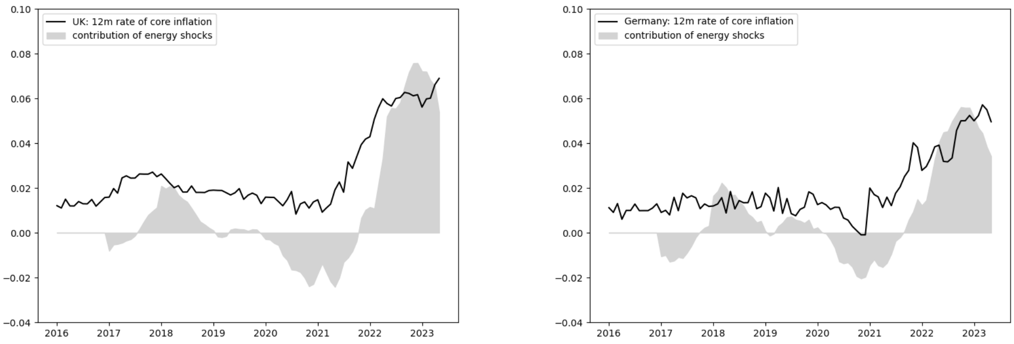

Figure 7: Historical Contributions of Energy Prices to Core Inflation

level of core prices is given by

$$c_{i,t}^{core} = \sum_{h=1}^{n} e_{i,t-h}\beta_h \tag{2}$$

Where $e_{i,t}$ are innovations to the log difference of the country specific energy prices. We find that a simple $AR(1)$ process in the one-period log difference of energy prices describes energy dynamics in our sample period well. The innovations $e_{i,t}$ are simply the residuals from the $AR(1)$ process. By calculating the 12-month difference of the resulting time-series for $c_{i,t}$, we obtain the contribution of lagged energy price changes to the 12-month rate of core inflation. This calculation can be performed for any country in the sample. By way of example, we show the results for the UK and Germany in figure 7.

Several interesting points emerge from this analysis. First, the lagged effect of energy price changes can potentially account for all of the peak core inflation increase in the UK and Germany. Second, the fact that the UK contributions are larger and later is also consistent with UK core inflation peaking higher and later than in Germany. At the end of the sample (May 2023), the UK energy contribution was still 2 percentage points higher than in Germany, potentially explaining all of the 2 percentage point gap in core inflation between the UK and Germany at that time. Some caution is warranted in interpreting the total size of the contribution, however. This is only a partial analysis, because we calculate the contribution from energy prices without having a full model that calculates the contribution from other shocks. Nevertheless, the contributions analysis illustrates the potential importance of taking lagged effects of energy prices into account when evaluating core inflation or services inflation. A standard interpretation of higher core or services inflation as being fully indicative of stronger domestic inflationary pressures might not be warranted once the effect of lagged energy price increases are accounted for.

5 Conclusion

This paper has used the cross-country variation in energy prices in the post-pandemic period to estimate the impact of energy prices on core inflation and services inflation. The cross-country variation in energy prices is the result of variation in countries‘ energy mix and variation in government energy subsidies. Following a positive shock to energy prices, core inflation and services inflation gradually rise for 14 months, before gradually falling back to the pre-shock rate of inflation. In the aftermath of large energy price shocks, neither core inflation nor services inflation are therefore reliable measures of underlying or persistent inflationary pressures. They should be adjusted for the predicted, country-specific, energy cost pass-through.

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