

Look-Through or Look Closer? Energy Shocks and Underlying Inflation in the Euro Area

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Abstract

This paper studies the transmission of energy supply shocks to underlying inflation in the euro area. Using an externally identified oil supply news shock and local projections, it shows that pass-through to core inflation is essentially absent when inflation is low and stable and emerges only when inflationary pressures are elevated. Over the full sample, the response of core inflation is delayed, persistent, and concentrated in non-energy industrial goods, but this average is driven by the 2021-23 episode: on data ending in 2020, the same shock raises energy, food, and headline inflation while leaving core inflation essentially unchanged. State-dependent estimates show that high inflation expectations, high headline inflation, and large oil price increases amplify the peak response of core inflation, while high wage growth makes it more persistent. The results reconcile the small pass-through found in earlier studies, which drew on samples dominated by low-inflation regimes, with the experience of 2021-23, and imply that the case for looking through energy shocks is itself state dependent.

Keywords: Energy Shocks, Core Inflation, Local Projections, State-Dependent Pass-Through.

JEL: C53, E31, E32, E52, Q43.

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1 Introduction

The post-pandemic episode of high inflation confronted central banks with a classic challenge: distinguishing transitory from persistent inflationary pressures in real time. In the euro area, headline inflation rose sharply from early 2021 and peaked at about 10.6 percent in October 2022. Much of the early rise was concentrated in food and energy prices, while common measures of underlying (core) inflation remained comparatively muted. This pattern led many policymakers and forecasters to view the initial inflation surge as largely transitory and therefore appropriate to “look through” from a monetary policy perspective (ECB, 2021a, 2021b; Schnabel, 2021), while others cautioned that energy price increases could spill over into wages, inflation expectations, and broader price-setting (Lane, 2022a, 2022b; Reis, 2021; Schnabel, 2022). The subsequent persistence of inflation made the distinction between these two views more consequential and raises a question that is relevant beyond the 2021-22 episode: when, and under what conditions, do energy shocks propagate into underlying inflation?

The focus of this paper on core inflation (defined as headline inflation excluding food and energy) reflects both policy practice and economic theory. Central banks typically define their objectives in terms of headline inflation, but core inflation is routinely used in policy analysis and communication. This distinction also features in theoretical models, which divide the economy into flexible-price and sticky-price sectors, where energy and unprocessed food prices are typically associated with the former, while core goods and services are predominantly associated with the latter.¹ Stabilising inflation in the sticky-price sector is welfare-optimal in canonical New Keynesian frameworks (Aoki, 2001; Benigno, 2004; Woodford, 2003). If shocks to energy prices remain isolated to the flexible sector, the “look-through” doctrine is appropriate. If, however, they spill over materially into sticky-price inflation, ignoring those shocks risks understating persistent inflationary pressures and delaying appropriate policy action.

Empirically, the literature on energy and inflation has emphasised that not all energy shocks are alike and that their macroeconomic effects vary by shock origin and over time (Baumeister & Peersman, 2013; Kilian, 2009). A consistent finding of the studies that estimate pass-through to underlying inflation is that it is small. Since the early 1980s, oil price changes appear to have affected consumer prices mainly through the direct weight of energy in the index, with small or negligible effects on core inflation (Clark & Terry, 2010; Conflitti & Luciani, 2019; Hooker, 2002). The 2021-23 episode is difficult to reconcile with this evidence. It raises the question of whether the small average pass-through found in earlier studies, estimated largely over low-inflation periods, masks important differences in how energy shocks affect core inflation across sectors, countries, and macroeconomic environments.

To examine the energy pass-through, the paper combines externally identified energy supply shocks (Känzig, 2021) with linear and state-dependent local projections (Auerbach & Gorodnichenko, 2012, 2013; Jordà, 2005; Jordà et al., 2015). The linear specification traces the average

¹Dhyne et al. (2006) show for the euro area that unprocessed food and energy prices adjust three to eight times more frequently than prices of core goods and services. More recent evidence from Gautier et al. (2024) likewise finds substantially greater price flexibility for energy and food than for core goods and services.

dynamic response of euro area core inflation and its components to exogenous energy shocks while controlling for lagged inflation, monetary policy, cyclical slack, and labour market conditions. The nonlinear extension allows impulse responses to vary with the macroeconomic environment. Following the smooth-transition local-projection approach of Auerbach and Gorodnichenko (2012, 2013), the model accommodates continuous switching variables through a logistic transition function and binary regimes through interacted local projections, allowing the response to vary with the state of the economy.

The paper documents how energy supply shocks transmit to inflation in the euro area and how this transmission differs across components of consumer inflation, countries, and macroeconomic states. In linear estimates over the full sample, energy, food, and headline inflation respond quickly but transitorily, reflecting the direct and largely mechanical role of energy prices in the consumption basket. Core inflation, by contrast, responds with a substantial delay: its increase becomes statistically significant roughly one year after the shock and remains elevated for much of the remaining horizon. The response is concentrated in non-energy industrial goods, particularly non-durables, while services inflation reacts later and less strongly, consistent with the transmission of energy costs along production chains.

The pass-through, however, varies significantly across periods and is state-dependent. Estimated on a sample that ends in 2020, the oil supply news shock still raises energy, food, and headline inflation, albeit by somewhat less than over the full sample, but leaves core inflation essentially unchanged. The delayed and persistent response of core inflation is therefore a feature of the 2021-23 episode.

State-dependent local projections show how pass-through depends on the conditions in which the shock arrives, and point to two distinct margins along which those conditions matter. Elevated inflation expectations, high headline inflation, and large increases in oil prices amplify the transmission of the shock: core inflation responds more strongly at its peak, but the response fades within the horizon considered. High wage growth instead contributes to propagation. The responses peak at similar magnitudes across the two states, but the response remains elevated two and a half years after the shock when wage growth is high. This additional persistence is present in both goods and services inflation. Amplification is consistent with state-dependent pricing and with greater attention to inflation when it is high, and propagation with feedback from prices to wages.

These findings qualify the look-through doctrine. In periods of low and stable inflation, which dominate the samples used in earlier work, energy supply shocks leave core inflation unaffected, and looking through them is appropriate. The pass-through of energy shocks to underlying inflation cannot be summarised by a single, state-invariant coefficient, and whether an energy shock can be looked through depends on the conditions under which it occurs.

The remainder of the paper is organised as follows. Section 2 situates the paper within the related theoretical and empirical literatures. Section 3 describes the data used in the analysis. Section 4 documents stylised facts and provides empirical motivation for the analysis. Section 5

describes the baseline (linear) empirical framework and identification strategy. Section 6 presents the results from the linear framework. Section 7 introduces the methodology for the nonlinear extension and discusses the associated findings, while Section 8 concludes.

2 Related Literature

The motivation for looking at core inflation (instead of overall inflation) comes from both monetary policy practice and the theory of sectoral price adjustment. Measures of underlying inflation are intended to capture the more persistent component of price movements and are widely used in policy analysis. In New Keynesian models with sectoral price rigidity, the distinction between flexible- and sticky-price sectors provides a theoretical basis for this focus. Welfare-optimal policy places greater weight on stabilising inflation in the sticky-price sector, while allowing relative prices to adjust in more flexible sectors (Aoki, 2001; Benigno, 2004; La'O & Tahbaz-Salehi, 2022; Rubbo, 2023; Woodford, 2003). The price index that a central bank should stabilise accordingly gives more weight to sectors with sticky prices (Mankiw & Reis, 2003), and stabilising the welfare-based index of Eusepi et al. (2011) is better approximated by targeting core than headline inflation. For energy supply shocks specifically, Bodenstein et al. (2008) show that a policy responding to forecasts of headline instead of core inflation generates greater volatility in core inflation and the output gap. Energy and unprocessed food are among the more flexible components of the consumption basket, with prices adjusting substantially more frequently than those of core goods and services (Dhyne et al., 2006). The case for looking through energy price movements therefore depends on whether their effects remain largely confined to these flexible-price components or instead feed into inflation elsewhere in the economy.

The empirical literature on energy price shocks has long stressed that their effects depend on the source of the shock. Oil supply disruptions, aggregate demand movements, and precautionary demand shocks can have different effects on output and inflation, so oil price changes cannot generally be treated as a single type of disturbance (Baumeister & Hamilton, 2019; Baumeister & Peersman, 2013; Kilian, 2008, 2009, 2014; Kilian & Murphy, 2014). This distinction is important for the present analysis, which uses the oil supply news shock of Känzig (2021).

Most empirical work on energy price pass-through focuses on headline inflation and generally finds a relatively rapid response, although the magnitude varies across countries and episodes (Casoli et al., 2024; Chen, 2009; Choi et al., 2018; Kilian & Zhou, 2023).² The literature on core inflation is smaller and finds considerably weaker effects. Hooker (2002) shows that oil price changes contributed substantially to US core inflation before the early 1980s, but that since then they have affected inflation mainly through the direct weight of energy in the price index. He finds that this change in regime fits the data better than asymmetric or nonlinear specifications and presents evidence that a change in the monetary policy response to oil shocks is part of the explanation. Clark and Terry (2010) document a similar decline in the pass-through of

²For example, Choi et al. (2018) estimate that a 10 percent increase in global oil inflation raises domestic inflation by around 0.4 percentage points on impact, with larger effects in emerging than advanced economies (Baba & Lee, 2022; Gelos & Ustyugova, 2017).

energy prices to core inflation, while De Gregorio et al. (2007) and Chen (2009) find a decline across industrial economies more generally. For the United States and the euro area, Conflitti and Luciani (2019) estimate a statistically significant but small pass-through to core inflation. Explanations for the decline include more credible monetary policy, more flexible labour markets, changes in wage indexation, and a smaller role for oil in production and consumption (Blanchard & Galí, 2010; Blanchard & Raggi, 2013). These estimates are, however, drawn almost entirely from the period of low and stable inflation that followed the early 1980s.

An important limitation of this literature is that most estimates impose a common response across time. A growing body of work instead shows that the effects of energy and other supply shocks can depend on the macroeconomic environment. Baumeister and Peersman (2013) find that the effects of oil shocks vary with inflation and monetary policy, while more recent work finds larger and more persistent effects of supply shocks in high-inflation regimes and emphasises the roles of nominal rigidities and the policy response (Afrouzi et al., 2024; Arndt & Enders, 2024). Recent work for the euro area also points to a role for inflation expectations and wage dynamics in shaping energy price pass-through (Boeck & Zörner, 2025; Casoli et al., 2024). The recent inflation surge has further revived interest in nonlinearities in the Phillips curve, with models and empirical work emphasising large shocks and labour market tightness (Benigno & Eggertsson, 2023; Bernanke & Blanchard, 2025; Gagliardone & Gertler, 2023; Harding et al., 2023). These findings suggest that the response to an energy shock may depend not only on the shock itself, but also on the macroeconomic conditions under which it is transmitted.

The literature distinguishes several mechanisms for expecting such non-linearities. In models of state-dependent pricing, firms are more likely to adjust prices when the underlying cost shock is large enough to justify paying the adjustment cost (Bils & Klenow, 2004; Dotsey et al., 1999; Golosov & Lucas, 2007). This implies that pass-through may depend on the size of the energy price movement and the level of inflation, and micro evidence confirms that the frequency of price adjustment rises with inflation and the size of cost shocks (Alvarez et al., 2019; Cavallo et al., 2024; Gagnon, 2009; Karadi & Reiff, 2019). Wage-setting models provide a different channel: when wage growth is already strong, higher energy costs may be more readily incorporated into wages and subsequently into prices (Erceg et al., 2000; Lorenzoni & Werning, 2023). Sticky-information and rational-inattention models likewise suggest that the transmission of aggregate price signals may depend on the inflation environment and on how closely agents pay attention to those signals (Maćkowiak & Wiederholt, 2009; Mankiw & Reis, 2002; Sims, 2003), and survey evidence shows that households and firms pay considerably more attention to inflation when it is high (Bracha & Tang, 2025; Weber et al., 2025).

This paper contributes to this literature in three ways. First, it shows that the pass-through of an identified energy supply shock to euro area core inflation is essentially absent in a sample that excludes the 2021-23 episode, which reconciles the small pass-through estimated in earlier studies with the recent experience. Second, it distinguishes two dimensions of state dependence, the amplification of the peak response and its propagation over time, and shows that they are associated with different state variables, which helps to discriminate between the mechanisms

proposed in the theoretical literature. Third, relative to work that has focused largely on headline inflation and aggregate data, it provides disaggregated evidence on where pass-through occurs, across the components of core inflation and across the member states of the euro area.

3 Data

The empirical analysis uses monthly euro area data spanning January 2002 to January 2025. Inflation measures are based on the Harmonised Index of Consumer Prices (HICP) published by Eurostat and are constructed as year-on-year changes. The analysis considers headline and core inflation, together with a decomposition into energy, food, services, and goods inflation. Goods are further divided into durable and non-durable categories. This allows tracing the transmission of energy price shocks across sectors that differ in price flexibility and exposure to input costs.

The key identifying variable is the oil supply news shock of Känzig (2021), used at monthly frequency over the sample. It is constructed from movements in oil futures prices within a tight window around OPEC production announcements and is designed to isolate unexpected news about future oil supply. Its construction and identifying assumptions are discussed in Section 5, while the time series and its distribution are shown in Figure 15 (Appendix B).

To control for domestic macroeconomic conditions relevant for inflation dynamics, monetary policy is proxied by the euro area short-term (three-month) nominal policy interest rate at monthly frequency. Measures of economic slack include the output gap and the non-accelerating wage rate of unemployment (NAWRU), which are available at annual frequency, as well as a labour cost index capturing wage dynamics, observed at quarterly frequency. These lower-frequency series are converted to monthly frequency using cubic spline interpolation, which preserves their low-frequency variation while producing a smooth monthly path.³ The unemployment gap is constructed as the difference between the seasonally adjusted unemployment rate (for individuals aged 25–74) and the interpolated NAWRU series.

The robustness analysis considers alternative measures of energy prices, including consumer energy inflation (HICP energy and HICP fuel), Brent crude oil prices, and import prices for energy and crude petroleum. HICP energy and import prices for energy cover a broader set of energy products than HICP fuel and crude petroleum, respectively, as they also include electricity and gas.⁴ Inflation expectations, also used in the robustness analysis, are measured using the European Commission’s Business and Consumer Survey. The measure is based on households’ qualitative assessments of price developments over the following twelve months and is reported as a balance statistic.

All variables are aggregated at the euro area level unless otherwise stated (see Section 6.2, which

³Regression-based temporal disaggregation using related monthly indicators (Chow & Lin, 1971) is the standard alternative to spline interpolation.

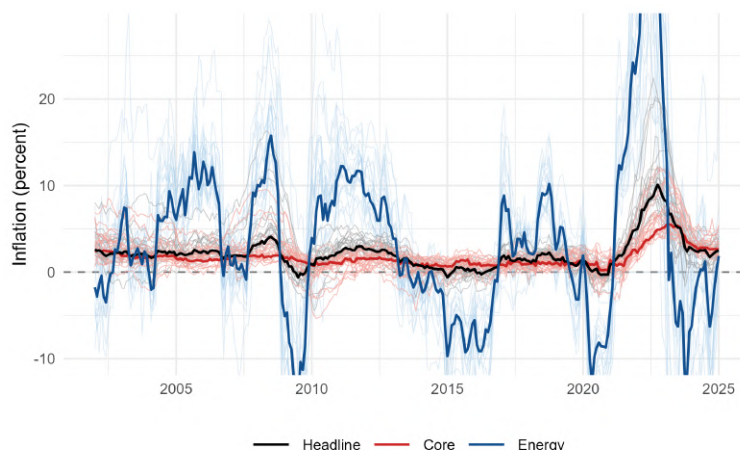
⁴While gas prices played an important role during the 2021-22 inflation episode, this analysis focuses on oil shocks. Since retail gas prices are fully or partially administered in many euro area countries, their pass-through to consumer prices is shaped by institutional and regulatory arrangements, which change over time. Extending the analysis to gas supply shocks is left for future work, including consideration of how best to account for these institutional differences.

explores cross-country variation in the energy shock pass-through into core inflation). The euro area is defined as a weighted but constant set of all EA-20 countries to avoid compositional changes arising from euro area enlargement over the sample period. Summary statistics for the main variables used in the analysis are reported in Table 3 (Appendix A).

4 Stylised Facts

The discussion in Section 2 provides the theoretical rationale for focusing on core inflation; the data provide a corresponding empirical motivation. Headline inflation is substantially more volatile than core inflation, with much of the difference driven by energy prices. Figure 1 plots euro area energy, headline, and core inflation together. Large movements in energy inflation generate pronounced swings in headline inflation, while core inflation is considerably smoother. Much of the short-run variation in headline inflation therefore reflects movements in flexible-price components.⁵ The difference is also clear from the standard deviations (see Table 3, Appendix A), where energy inflation is by far the most volatile component in the consumption basket, at around five times the volatility of headline inflation, while services inflation is the least volatile.

Figure 1. Energy price movements drive volatility in headline inflation



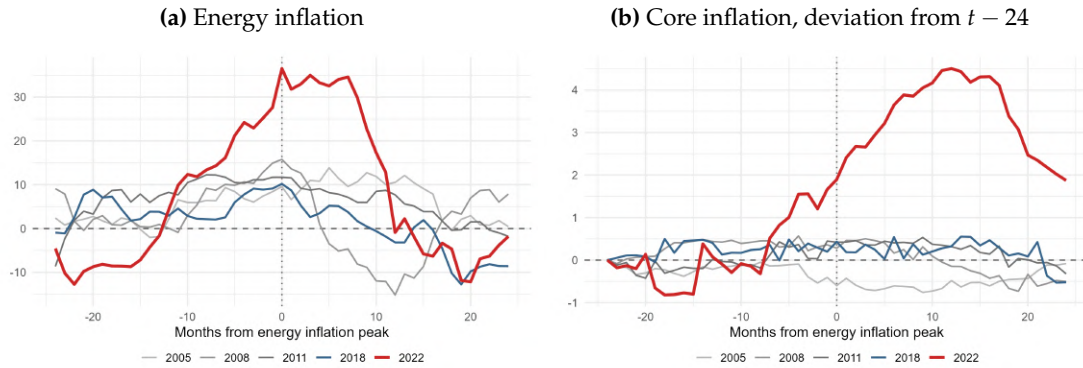
Note: Dark lines show the euro area aggregate, while faint lines show the corresponding series for the 20 individual EA member states in the sample. Data source: Eurostat.

Figure 2 zooms into the largest energy inflation episodes in the sample and compares their evolution with the corresponding change in core inflation. The earlier episodes show a strikingly similar pattern, where energy inflation rises sharply, but core inflation moves little or not at all. The 2021-22 episode is markedly different, however. Energy inflation rises to levels well above those seen in the earlier episodes, and core inflation increases sharply alongside it, reaching more than 4 percentage points above its pre-episode level. Moreover, the increase in core inflation persists even after energy inflation has fallen back.⁶

⁵Figure 14 in Appendix B plots energy inflation against headline and core inflation. The correlation with headline is strong (0.77), since energy enters the headline index directly, while the correlation with core is much weaker (0.30).

⁶Figure 13 in Appendix B shows that this was driven by services.

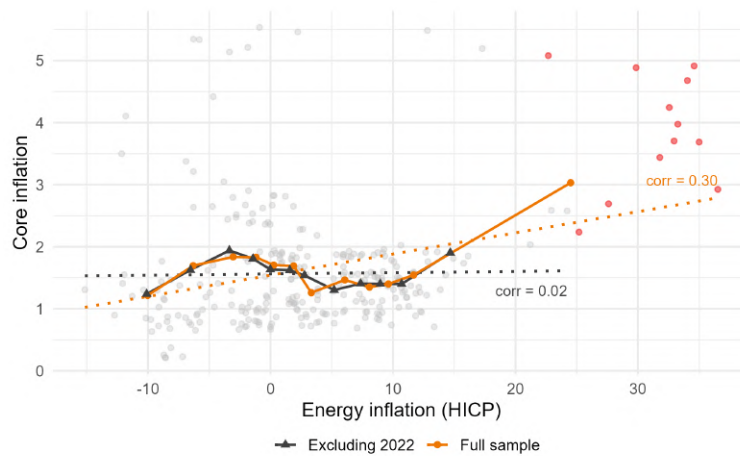
Figure 2. Core inflation responds differently during the 2021-22 energy episode



Note: Each episode is centred on the peak of energy inflation and normalised to month 0. Panel (a) shows energy inflation and panel (b) shows the change in core inflation relative to its value 24 months before the energy inflation peak. Episodes shown: April 2005, July 2008, October 2011, October 2018, and March 2022. Data source: Eurostat.

Figure 3 provides a complementary view of this relationship. The full-sample correlation between energy and core inflation is 0.30, but falls to 0.02 when observations from 2022 are excluded. The binscatter shows that this difference is concentrated at the upper end of the energy-inflation distribution. The binned means in the two samples are very similar up to around 12 percent energy inflation, while the full-sample relationship becomes increasingly positive at higher values, where 2022 provides most of the observations. Thus, the 2022 episode accounts for much of the unconditional correlation because it extends the sample into a part of the energy-inflation distribution that is otherwise sparsely observed.

Figure 3. Binscatter of core on energy inflation

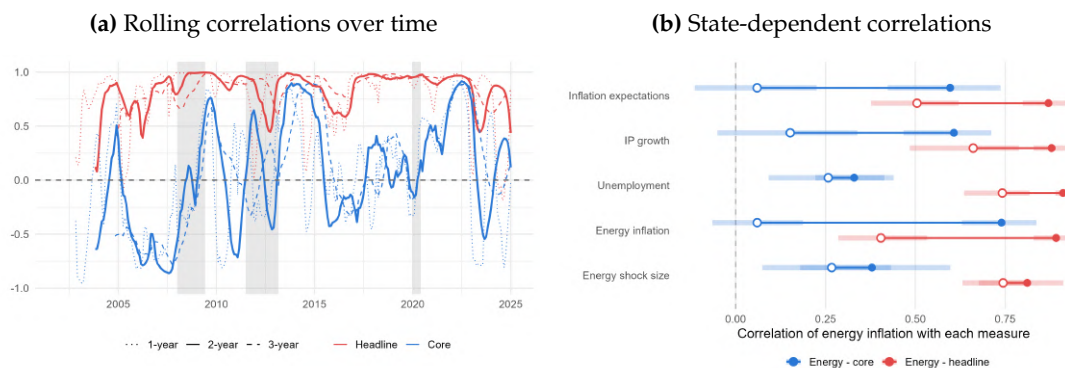


Note: Each marker reports the mean of an equal-count bin (12 bins) for energy inflation and the corresponding mean of core inflation. The full sample includes all observations; the comparison sample excludes 2022 observations. Dotted lines report the corresponding linear correlations.

Although 2022 accounts for much of the unconditional correlation, energy and core inflation have moved together in earlier episodes too. Figure 4a reports rolling correlations of energy inflation

with headline and core inflation over one-, two-, and three-year windows. The correlation with headline is high and stable throughout, whereas the correlation with core changes sign repeatedly, with earlier peaks around 2008 and in the first half of the 2010s. The instability of the energy-core relationship, set against the stable and largely mechanical link between energy and headline, is what makes pass-through to core a substantive question, and Figure 4b indicates that the variation is related to the macroeconomic environment. Splitting the sample by five state variables shows that the energy-core correlation is small or close to zero in all low states, but substantially higher when these variables are elevated.⁷ These patterns motivate the state-dependent analysis that follows in Section 7.

Figure 4. Energy inflation correlates closely with headline inflation, but less stably with core



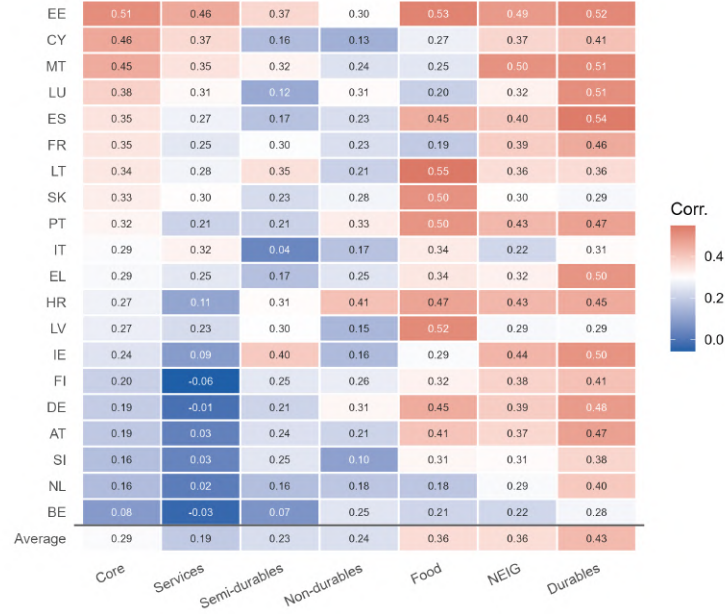
Note: In both panels, blue denotes the correlation of energy inflation with core inflation and red the correlation with headline inflation. Panel (a) reports Pearson correlations over rolling one-, two-, and three-year backward-looking windows; shaded regions denote euro area recessions. Panel (b) reports the same correlations computed separately in the low and high state of each switching variable (open circles denote low states, filled circles denote high state). States are defined by a split at the sample mean, except for energy shock size, which contrasts Känzig shocks more than one standard deviation from the mean with the rest. Confidence intervals are based on an iid bootstrap.

The relationship also differs across components of core inflation and across euro area countries. Figure 5 decomposes the correlation between energy inflation and inflation across countries and components. Comovement is generally stronger for goods than for services, while services display considerably more cross-country variation. While these correlations do not by themselves identify the mechanisms behind this heterogeneity, they indicate where the relationship is strongest and motivate the more detailed component and country analysis below.

Taken together, the descriptive evidence points to a weak average relationship between energy and core inflation, but one that varies considerably across time and across states of the economy. Energy movements feed mechanically into headline inflation, but their relationship with core inflation varies across episodes, over time, and across macroeconomic states, with stronger comovement concentrated in particular components and countries. These patterns motivate estimating the dynamic response to an identified energy supply shock and then examining how that response differs across components, countries, and states of the economy.

⁷The state variation is much more pronounced for the energy-core correlation than for energy and headline. The latter varies less across states because energy enters the headline index directly, so its level is mechanically linked to energy inflation.

Figure 5. Correlations between energy inflation and inflation components across countries



Note: Entries report the full-sample Pearson correlation between euro area energy inflation and inflation in each component for each country. NEIG: Non-energy industrial goods. Data source: Eurostat.

5 Baseline (Linear) Framework

To quantify the dynamic pass-through from energy price shocks into core inflation, the paper uses a reduced-form approach based on local projections (LPs) à la Jordà (2005). The baseline specification estimates the response of euro area inflation to an exogenous energy price shock in a time-series framework.

Let π_t^k denote monthly inflation of component k . For each horizon $h = 0, 1, \dots, H$ and each k , the following local projection is estimated:

$$\pi_{t+h}^k = a_h + \sum_{j=1}^J \rho_{j,h} \pi_{t-j}^k + \sum_{l=1}^L \delta'_{l,h} Z_{t-l} + \theta_h \varepsilon_t^E + u_{t+h} \quad (1)$$

where ε_t^E is an exogenous energy shock, Z_t is a vector of macroeconomic controls, and u_{t+h} is an error term. The sequence $\{\theta_h\}_{h=0}^H$ traces out the impulse response of inflation component k to the shock. The analysis focuses primarily on core inflation, while headline inflation and its subcomponents are also examined separately, for comparison.

A key challenge in estimating pass-through effects is the identification of exogenous energy price movements, since observed energy prices respond endogenously to global demand conditions and macroeconomic developments. The paper therefore uses the oil supply news shock con-

structed by Känzig (2021).⁸ The shock is based on movements in oil futures prices around OPEC production announcements and is intended to capture unexpected news about future oil supply.

In the baseline specifications, the oil supply news shock enters Equation (1) directly as ε_t^E , following recent applications that use the Känzig (2021) series as an exogenous shock (Gomes et al., 2025; Sardar & Qureshi, 2024; Zhu et al., 2025). To account for potential measurement error in the shock series, the paper additionally implements a two-stage least squares instrumental variable (2SLS LP-IV) local projection (Jordà et al., 2015) as a robustness check (see Afrouzi et al., 2024; Drossidis et al., 2024), using the Känzig shock as an external instrument for different energy inflation series. Appendix C provides details on the 2SLS LP-IV specification.

The empirical framework is motivated by an augmented Phillips curve in which core inflation depends on its own lags, economic slack, monetary policy, and energy-related cost pressures. Lagged inflation captures intrinsic persistence in price-setting, while slack in the economy and labour market conditions capture cyclical demand and labour-market pressures that may affect inflation dynamics (Erceg et al., 2000). In the main specification, the vector Z_t includes the short-term policy interest rate, proxying for the monetary policy stance, the output gap, and the non-accelerating wage rate of unemployment (NAWRU). In the baseline estimation, both the dependent variable and the control variables enter the regression with six monthly lags ($J = L = 6$). Robustness checks consider alternative control sets and lag specifications.

The maximum horizon is set to $H = 30$ months. Local projections are estimated by ordinary least squares, and confidence intervals are constructed using heteroskedasticity- and autocorrelation-robust standard errors (Newey & West, 1987). The number of lags used in the standard error correction increases with the forecast horizon.

6 Linear Pass-Through of Energy Price Shocks

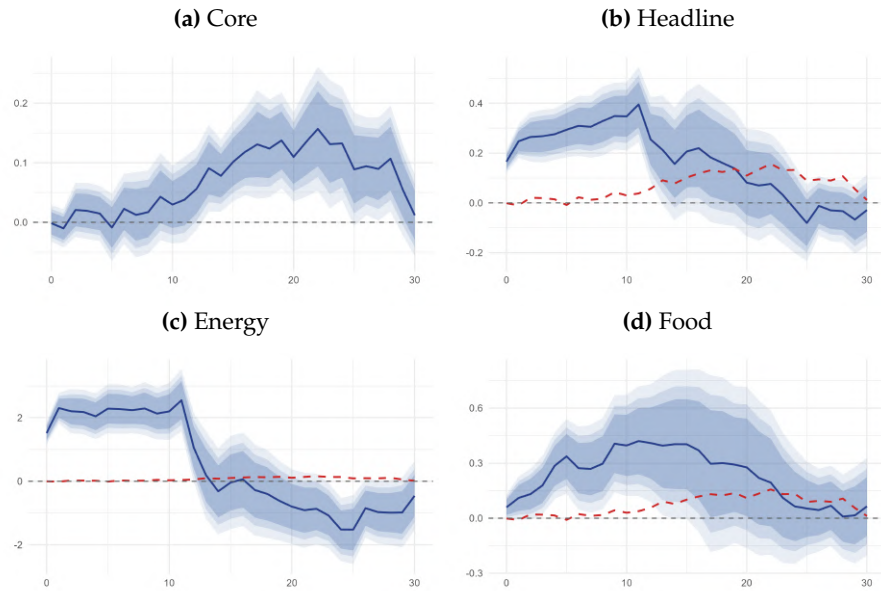
This section estimates the dynamic response of euro area inflation to the identified oil supply news shock. It first presents the baseline responses of core, headline, energy, and food inflation, their robustness, and their dependence on the 2021-22 episode. It then examines where the core response originates, across the components of core inflation and across euro area member states.

⁸Building on high-frequency identification methods in the spirit of Gertler and Karadi (2015) and Ramey (2016), Känzig (2021) measures changes in oil futures prices within a narrow event window around these announcements. The identifying assumption is that macroeconomic conditions and demand expectations are already priced in at the time of the announcement and are unlikely to change materially within the event window. Announcements implying lower (higher) future oil supply are classified as negative (positive) supply news. Figure 15 shows the histogram and time series of the Känzig shock.

6.1 Baseline Empirical Results

Figure 6 reports impulse response functions to a one unit oil supply news shock identified using the methodology of Känzig (2021).⁹ The responses differ substantially across components, particularly in the timing and persistence of the core inflation response.

Figure 6. Responses to an oil supply news shock over the full sample



Note: Impulse responses are reported in percentage point deviations from baseline inflation after a one percentage point shock. The red-dashed line overlays the core response for scale comparability across panels. Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

The response of consumer energy inflation is immediate and large, as expected given the direct exposure of consumer energy prices to oil prices. HICP energy inflation rises by around 1.5 percentage points on impact and continues to increase over the following months, peaking at approximately 2.5 percentage points eleven months after the shock. The response is statistically significant throughout the first year before dissipating as base effects unwind. This profile is consistent with rapid pass-through from wholesale energy prices to retail energy components of the HICP basket. Food inflation also increases following the shock, but with a slower and more muted response. It builds gradually over the first year, reaching a peak of about 0.42 percentage points after eleven months, and remains significant for just over a year. The delayed response is consistent with transmission via higher production, transportation, and processing costs, which operate with longer lags than retail energy pricing.

The direct contribution of energy prices, together with the subsequent response of food prices, translates into a rapid increase in overall HICP inflation. Headline inflation increases by 0.16

⁹A one percentage point energy shock lies at approximately the 95th percentile of the empirical distribution (Figure 15a). The shock is therefore large relative to the historical distribution, but remains within the range of observed realisations. Figure 15b shows that shocks of this size or larger occur in several periods of pronounced energy price movements, including 2007-08, parts of the early and mid-2010s, and 2020-22.

percentage points on impact and continues to rise over the following months, peaking at 0.40 percentage points around eleven months after the shock. Yet, as with energy and food inflation, statistical significance is short-lived and largely disappears after about one year, so the effect on headline inflation is concentrated only in the first half of the response horizon. A transitory rise in headline inflation that is confined to the components directly exposed to energy prices is the pattern that the look-through doctrine presupposes.

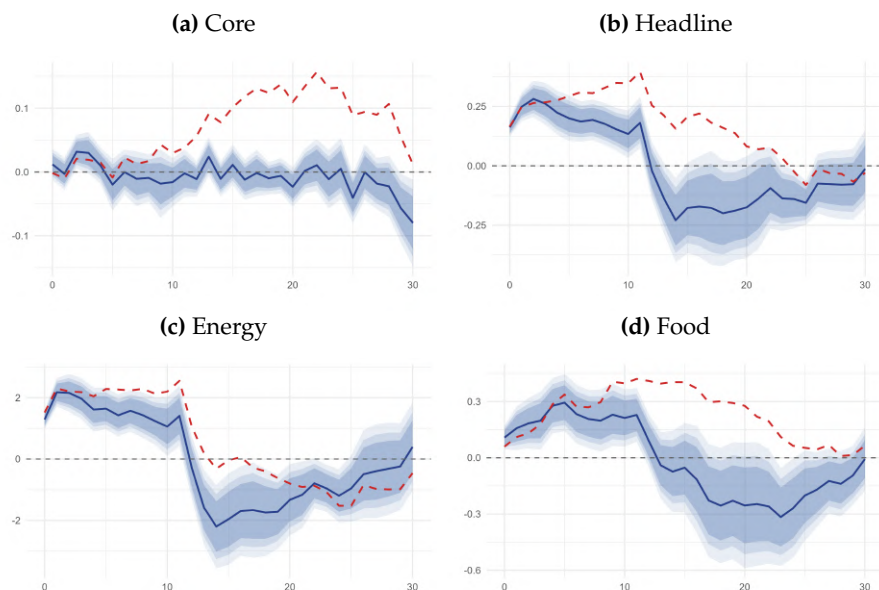
In contrast, the response of core inflation exhibits markedly different timing and persistence. Core inflation increases only gradually following the energy shock and remains statistically insignificant for almost a full year. It becomes positive and significant only thereafter, peaking at 0.16 percentage points 22 months after the shock. Although the peak response is less than half the magnitude of the headline response, once it materialises it proves persistent and remains statistically significant over most of the 2.5-year horizon. Because core inflation excludes the components directly exposed to energy prices, a delayed response of this kind points to indirect and second-round effects, as higher energy costs work their way through production chains, and possibly wages, into the prices of other goods and services. Taken at face value, the full-sample estimates therefore suggest that an energy shock whose effect on headline inflation fades within a year can nonetheless leave a lasting imprint on underlying inflation, which would weaken the case for looking through it.

The baseline results are robust to a range of specification checks. Appendix D shows that the qualitative pattern is preserved under alternative controls (Figures 18 and 19) and under alternative treatments of trend and smoothing in the output gap and NAWRU measures. As a check against potential measurement error in the Känzig (2021) series, Appendix C re-estimates the core response using a two-stage least squares local-projection instrumental-variable approach (Jordà et al., 2015), in which the Känzig shock is used as an external instrument for a range of alternative energy price measures rather than entering as a regressor directly.¹⁰

The core response does not, however, survive the exclusion of the 2021-22 episode. Figure 7 re-estimates the baseline specification on data ending in December 2020 and overlays the full-sample responses, and Table 1 compares the two sets of estimates. The oil supply news shock still raises energy, food, and headline inflation, with peak responses of 2.2, 0.29, and 0.28 percentage points within the first six months, between 70 and 85 percent of their full-sample peaks, so it continues to move the prices directly exposed to it. The response of core inflation is flat: it peaks at 0.03 percentage points two months after the shock, a fifth of its full-sample peak, and is significant at only three of the thirty-one horizons. The direct effects are also shorter-lived before 2021. The responses of energy, food, and headline inflation reverse in the second year after the shock, so that their cumulative responses over the thirty-month horizon, like that of core inflation, are close to zero. Before 2021, energy supply shocks thus changed relative prices in the euro area only temporarily and without affecting underlying inflation, which is precisely the condition under which looking through them is appropriate.

¹⁰The exercise shows that the estimated pass-through shape is robust, but that the level differs substantially across the price measures, with the response becoming larger as the measure moves from global oil prices towards consumer energy prices.

Figure 7. Responses estimated on the pre-2021 sample



Note: Impulse responses are reported in percentage point deviations from baseline inflation after a one percentage point shock, estimated on data from January 2002 to December 2020. The red-dashed line overlays the full-sample response of the same variable (Figure 6). Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

The delayed and persistent core response in the full sample is therefore a feature of the 2021-22 episode. Excluding the observations from 2021 onwards, less than a fifth of the sample, removes it entirely, which is difficult to reconcile with a constant pass-through coefficient, although the difference may reflect the greater persistence of the energy price increases in the recent episode as well as the conditions under which they were transmitted. The result reconciles the recent experience with the earlier literature. The studies that found small or negligible pass-through to core inflation (Chen, 2009; Clark & Terry, 2010; Conflitti & Luciani, 2019; De Gregorio et al., 2007; Hooker, 2002) were estimated almost entirely on data from the low-inflation period that followed the early 1980s, and on data of this kind the present estimates agree with theirs: before 2021, euro area headline inflation exceeded 4 percent in a single month, whereas from November 2021 it did so for almost two years. What such samples could not reveal is that the small pass-through was conditional on the environment. The contrast is sharpest for Hooker (2002), whose sample spans both periods: he finds sizeable pass-through to core inflation before the early 1980s and little or none thereafter, but the nonlinearities he considers concern the oil price change itself rather than the environment in which it occurs. The pass-through he documents before the early 1980s re-emerged in the euro area in 2021-22, when inflation was again high.

Several of the factors to which Blanchard and Galí (2010) attribute the milder effects of oil shocks in the 2000s, such as more flexible labour markets and more credible monetary policy, are not fixed features of the economy. In 2021-22, the energy shock coincided with other adverse supply shocks and tight labour markets (Bernanke & Blanchard, 2025), and inflation expectations rose,

Table 1. Responses in the full and pre-2021 samples

	Core	Headline	Energy	Food
<i>Peak response (pp) [month of peak]</i>				
Full sample	0.16** [22]	0.40*** [11]	2.55*** [11]	0.42** [11]
Pre-2021 sample	0.03** [2]	0.28*** [2]	2.17*** [1]	0.29*** [5]
Pre-2021 relative to full sample	20%	71%	85%	70%
<i>Horizons with a significant positive response (of 31)</i>				
Full sample	18	19	13	21
Pre-2021 sample	3	12	12	13
<i>Cumulative response, $h = 0, \dots, 30$ (pp)</i>				
Full sample	2.35**	5.57***	17.77*	7.78**
Pre-2021 sample	−0.23	0.20	0.81	−0.49

Note: Responses to a one percentage point oil supply news shock. Significant horizons are those at which the response is positive and significant at the 68 percent level, as in the confidence bands of Figure 7. The cumulative response, $\sum_{h=0}^{30} \theta_h$, is estimated directly by replacing the dependent variable in Equation (1) with $\sum_{j=0}^{30} \pi_{t+j}^k$. *, **, and *** denote significance at the 10, 5, and 1 percent levels, based on Newey & West (1987) standard errors. Full sample: January 2002 to January 2025; pre-2021 sample: January 2002 to December 2020. Data sources: Eurostat, EC/AMECO, Känzig (2021).

so that the conditions that had kept pass-through low no longer held. This is consistent with models in which the Phillips curve is flat in normal times but steepens in response to large shocks or tight labour markets (Benigno & Eggertsson, 2023; Harding et al., 2023), and points to state dependence in the transmission of energy shocks.

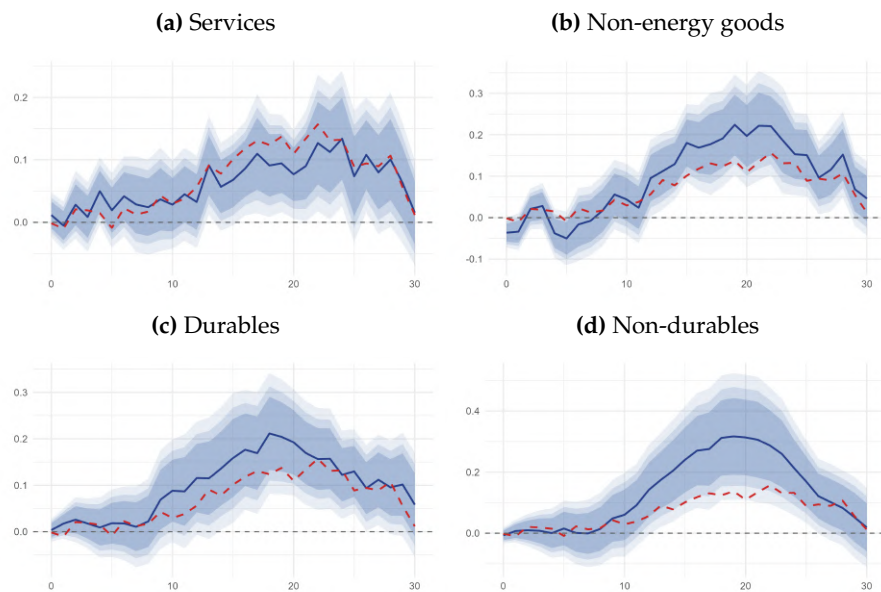
6.2 Composition of the Core Response Across Components and Countries

Although the response of core inflation hinges on the 2021-22 episode, the full-sample estimates remain informative about where that response originates. This subsection disaggregates it across the components of core inflation and individual euro area member states.

Figure 8 first decomposes core inflation into services and non-energy industrial goods (NEIG), with the latter further split into durables and non-durables. Services inflation responds only weakly to the energy shock, becoming significant later than core inflation and peaking at 0.13 percentage points two years after the shock. This muted response is consistent with the greater importance of labour costs and domestic demand in services pricing, which makes services less directly exposed to energy costs. Because the services response builds slowly and persists, however, its cumulative response over the thirty-month horizon, estimated as in Table 1, is 2.33 percentage points, close to the 2.74 percentage points for NEIG and the 2.35 percentage points for core inflation as a whole. This later and more gradual transmission is consistent with energy costs reaching services prices indirectly, through intermediate inputs and wages. The response of NEIG inflation is both larger and somewhat earlier, peaking at 0.22 percentage points after 19 months and remaining significant for roughly twenty-eight months. The stronger pass-through is consistent with the role of energy in the production and distribution of goods, as well as their greater exposure to global value chains. Within goods, the response is concentrated in

non-durables: inflation in this category peaks at about 0.32 percentage points after 19 months, while the response of durable goods is smaller but peaks at a similar horizon. The particularly strong response of non-durables is consistent with a cost channel operating through production and distribution: these goods sit close to the energy input in the production chain, through fuel, fertiliser, packaging, and transport costs, and their prices are adjusted frequently (Gautier et al., 2024). Overall, goods prices, and non-durables in particular, account for the larger and earlier part of the core response, while services add a later and more gradual contribution.

Figure 8. Responses of goods and services to an oil supply news shock

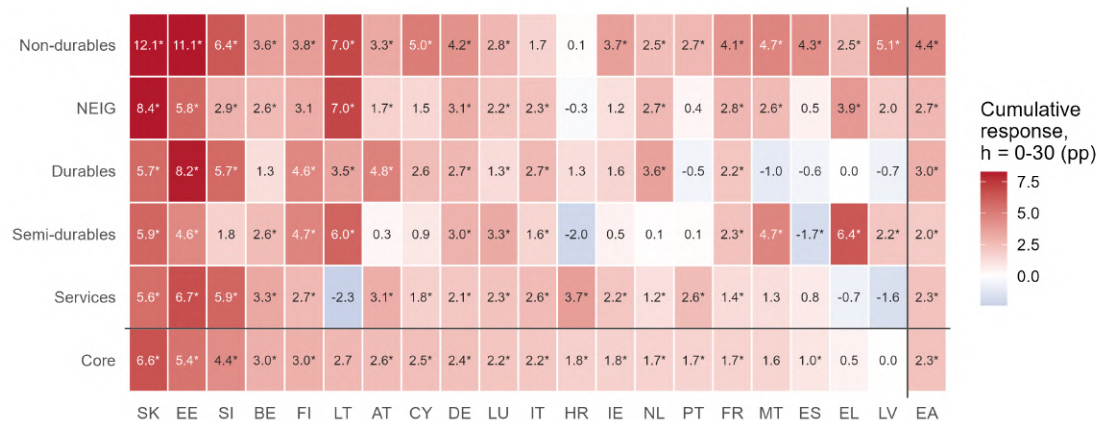


Note: Impulse responses are reported in percentage point deviations from baseline inflation after a one percentage point shock. The red-dashed line overlays the core inflation response for scale comparability across panels. Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

Figure 9 adds the cross-country dimension. It reports the cumulative response over the thirty-month horizon for each component of core inflation in each member state, with core inflation itself in the final row. The component pattern of the euro area aggregate recurs across countries: non-durables respond more strongly than services in 18 of the 20 member states. The cumulative core response, however, varies widely, from 6.6 percentage points in Slovakia, 5.4 in Estonia, and 4.4 in Slovenia to 1.0 in Spain, and it is not statistically significant in Lithuania, Malta, Greece, and Latvia. The heatmap shows that these differences do not stem from the composition of national consumption baskets. If they did, member states would differ mainly in the weights of components whose responses are similar across countries. Instead, the ranking of member states is similar across components: countries with a large response in one component tend to have large responses in the others, and Slovakia, Estonia, and Slovenia are among the largest in almost every component. Differences between member states account for half of the variation across the component-by-country cells, while differences between components account for about

a tenth.¹¹ Cross-country differences in core pass-through therefore reflect characteristics of the national economies rather than differences in what their consumers buy.¹²

Figure 9. Cumulative pass-through by component of core inflation and member state



Note: Each cell reports the cumulative response over the 30-month horizon, $\sum_{h=0}^{30} \theta_h$, of the indicated component in the indicated member state to a one percentage point oil supply news shock, in percentage points, estimated as in Table 1. Asterisks denote responses significant at the 68 percent level, based on Newey & West (1987) standard errors. The first five rows are ordered by their average response across the twenty member states, and the final row reports core inflation. Member states are ordered by their core response, and the final column reports the euro area aggregate. NEIG: non-energy industrial goods. Data sources: Eurostat, EC/AMECO, Känzig (2021).

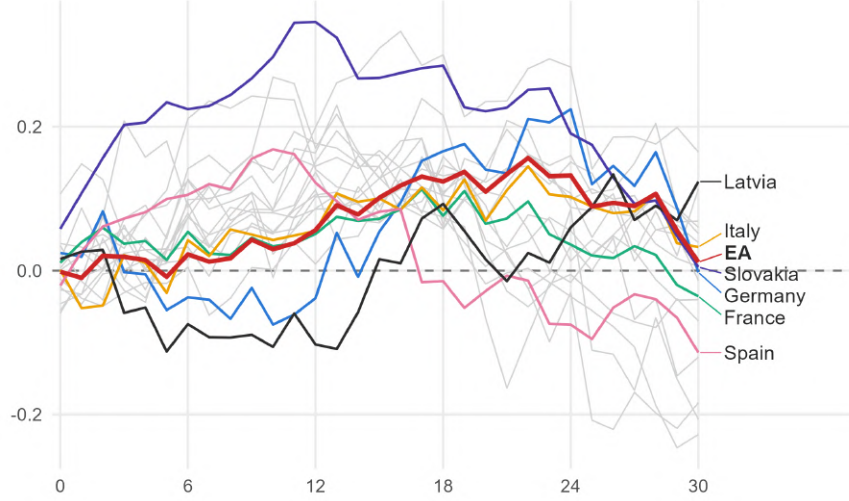
The country results show that the euro area aggregate conceals substantial variation in the size and timing of energy pass-through across member states. Figure 10 plots the core inflation response of each member state together with the response estimated on the euro area aggregate, highlighting the four largest economies and the member states with the largest and smallest cumulative responses. Germany has a relatively large peak response, with core inflation rising by 0.22 percentage points two years after the shock, which is consistent with greater exposure to energy costs in an economy with a relatively large industrial sector, given the stronger response of NEIG than services inflation in the aggregate decomposition. Italy's response is broadly similar to the euro area aggregate in size and timing, although it is significant at fewer horizons. France follows a similar pattern with a smaller peak of 0.11 percentage points, which may partly reflect the prevalence of administered electricity and gas prices (Kuik et al., 2022), but its response remains significant at nineteen of the thirty-one horizons. Spain responds earlier, with core inflation peaking within the first year, but the response fades thereafter and its cumulative response is the smallest of the four. The extremes are Slovakia, where the response is significant from the month of the shock, peaks at 0.35 percentage points after a year, and remains significant at 27 of the 31 horizons, and Latvia, where it is significant at only two horizons and the cumulative response is essentially zero. The responses of all twenty member states are reported in Appendix

¹¹Shares of the sum of squares in a two-way decomposition of the cumulative responses of the five components into member-state and component effects; the remaining 38 percent reflects component-specific differences across member states. Kendall's coefficient of concordance is 0.47 for the ranking of member states across components and 0.23 for the ranking of components across member states.

¹²Figure 20 in Appendix E reports the same exercise for the twelve COICOP divisions. The responses are largest for transport, food, and housing and utilities, the first and last of which contain energy directly, followed by restaurants and hotels, furnishings, and recreation and culture.

E (Figures 22 and 23), where Figure 21 also shows that countries with large peak responses do not necessarily have the most persistent ones.

Figure 10. Dispersion of euro area member state responses



Note: Impulse responses of core inflation to a one percentage point oil supply news shock, in percentage points, over the 30 months after the shock. Grey lines show the individual member states, with Germany, France, Italy, Spain, Slovakia, and Latvia highlighted; the red line (EA) is the response estimated directly on the euro area aggregate index. Data sources: Eurostat, EC/AMECO, Känzig (2021).

This dispersion in timing shapes the euro area aggregate. National responses peak between three and twenty-eight months after the shock, so at any horizon some member states are still approaching their peak while others have already passed it. As a result, the peak of the euro area response, 0.157 percentage points, lies below the weighted average of the national peaks, 0.174 percentage points. This is an instance of Jensen's inequality: because the maximum is a convex function, for national responses $\theta_{i,h}$ and weights $w_i \geq 0$ with $\sum_i w_i = 1$,

$$\max_h \sum_i w_i \theta_{i,h} \leq \sum_i w_i \max_h \theta_{i,h}, \quad (2)$$

with equality only if all member states peak at the same horizon.¹³ Aggregation thus leaves the eventual increase in core inflation broadly unchanged but spreads it over time. Monitoring euro area core inflation therefore suggests a response that is shallower at its peak and more drawn out than in many individual member states, which can give a more benign impression of the shock than the experience of those member states.

¹³The weights are shares in household consumption expenditure, the basis of the country weights in the euro area HICP. The inequality holds exactly for the weighted average of the national responses, whose peak is 0.129 percentage points, and approximately for the response estimated directly on the euro area aggregate index, which is not a weighted average of the national estimates.

7 Nonlinear Transmission of Energy Shocks

7.1 Methodology

Section 6.1 shows that the pass-through of energy supply shocks to core inflation is absent before 2021 but emerges once the 2021-22 episode is included. Together with the descriptive evidence in Section 4, this suggests that the response of core inflation depends on the conditions in which the shock occurs, and that the linear estimates average over very different responses. Whether higher energy costs are absorbed as a one-off relative-price adjustment or instead feed into broader price- and wage-setting plausibly depends on the conditions prevailing when the shock arrives. This motivates extending the baseline linear local projection to allow the response to vary with the state of the economy.

As set out in Section 2, several mechanisms could generate such state dependence, but they do not point to the same state variable: menu-cost pricing implies dependence on the size of the energy shock, wage indexation on the state of wage growth, and imperfect-information mechanisms on the level of expectations and headline inflation. The analysis therefore examines state dependence along these four dimensions. Wage growth, inflation expectations, and headline inflation describe the environment in which the shock occurs, while the Brent-based regime captures variation in the size of the oil price movement. The empirical specification tests this possibility by allowing the response to vary across these dimensions.

As before, π_t^C denotes core inflation, Z_t is a vector of control variables, and the Känzig (2021) shock, ϵ_t^E , enters directly as an externally identified shock. Unlike Equation 1, however, the framework now incorporates a switching variable z_t that governs regime dependence. The local projection estimated at horizon h is:

$$\begin{aligned} \pi_{t+h}^C = & \alpha_h + \sum_{j=1}^J \left[(1 - \Omega_{t-1}) \rho_{j,h}^{(1)} + \Omega_{t-1} \rho_{j,h}^{(2)} \right] \pi_{t-j}^C \\ & + \sum_{l=1}^L \left[(1 - \Omega_{t-1}) \delta_{l,h}^{(1)} + \Omega_{t-1} \delta_{l,h}^{(2)} \right] Z_{t-l} \\ & + \left[(1 - \Omega_{t-1}) \theta_h^{(1)} + \Omega_{t-1} \theta_h^{(2)} \right] \epsilon_t^E + u_{t+h}, \end{aligned} \quad (3)$$

The model allows the coefficients on lagged core inflation, control variables, and the energy shock to differ across regimes, with regime weights given by $1 - \Omega_{t-1}$ and Ω_{t-1} . The switching variable enters the transition function with a lag, so that z_{t-1} determines the regime prevailing at time t . This ensures that the state is predetermined with respect to the energy shock, mitigating concerns about contemporaneous feedback effects (Auerbach & Gorodnichenko, 2012, 2013).

The regime weight Ω_{t-1} is defined as:

$$\Omega_{t-1} = \begin{cases} F(z_{t-1}) = \frac{\exp(-\gamma z_{t-1})}{1 + \exp(-\gamma z_{t-1})}, & \text{if } z_{t-1} \text{ is continuous,} \\ D_{t-1} \in \{0, 1\}, & \text{if } z_{t-1} \text{ is discrete.} \end{cases} \quad (4)$$

For continuous switching variables, the specification follows the smooth-transition local projection approach of Auerbach and Gorodnichenko (2012, 2013). The switching variable is HP-filtered, and its cyclical component is standardised to have zero mean and unit variance before the logistic function $F(\cdot)$ is applied. This removes the long-run component of the variable and makes the regime measure depend on its medium-term fluctuations.¹⁴ The parameter γ determines the steepness of the transition function, with lower values implying gradual transitions across regimes and larger values approximating a discrete threshold model.¹⁵

The continuous switching variables are inflation expectations, wage growth, and headline inflation. Appendix Figure 16 plots the estimated regime weight Ω_{t-1} for each continuous switching variable over the sample. For the discrete specification, the regime is based on the size of Brent price increases. Observations for which the change in Brent prices lies outside the sample mean plus or minus one standard deviation are classified as large movements, with the remaining observations forming the reference regime. The resulting large-movement regime includes episodes such as 2008, 2014-16, and 2020-22. The impulse responses are estimated separately for the “high” and “low” states as the corresponding sequences of $\theta_h^{(1)}$ and $\theta_h^{(2)}$. The horizon, lag structure, and inference procedures are the same as in the linear specification.¹⁶

7.2 Nonlinear Results

The nonlinear estimates show that the pass-through of energy supply shocks to core inflation varies substantially across states of the economy, revealing heterogeneity that is obscured in the linear specification. Figure 11 summarises the nonlinear responses for different switching variables. Across the specifications, pass-through is stronger at its peak, more persistent, or both when inflationary pressures are elevated, while responses are weaker or shorter-lived when such

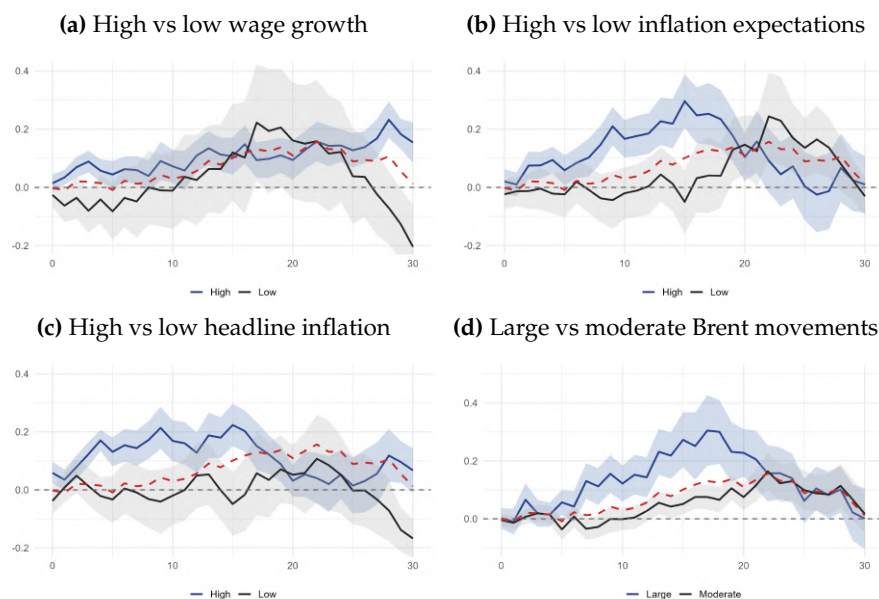
¹⁴The smoothing parameter is set to $\lambda = 14,400$, following Ravn and Uhlig (2002).

¹⁵As $\gamma \rightarrow \infty$, the smooth-transition specification converges to a binary regime-switching model. Robustness checks consider alternative values of γ to assess the sensitivity of the results to the degree of smoothness in the transition between regimes, and yield qualitatively similar patterns.

¹⁶When the shock is observed and independent of the lagged state, as is plausible here, state-dependent local projections recover weighted averages of the marginal effects of the shock, with the same weights in each state, so that a difference between the regime-specific responses reflects genuine state dependence (Winkler, 2026). When the switching variable itself depends on macroeconomic shocks, as inflation, expectations, and wage growth do, local projections recover the response to an infinitesimal shock conditional on the state at the time of the shock, but not the response to larger shocks, part of which operates through the change in the state that the shock induces (Gonçalves et al., 2024). David et al. (2026) show that even with an exogenous shock, interacted local projections generally recover only a projection of the state-dependent response function, a weighted average of its local derivatives, rather than the function itself, while Cloyne et al. (2023) interpret the interacted specification as a decomposition of how the response varies with the state of the economy. The estimates below should therefore be read as describing how the response to an energy shock differs with the conditions prevailing when the shock arrives, which is the object relevant for the look-through question, rather than as structural regime-specific responses to shocks of a given size, which would require modelling how the state evolves after the shock.

pressures are subdued.

Figure 11. Pass-through nonlinearity across switching variables



Note: Impulse responses are reported in percentage point deviations from baseline inflation after a one percentage point shock. The red-dashed line overlays the (linear) core inflation response for scale comparability across panels. Shaded areas denote 68 percent confidence intervals based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

When wage growth is high, an energy shock generates a sizable and persistent increase in core inflation (Figure 11a): the response becomes significant much earlier than in the linear benchmark, builds to a peak of 0.23 percentage points 28 months after the shock, and remains significant to the end of the horizon. The main difference from the linear response is therefore the greater persistence. This pattern is consistent with wage-price models in which stronger wage pressures allow cost shocks to feed more readily into prices (Blanchard & Galí, 2010; Erceg et al., 2000). After an adverse supply shock, workers seek to recover lost real income, and the resulting wage increases raise costs and prices further (Lorenzoni & Werning, 2023). Such feedback is weak when wage growth is subdued, since the initial price increase is then absorbed in lower real wages, but it prolongs the response when wage growth is already strong. The pattern is also consistent with the role of wage dynamics emphasised in recent accounts of the persistence of the 2021-22 inflation (Arndt & Enders, 2024; Boeck & Zörner, 2025).

Higher inflation expectations, by contrast, primarily amplify the initial transmission of the shock (Figure 11b). Core inflation responds significantly within the first months and peaks at 0.30 percentage points after 15 months, well above the unconditional estimate in Figure 6. Unlike the wage-growth regime, however, the stronger response is concentrated in the earlier part of the horizon and then declines. This pattern is compatible with mechanisms in which the inflation environment affects how firms and households respond to aggregate price changes (Mankiw & Reis, 2002; Sims, 2003). When inflation is low and stable, households and firms have little

reason to monitor it, and price setters respond only slowly to aggregate conditions (Maćkowiak & Wiederholt, 2009; Sims, 2003). Attention rises sharply when inflation is high: households and firms are better informed about inflation in high-inflation than in low-inflation environments (Bracha & Tang, 2025; Weber et al., 2025), and measures of attention based on internet searches and news coverage display thresholds, typically between 2 and 4 percent inflation, above which attention increases markedly (Korenok et al., 2026; Pfäuti, 2024). Before 2021, euro area headline inflation crossed the upper end of this range only once (Section 6.1). An energy shock that arrives when attention is low is therefore more likely to be treated as a change in relative prices, while the same shock arriving when inflation is salient is more likely to feed into expectations and price setting. The pattern also speaks to the concern that pass-through intensifies when expectations risk becoming de-anchored (Casoli et al., 2024; Reis, 2021; Schnabel, 2022).

Transmission is similarly amplified when headline inflation is elevated (Figure 11c). Energy shocks generate a significant response in core inflation almost immediately, which peaks at 0.22 percentage points after 15 months. As under elevated inflation expectations, the response builds much faster than in the linear benchmark, but it declines only gradually and is still about a third of its peak thirty months after the shock. The high-wage regime is nonetheless distinguished by the greatest persistence of the response.

Finally, when the shock arrives during a large increase in oil prices, pass-through is stronger and faster (Figure 11d). The response becomes significant within a few months and peaks at 0.30 percentage points 17 months after the shock. The result is consistent with the prediction from state-dependent pricing that larger cost shocks are more likely to generate price adjustment (Bils & Klenow, 2004; Dotsey et al., 1999; Golosov & Lucas, 2007). In menu-cost economies, firms adjust prices when the gap between their actual and desired price is large enough to justify the cost of adjustment. When inflation is low and cost shocks are small, few firms adjust in response to a given shock and its effect on the aggregate price level is muted; when inflation is high or shocks are large, the fraction of firms adjusting rises and pass-through becomes larger and faster (Ascari & Haber, 2022; Blanco et al., 2024). The micro evidence supports each step of this argument. The frequency of price adjustment changes little with inflation when inflation is low but rises once inflation is high (Alvarez et al., 2019; Gagnon, 2009; Nakamura et al., 2018), large cost shocks pass through to prices faster and more completely than small ones (Cavallo et al., 2024; Karadi & Reiff, 2019), and firm-level cost-price dynamics were close to linear, with a stable frequency of adjustment, before the pandemic but became markedly nonlinear during the inflation surge (Gagliardone et al., 2025). Ascari and Haber (2022) show that in a menu-cost economy the same mechanism strengthens and accelerates the transmission of shocks both when shocks are large and when trend inflation is high, which offers a common interpretation of the amplification found here across the size, headline-inflation, and expectations regimes.

In contrast, when inflationary pressures are muted, the response of core inflation is weaker, later, or shorter-lived. When headline inflation is low, the response is never significantly positive and turns significantly negative towards the end of the horizon. When wage growth is low, core inflation rises only briefly: the response is significant at two horizons and reverses before the end

of the horizon. When inflation expectations are low, the response arrives only with a long delay and becomes significant about a year and a half after the shock, while under moderate Brent price movements it is close to the linear benchmark. Energy shocks arriving in lower-pressure states therefore do not generate a prompt or lasting rise in underlying inflation. The nonlinear estimates therefore point to substantial state dependence in the pass-through from oil supply news shocks to core inflation.

7.3 Amplification and Propagation

The state-dependent responses in Figure 11 differ along two dimensions with distinct economic interpretations. The first is amplification, the size of the response at its peak, which measures how much of the shock reaches core prices. The second is propagation, which measures how long the shock continues to shape underlying inflation. Table 2 reports both for each regime, measuring amplification by the peak response and propagation by the response at the end of the horizon, thirty months after the shock. It also reports the cumulative response over the thirty-month horizon, estimated as in Table 1, which combines the size and the persistence of the response.

Table 2. Amplification and propagation of the core inflation response

	Peak (pp)	Month of peak	Response at $h = 30$ (pp)	Cumulative response, $h = 0, \dots, 30$ (pp)
Linear	0.16**	22	0.01	2.35**
Inflation expectations, high	0.30***	15	0.01	2.72
Inflation expectations, low	0.24	22	−0.03	2.84
Headline inflation, high	0.22***	15	0.07	3.04*
Headline inflation, low	0.11	22	−0.17**	0.61
Brent price increases, large	0.30**	17	0.00	2.85*
Brent price increases, moderate	0.16***	22	0.02	2.08*
Wage growth, high	0.23***	28	0.15**	3.69***
Wage growth, low	0.22	17	−0.20	0.77

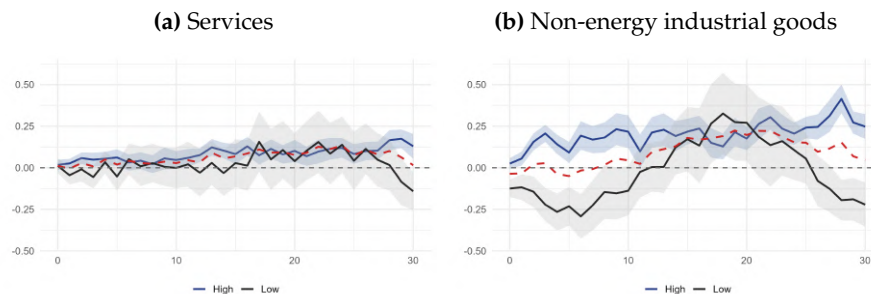
Note: Responses of core inflation to a one percentage point oil supply news shock. The cumulative response is estimated directly by regressing $\sum_{j=0}^{30} \pi_{t+j}^C$ on the regressors of the corresponding specification. *, **, and *** denote significance at the 10, 5, and 1 percent levels, based on Newey & West (1987) standard errors. For the smooth-transition specifications, the high- and low-state responses are those implied by the regime-specific coefficients, that is, the responses when the transition function places full weight on one regime. Data sources: Eurostat, EC/AMECO, Känzig (2021).

The table shows a clear division between the state variables. Elevated inflation expectations, high headline inflation, and large increases in Brent prices raise the peak response above that in the corresponding low state, to 0.30 against 0.24, 0.22 against 0.11, and 0.30 against 0.16 percentage points, respectively, and for expectations and headline inflation the peak is statistically significant at conventional levels only in the high state. In each case, however, the response has largely dissipated by the end of the horizon, when it stands at between zero and a third of its peak. A larger peak does not always translate into a larger cumulative effect. It does for headline

inflation, where the cumulative response is 3.0 percentage points in the high state against 0.6 in the low state, and to a lesser extent for oil price increases, at 2.8 against 2.1, but not for inflation expectations, where the response in the low state arrives later but accumulates to a similar total. Wage growth works differently. The peak response is essentially the same in the high- and low-wage states, at 0.23 and 0.22 percentage points, but when wage growth is high the response builds more slowly and is still 0.15 percentage points, about two thirds of its peak, thirty months after the shock, whereas when wage growth is low it turns negative before the end of the horizon. As a result, the cumulative response in the high-wage state is 3.7 percentage points, the largest of any regime, against 0.8 in the low-wage state. High wage growth leaves the peak unchanged and extends the persistence of the response.

If the propagation associated with wage growth reflected a wage-price channel operating mainly through labour-intensive sectors, it should be concentrated in services. Figure 12 re-estimates the wage-growth specification separately for services and for non-energy industrial goods. The pattern is the same in both. The peak response differs relatively little across wage states, at 0.18 against 0.16 percentage points for services and 0.42 against 0.33 percentage points for goods, and in the low-wage state it is not statistically significant at conventional levels. Persistence, by contrast, differs markedly: the response at the end of the horizon is at 60 to 75 percent of its peak when wage growth is high and negative when it is low, and the cumulative response of services and goods inflation is 3.2 and 6.1 percentage points in the high-wage state, against 1.4 and -1.5 in the low-wage state. The additional persistence is therefore not confined to services. This is consistent with labour costs entering the prices of goods as well as services, for instance through distribution and retail margins, and with high wage growth reflecting broader second-round dynamics.

Figure 12. Wage-growth regime: services and non-energy industrial goods



Note: Responses of services and non-energy industrial goods inflation to a one percentage point oil supply news shock in the high and low wage-growth states, estimated with the same smooth-transition specification as Figure 11a. The red-dashed line shows the linear response of the same component. Both panels share a common vertical scale. Shaded areas denote 68 percent confidence intervals based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

The distinction between amplification and propagation helps to discriminate between the mechanisms discussed in Section 2. Mechanisms that raise the share of a cost shock passed into prices when it occurs, such as state-dependent pricing or greater attention to inflation, should amplify the response without necessarily prolonging it, which is the pattern associated with

expectations, headline inflation, and the size of oil price increases. Mechanisms that feed the initial price increase back into subsequent costs, such as wage-price feedback, should instead prolong the response, which is the pattern associated with wage growth. The combination of amplification through pricing and attention with propagation through wages provides a coherent account of why the same shock can leave core inflation unaffected in one environment and raise it persistently in another.

8 Conclusion

This paper studies the transmission of exogenous energy supply shocks to underlying inflation in the euro area. Motivated by the role of energy price movements in recent inflationary episodes, the analysis asks whether, and under which conditions, energy shocks propagate beyond energy inflation into core inflation. To address this question, the paper combines the externally identified energy supply shocks from Känzig (2021) with local projection methods, allowing for rich dynamics, alternative price measures, and nonlinear state dependence.

The empirical results point to three main findings. First, energy supply shocks generate a sharp but transitory increase in energy and food inflation, which passes through quickly to headline inflation and largely dissipates within a year. Over the full sample, core inflation responds much more slowly: pass-through materialises only with a substantial delay, peaks after roughly two years, and remains considerably more persistent, and this response is robust to alternative controls and energy price measures. It is, however, specific to the high-inflation episode of 2021-22. Estimated on data ending in 2020, the same shock raises energy, food, and headline inflation but leaves core inflation essentially unchanged, so that in periods of low inflation energy shocks change relative prices without affecting underlying inflation.

Second, the pass-through is concentrated in food and in non-energy industrial goods, particularly non-durables, while services respond later and less strongly at their peak, although their cumulative response over the horizon approaches that of non-energy industrial goods. Across member states, the size and timing of the response vary widely, with national peaks occurring between three and twenty-eight months after the shock. The same countries display large responses in almost every component.

Third, the pass-through is state dependent in two distinct ways. Elevated inflation expectations, high headline inflation, and large increases in oil prices amplify the response of core inflation at its peak, while high wage growth propagates it, leaving the peak unchanged but keeping core inflation elevated two and a half years after the shock, in goods and services alike. In lower-pressure states, the response is weaker or short-lived. These results provide disaggregated euro area evidence for the state dependence documented in recent work mainly for headline inflation and aggregate shocks (Afrouzi et al., 2024; Arndt & Enders, 2024; Baumeister & Peersman, 2013), and they reconcile the small pass-through found in earlier studies, which were estimated over periods of low inflation, with the experience of 2021-22.

Taken together, these findings support a state-dependent reading of the look-through doctrine. In periods of low and stable inflation, energy supply shocks change relative prices without affecting underlying inflation, and looking through them is appropriate. When inflation expectations, headline inflation, or wage growth are elevated, the same shocks spill over into core inflation, more strongly and, when wage growth is high, for longer. The mechanisms that can account for this pattern, state-dependent pricing, attention to inflation, and feedback from prices to wages, all imply that pass-through depends on the environment in which a shock is transmitted and not only on the shock itself.

From a policy perspective, the results suggest that the response to an energy price shock cannot be assessed independently of the inflationary environment in which it occurs. Wage growth, inflation expectations, and broader inflation developments may therefore be useful indicators of the extent to which an energy shock is likely to pass through to underlying inflation. For researchers, the results point to the value of allowing for state-dependent transmission when studying the inflationary effects of energy shocks, and they caution against treating estimates obtained over periods of low inflation as structural.

A Appendix:

Data and Descriptive Statistics

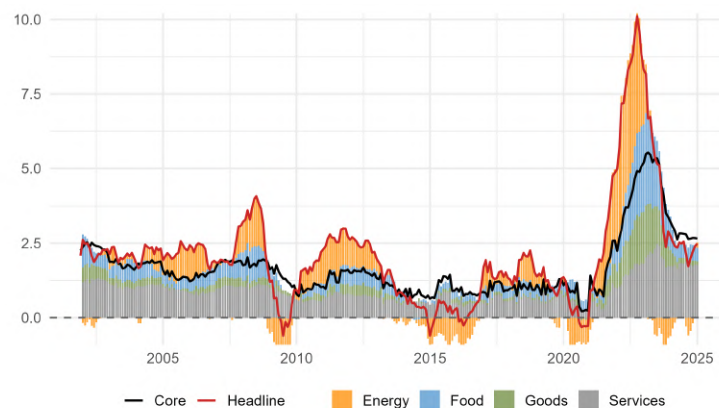
Table 3. Summary statistics

Variable	Source	Start	End	Mean	Min	Max	SD	IQR
Brent crude price chg	U.S. EIA	2001-01	2025-01	4.3	-135.5	126.0	36.2	46.1
CP01: Food & non-alc. HICP infl	Eurostat	2001-01	2025-01	2.6	-1.6	16.1	3.0	1.9
CP02: Alc. & tobacco HICP infl	Eurostat	2001-01	2025-01	3.8	1.3	8.2	1.5	1.6
CP03: Clothing & footwear HICP infl	Eurostat	2001-01	2025-01	0.8	-3.3	6.1	1.2	1.2
CP04: Housing, water, elect., gas HICP infl	Eurostat	2001-01	2025-01	2.8	-6.3	20.8	3.6	3.0
CP05: Furnishings, household equip. HICP infl	Eurostat	2001-01	2025-01	1.3	-0.5	8.7	1.7	1.2
CP06: Health HICP infl	Eurostat	2001-01	2025-01	1.7	-0.6	8.1	1.5	1.3
CP07: Transport HICP infl	Eurostat	2001-01	2025-01	2.3	-5.7	13.6	3.4	4.1
CP08: Commun. HICP infl	Eurostat	2001-01	2025-01	-1.7	-8.8	1.0	1.4	1.8
CP09: Rec. & culture HICP infl	Eurostat	2001-01	2025-01	1.0	-1.4	6.4	1.4	1.5
CP10: Education HICP	Eurostat	2001-01	2025-01	2.1	-3.6	9.0	2.2	2.9
CP11: Rest. & hotels HICP infl	Eurostat	2001-01	2025-01	2.8	0.2	8.5	1.7	1.6
CP12: Miscellaneous HICP infl	Eurostat	2001-01	2025-01	2.1	0.5	5.4	1.0	1.0
Core HICP infl	Eurostat	2001-12	2025-01	1.7	0.2	5.5	1.0	0.9
Crude oil import infl	Eurostat	2006-01	2023-11	3.6	-108.2	92.9	33.9	42.3
Durable goods HICP infl	Eurostat	2001-12	2025-01	0.4	-1.1	6.8	2.5	0.7
Energy HICP infl	Eurostat	2001-01	2025-01	3.6	-15.2	36.5	9.0	10.7
Energy import infl	Eurostat	2006-01	2023-12	4.3	-78.6	88.8	33.5	43.5
Food HICP infl	Eurostat	2001-01	2025-01	2.9	-0.4	14.4	2.5	1.7
Fuel HICP infl	Eurostat	2001-01	2025-01	2.9	-28.0	38.0	12.1	16.3
Headline HICP infl	Eurostat	2001-01	2025-01	2.1	-0.6	10.1	1.8	1.3
Ind. non-energy goods HICP infl	Eurostat	2001-12	2025-01	1.0	-0.5	6.6	1.3	0.7
Inflation expectations (12 months ahead)	EC	2001-01	2025-01	20.3	-6.8	64.5	10.5	14.3
Känzig shock	Känzig (2021)	2001-01	2025-01	0.0	-3.0	1.9	0.6	0.8
Labour cost index	Eurostat	2002-01	2025-01	2.5	-2.0	5.7	1.2	1.5
NAWRU	EC	2001-01	2025-01	8.4	6.6	9.3	0.9	1.5
Nominal interest rate	Eurostat	2001-01	2025-01	1.5	-0.6	5.1	1.7	3.3
Non-durable goods HICP infl	Eurostat	2001-12	2025-01	1.9	0.2	9.1	1.6	1.2
Output gap	EC	2001-01	2025-01	-0.6	-6.0	2.7	1.8	2.6
Services HICP infl	Eurostat	2001-12	2025-01	2.1	0.4	5.5	1.0	1.2
Unemployment gap	Author calc.	2001-01	2025-01	-0.5	-2.7	2.0	1.2	1.3
Unemployment rate	Eurostat	2001-01	2025-01	7.9	5.4	10.9	1.5	2.1

HICP: Harmonised Index of Consumer Prices, NAWRU: Non-Accelerating Wage Rate of Unemployment, EC: European Commission, EIA: Energy Information Administration, SD: Standard Deviation, IQR: Interquartile Range.

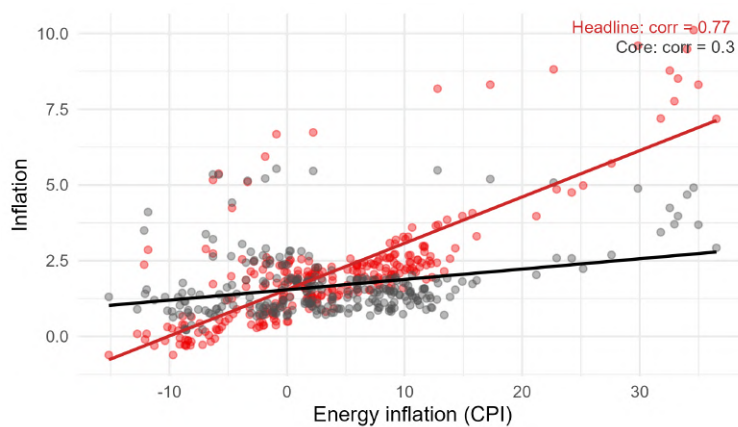
B Supporting Figures and Empirical Evidence

Figure 13. Contributions to headline inflation



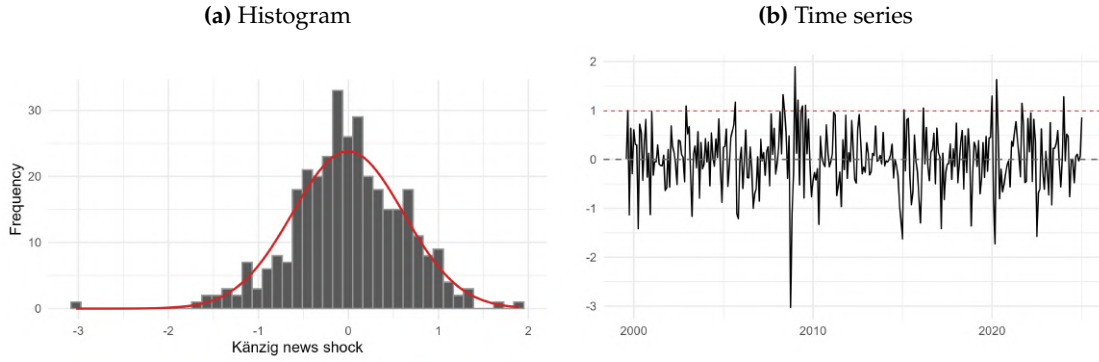
Note: lines show headline and core inflation; bars report percentage-point contributions of each component to headline inflation. Data source: Eurostat.

Figure 14. Correlations of energy inflation with core and headline inflation



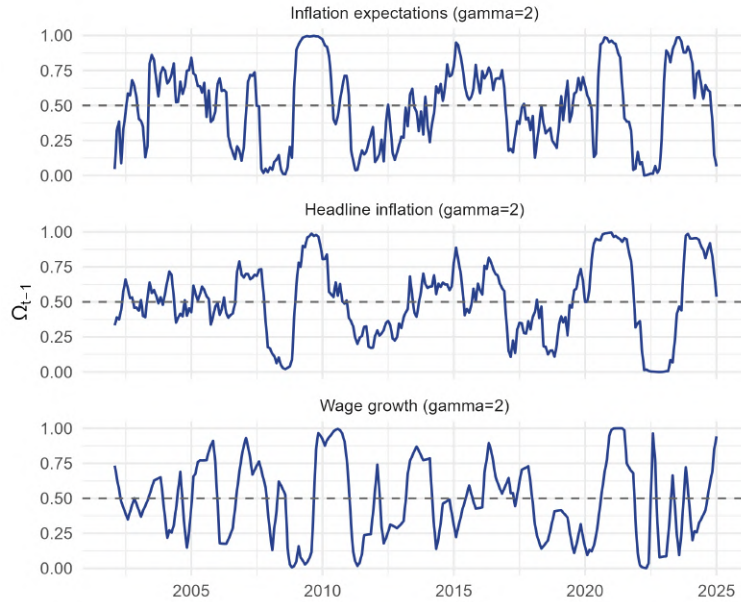
Note: scatterplots of energy HICP inflation against headline inflation (red) and core inflation (black), with linear regression fits; Pearson correlations are 0.77 (headline) and 0.30 (core). Data source: Eurostat.

Figure 15. Properties of the Känzig-shock



Note: Panel (a) The red line is a normal density evaluated at the sample mean and standard deviation of the shock and scaled to the histogram. Panel (b): the red-dashed line marks the one percentage point threshold used to scale the impulse responses reported in the main text. Data source: Känzig (2021).

Figure 16. Estimated transition dynamics: evolution of Ω_{t-1}



Note: Each panel plots the estimated regime weight $\Omega_{t-1} = F(z_{t-1})$ for the corresponding continuous switching variable used in Figure 11. Values near 1 (0) indicate that the low-pressure (high-pressure) regime dominates at $t-1$. The dashed line marks $\Omega_{t-1} = 0.5$, where the two regimes are weighted equally.

C Instrumental Variable Local Projections

To assess robustness to potential measurement error in the Känzig (2021) oil supply news shock, the paper implements an instrumental-variable strategy within a local projection framework following Jordà et al. (2015). Rather than using the Känzig shock directly as an exogenous regressor, the analysis uses it as an external instrument to isolate exogenous variation in alternative measures of energy inflation.

Second-stage local projection. The second-stage equation mirrors the baseline LP specification in Equation (1), with the difference that the energy shock is replaced by an instrumented energy inflation series. For each horizon $h = 0, 1, \dots, H$, the estimated equation is:

$$\pi_{t+h}^C = a_h + \sum_{j=1}^J \rho_{j,h} \pi_{t-j}^C + \sum_{l=1}^L \delta'_{l,h} Z_{t-l} + \theta_h \widehat{\pi}_t^E + u_{t+h}, \quad (5)$$

where π_t^C denotes monthly core inflation and $\widehat{\pi}_t^E$ is the fitted value from the first-stage regression described below. As in the baseline specification, Z_t is the vector of macroeconomic controls and u_{t+h} is an error term. The sequence $\{\theta_h\}_{h=0}^H$ traces out the impulse response of core inflation to an exogenous energy price shock identified through the instrument.

First-stage regression. In the first stage, alternative measures of energy inflation are instrumented using the oil supply news shock constructed by Känzig (2021). For each energy inflation series π_t^E , the first-stage regression is

$$\pi_t^E = \alpha + \gamma \varepsilon_t^E + \sum_{j=1}^J \psi_j \pi_{t-j}^C + \sum_{l=1}^L \phi'_l Z_{t-l} + v_t, \quad (6)$$

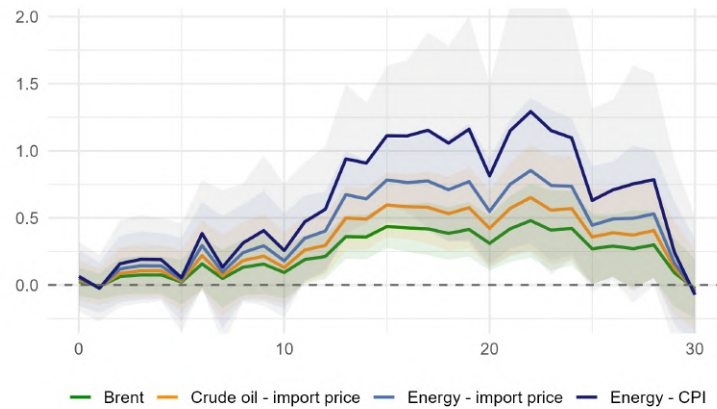
where ε_t^E denotes the Känzig oil supply news shock. The fitted values $\widehat{\pi}_t^E$ are then used in Equation (5). Within the IV local projection framework, this two-stage least squares procedure is implemented separately at each horizon, as in Jordà et al. (2015).

The instrumented energy price measures, π_t^E , include global oil price changes (Brent), crude oil import prices, energy import prices, HICP fuel inflation, and HICP energy inflation. To facilitate comparison across energy price measures with markedly different volatilities (see Table A), all energy inflation series are standardised prior to estimation. Specifically, each series is scaled by its sample standard deviation, such that the reported impulse responses correspond to a one standard deviation increase in the respective energy price measure. This standardisation ensures that differences in response magnitudes across specifications reflect economic transmission mechanisms rather than arbitrary differences in units or volatility.

Results. Figure 17 overlays the impulse responses of core inflation to a one standard deviation shock in each instrumented energy price measure. Because the standardisation changes the units relative to the baseline in Figure 6, magnitudes are not directly comparable across the two and the

focus should be on the shape and timing of the responses. Across all specifications the dynamic shape of the core response is consistent: the effect emerges after roughly one year, peaks near the two-year horizon, and decays thereafter. This consistency strengthens the interpretation of the baseline results, implying that the delayed and persistent transmission to core inflation is not an artifact of any single energy price measure.

Figure 17. Core inflation response (2SLS LP-IV)

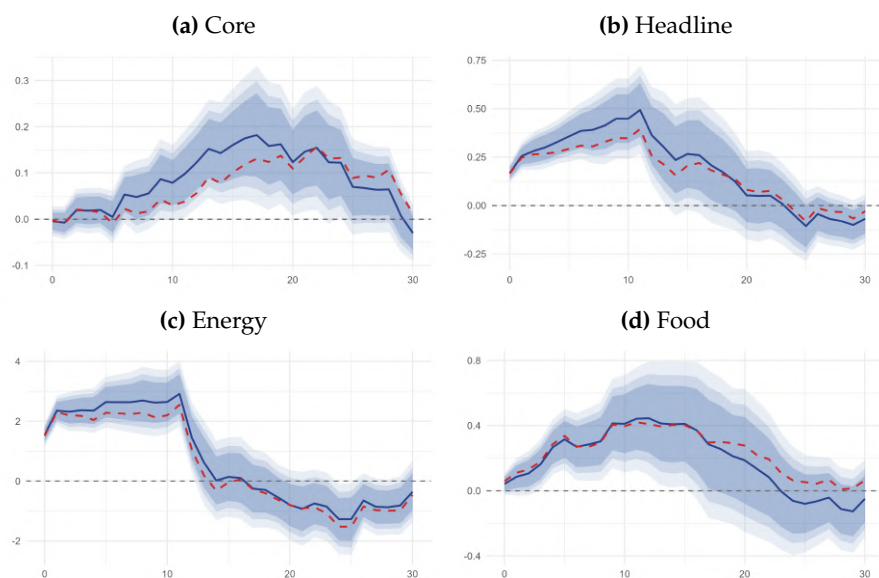


Note: Impulse responses are reported in percentage point deviations from baseline inflation, following a one standard deviation shock. Shaded areas denote 90 percent confidence intervals based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, FRED, Känzig (2021).

Beyond validating the shape of the baseline response, the exercise also yields economically meaningful information about the transmission of global energy prices. The peak core responses to a one standard deviation shock range from roughly 0.40 percentage points for Brent (1.1 percent pass-through) to 1.27 percentage points for HICP energy (14.1 percent pass-through), with intermediate values for crude and energy import prices and HICP fuel. This ordering is intuitive, as global commodity price movements transmit into import prices, which in turn feed into consumer energy prices, with some attenuation at each stage. The differences in peak magnitudes thus appear to be driven by attenuation along the price chain (from volatile global prices to smoother consumer prices), and they illustrate that the choice and scaling of the energy price measure can substantially affect estimated pass-through magnitudes, which may contribute to the dispersion of estimates across the literature.

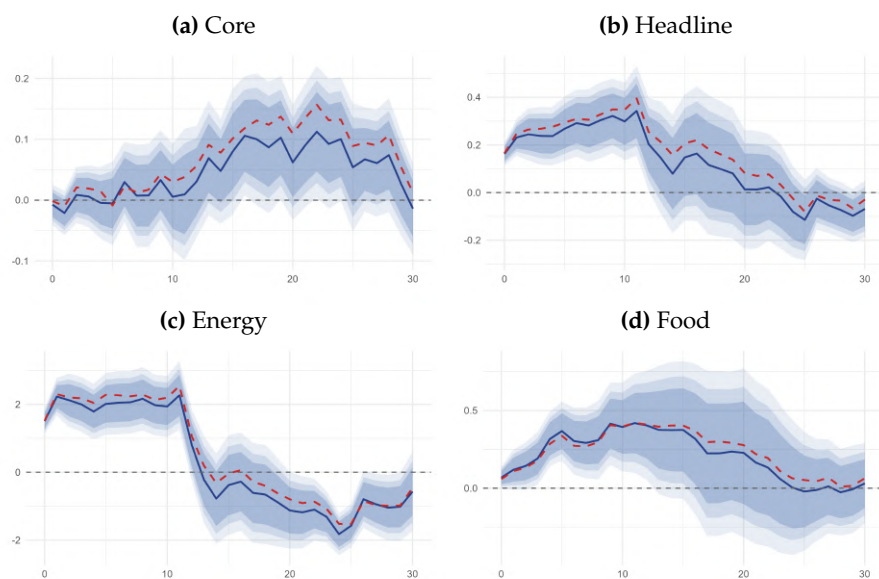
D Robustness of Impulse Responses in the Main Analysis

Figure 18. Responses when interest rate is omitted



Note: Impulse responses are reported in percentage point deviations from baseline inflation after a one percentage point shock. The red-dashed line overlays the core inflation response for scale comparability across panels. Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

Figure 19. Responses when output gap is replaced by unemployment gap



Note: Impulse responses are reported in percentage point deviations from baseline inflation after a one percentage point shock. The red-dashed line overlays the core inflation response for scale comparability across panels. Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

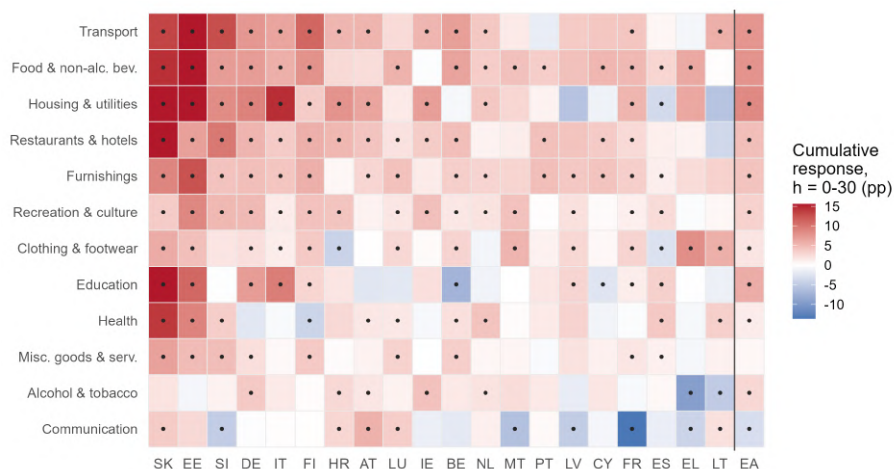
Table 4. First-stage F-statistics across horizons

Horizon	Energy import inflation	Brent price changes	Crude oil import inflation	Energy HICP inflation
0	207.41	200.20	200.79	215.84
1	140.99	127.93	129.95	150.18
2	99.17	83.94	86.63	108.84
3	82.05	65.47	68.83	92.47
4	77.73	58.38	62.59	90.98
5	75.48	53.39	58.10	89.26
6	75.98	51.98	56.79	91.40
7	63.56	42.76	46.64	76.31
8	54.05	37.40	40.20	66.64
9	47.26	32.66	35.26	57.04
10	44.50	30.65	33.02	52.47
11	40.53	28.12	30.28	45.98
12	42.71	30.86	32.91	44.61
13	44.71	33.36	35.27	45.87
14	42.39	32.86	34.73	43.07
15	38.27	30.02	31.62	38.47
16	35.44	28.16	29.65	34.77
17	32.09	26.81	27.69	31.11
18	27.98	24.32	24.91	26.79
19	27.73	25.19	25.58	26.50
20	28.29	26.44	26.87	26.73
21	27.10	26.04	26.20	25.66
22	25.67	25.26	25.25	24.49
23	25.32	25.34	25.13	24.27
24	24.70	25.00	24.72	23.96
25	24.29	24.78	24.49	23.91
26	24.74	25.35	25.03	24.56
27	24.94	25.54	25.28	24.85
28	25.43	25.77	25.60	25.43
29	26.71	26.62	26.60	26.67
30	27.17	27.00	27.00	27.06

Note: All first-stage F-statistics from the instrumental-variable approach described in Appendix C exceed the Staiger-Stock threshold of 10.

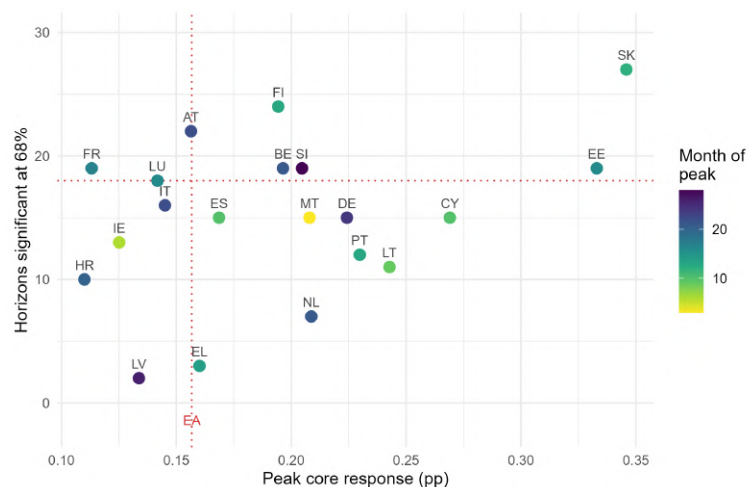
E Breakdown of Impulse Responses into Groups

Figure 20. Pass-through by COICOP division and member state



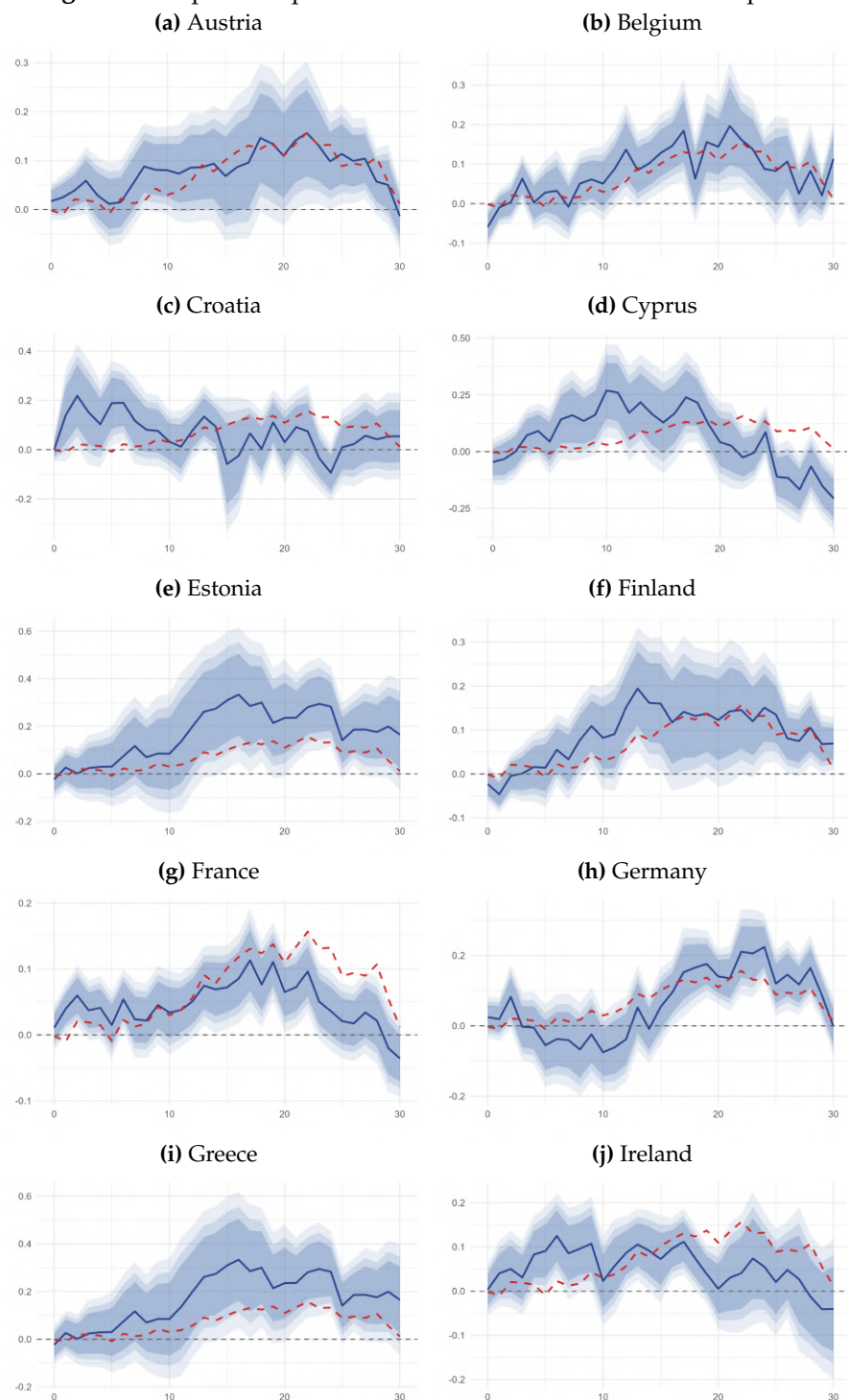
Note: Each cell reports the cumulative response over the 30-month horizon. Dots denote responses significant at the 68 percent level, based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

Figure 21. Peak, persistence and timing of the core inflation response by member state



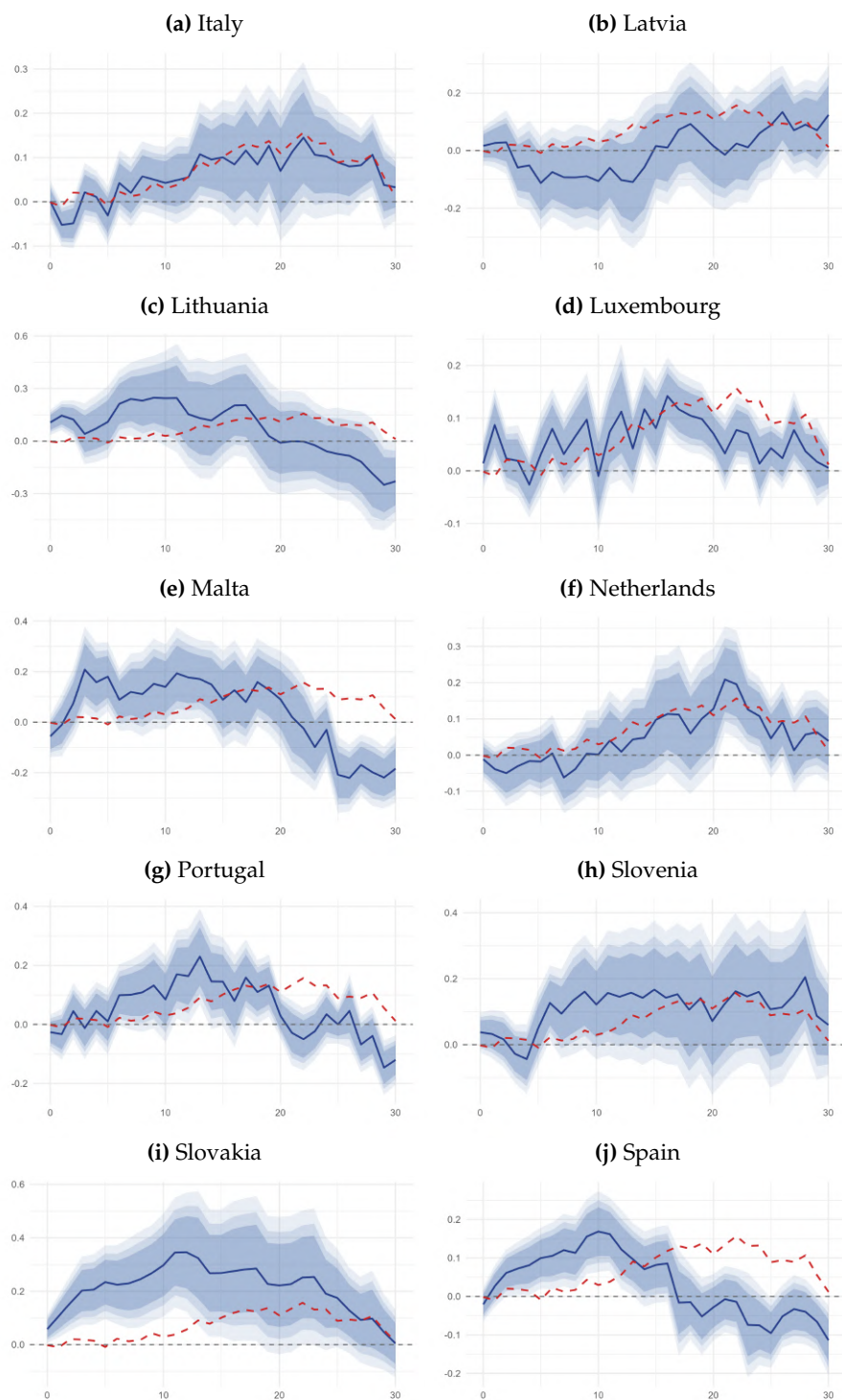
Note: Points shaded by the horizon at which the response peaks. Red-dotted lines mark the corresponding values for the euro area aggregate. Data sources: Eurostat, EC/AMECO, Känzig (2021).

Figure 22. Impulse responses across euro area member states - part 1



Note: The red-dashed line overlays the euro area aggregate core inflation response for scale comparability across panels. Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

Figure 23. Impulse responses across euro area member states - part 2



Note: The red-dashed line overlays the euro area aggregate core inflation response for scale comparability across panels. Shaded areas denote 68, 80, and 90 percent confidence intervals (from darkest to lightest) based on Newey & West (1987) standard errors. Data sources: Eurostat, EC/AMECO, Känzig (2021).

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