Analyse

The Euro Area Great Inflation Surge

Guido Ascari, Paolo Bonomolo, Marco Hoeberichts and Riccardo Trezzi

February 2023

DeNederlandscheBank

EUROSYSTEEM

The Euro Area Great Inflation Surge

Authors: Guido Ascari (DNB, University of Pavia), Paolo Bonomolo (DNB), Marco Hoeberichts (DNB) and Riccardo Trezzi (University of Geneva). We thank Olaf Sleijpen, Niels Gilbert and Mark Mink for comments and suggestions, and Martin Admiraal for data support. All remaining errors are our own.

De Nederlandsche Bank n.v.
Postbus 98 1000 AB
Amsterdam
Internet: www.dnb.nl
Email: info@dnb.nl

1 Introduction

How did inflation get so high, and what are its main drivers? This question is at the center of the academic and policy debate right now. Its answer is crucial for policy-making.

In this note, we propose a narrative of the Euro Area inflation surge, supported by theoretical and empirical analyses. We show why the current debate, often solely focusing on energy prices, has at times failed to appreciate the complexity of what happened: demand and supply both contributed to output and inflation dynamics but their absolute (and relative) contributions have changed over time. The main result of this note is that while price pressures were already building before the natural gas shock, an inflationary impulse in one sector (energy) has quickly become broad based because demand conditions remained accommodative facing the negative supply shock. Our analysis also sheds some light on the 'real time' debate during the inflation surge period, regarding the broad-basedness of price changes, the persistence of the energy shock, and the idea that monetary policy should look-through supply shocks.

The first part of this note presents a narrative of what happened through the lens of an undergraduate textbook aggregate demand (AD) - aggregate supply (AS) model. By considering three phases of the pandemic (the covid shock (phase I), the re-opening of the economy (phase II), and the post re-opening (phase III)), we conjecture how the contribution of demand and supply-side shocks evolved from one phase to the next. Specifically, the behavior of output and inflation appears consistent with (i) aggregate demand experiencing a negative shock in phase I followed by a sequence of positive shocks in phase II and III, and (ii) aggregate supply experiencing a negative shock in phase I followed by a positive shock in phase II and another negative shock in phase III.

In the second part of this note, we show that our narrative is supported by empirical evidence. We show that the distribution of price changes started to shift upward (to the right) in phase II and accelerated markedly in phase III when both demand and supply-side factors contributed to the runup. Also, using a Bayesian vector autoregressive (VAR) model identified with sign restrictions, we show that the contributions of demand and supply evolved in the three phases, as described by the AS-AD diagram. According to our empirical VAR model, inflation in the euro area accelerated during the re-opening because the positive demand shock more than offset the positive supply shock. The VAR decomposition also suggests that in the post-reopening period, inflation surprised to the upside not only because of energy prices but also due to the contribution of additional shocks both on the demand and supply side.

Our results are in line with a growing empirical literature (Shapiro (2022a and 2022b), Gonçalves and Koester (2022), Eickmeier and Hofmann (2022), Cascaldi-Garcia et al. (2023)). The main takeaway of this literature is that the inflation runup in the United States has dynamics more similar to the Euro area than previously

assumed; price increases in both continents have been broad based and the contribution of demand-side factors has been non-negligible. In the last few months, in the United States there are signs that monetary policy is starting to have the intended effects on inflation (as stressed by Fed Chair Powell in his press conference on February 1st, 2023), while this does not seem yet to be the case for the Euro area, where core inflation remains elevated and shows few signs of abating yet.

In the Conclusions, we discuss the implications of our analysis for the dynamics of inflation and for monetary policy.

2. What happened through the lens of a Macro101 AS-AD model

In this Section we interpret what happened to Euro Area (EA) inflation in the last three years with the lens of one of the simplest models in macroeconomics, as taught in first-year undergraduate courses. We distinguish three chronological phases:

Phase I: the covid shock (roughly Q1 and Q2:2020);
Phase II: the re-opening of the economy (roughly from Q3:2020 to Q3:2021)
Phase III: the post re-opening (from Q4:2021 onwards)

2.1 Phase I: the Covid Shock

The Covid shock and the following restrictions are usually interpreted as a combination of a negative supply shock (factories and shops shut down, restrictions on number of workers on the workplace => decrease in productivity) **and a negative demand shock** (lockdowns with households forced at home or voluntary decisions not to consume for risks of infection). A basic AS-AD model[1], shown in Figure 1, helps thinking about the effects on aggregate quantities (GDP) and inflation of the combination of these two shocks.[2] Aggregate supply (S) shifts up and to the left (from S to S'), and aggregate demand (D) shifts down to the left (from D to D'). Net of policy response, the economy moves from point E to point E' and experiences a recession, i.e., a contraction of aggregate output (Q). The effect on inflation (π) is, instead, a priori ambiguous, depending on the relative size of the two shocks.

[1] In undergraduate textbooks, the AS-AD model is most often drawn in the output-price space, but we prefer here to draw it in the output-inflation space. Blanchard's textbook, for example, shows how to go from one to the other.
[2] Of course, the AS-AD model is an elementary model and it abstract from other important factors of the Covid shock as its asymmetric effect across sectors.

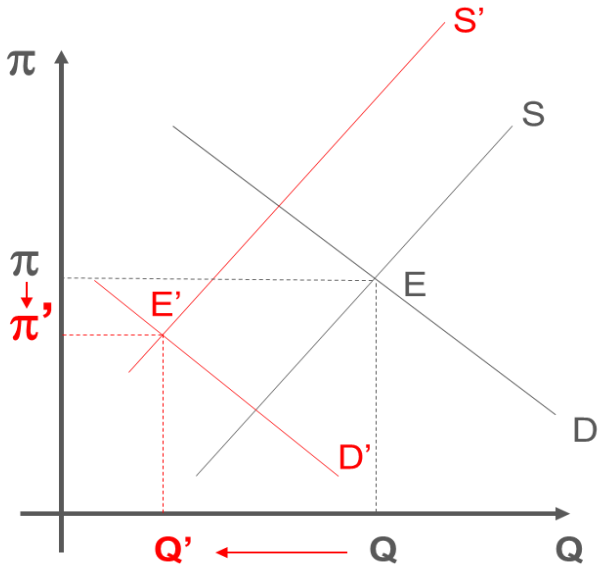

Figure 1. Phase I: Covid Shock

Intepreting the data with the lens of the simple AS-AD model (a recession and lower inflation) suggests that in phase I the negative demand shock was larger than the negative supply shock. During the first months of Covid, European governments shut down the economies and imposed stringency measures. Euro area industrial production contracted sharply. European households were forced to stay at home, aggregate consumption decreased and aggregate savings increased. As a result, Euro Area GDP exhibited an unprecedented fall that exerted downward pressure on prices (see Figure 2), suggesting that in phase I the deflationary effects of the large negative demand shock more than offset the inflationary effects of the negative supply shock.

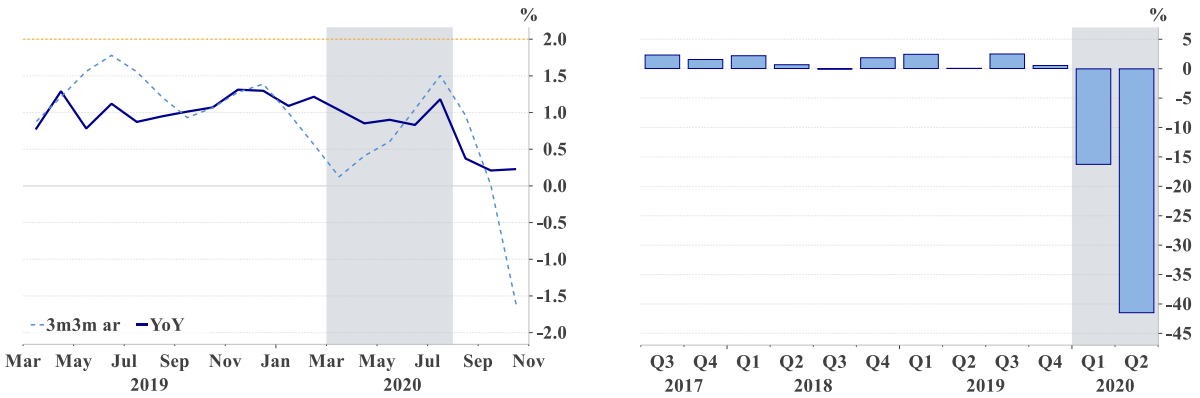

Figure 2. Left panel: Euro Area Core HICP (3m/3m at annual rate calculated on data seasonally adjusted using X-13, and YoY); Right panel: Euro Area real GDP (QoQ ar).

2.2 Phase II: the Re-opening

The re-opening of the economy was characterized by an increase in demand and supply constraints. As a result, output expanded and inflation increased. Aggregate demand, both private and public, expanded sharply in phase II. Private consumption rebounded in the summer, then contracted again in Q4:2020 and Q1:2021, and finally expanded again to reach roughly pre-pandemic levels in Q3:2021. In some dimensions (i.e. retail sales), demand went above pre-Covid levels. Real government consumption also expanded notably in phase II, reflecting the various stimuli that governments put in place to support the economy. In Q3:2021 government final real consumption expenditure for the Euro Area was 5.7% larger than in the pre-pandemic period (source: Eurostat). Investment, on the contrary, reacted more sluggish and stayed below pre-pandemic levels. Monetary policy remained accommodative during this period, since the ECB did not move the key rates. The 10 year ex-ante real government bond rate (calculated using inflation swaps) drifted down to -1.5% from mid-2020 to the end of 2021, while the 2 year was close to -4%. The ECB asset purchase programme (APP) exhibited net asset purchases (with an increase in the envelope between March and December 2020), reinforced by the still operational Pandemic Emergency Purchase Programme (PEPP) launched in phase I (March 2020). As a result, after a quick rebound in Q3:2020, Euro Area GDP stalled but then continued growing and reached pre-pandemic levels in Q3:2021 (Figure 3). Aggregate supply experienced difficulties in coping with the increase in demand, because of global supply chain bottlenecks and intermediate goods and labor shortages. Consequently, the mismatch between demand and supply resulted in upward pressures on prices. The level of real GDP at the end of phase II was comparable to pre-Covid. On the other hand, the 3m/3m (annual rate, ar) of core inflation accelerated from -1.5% to 2.1%, while the YoY increased from 0.2% to 1.9%.[3]

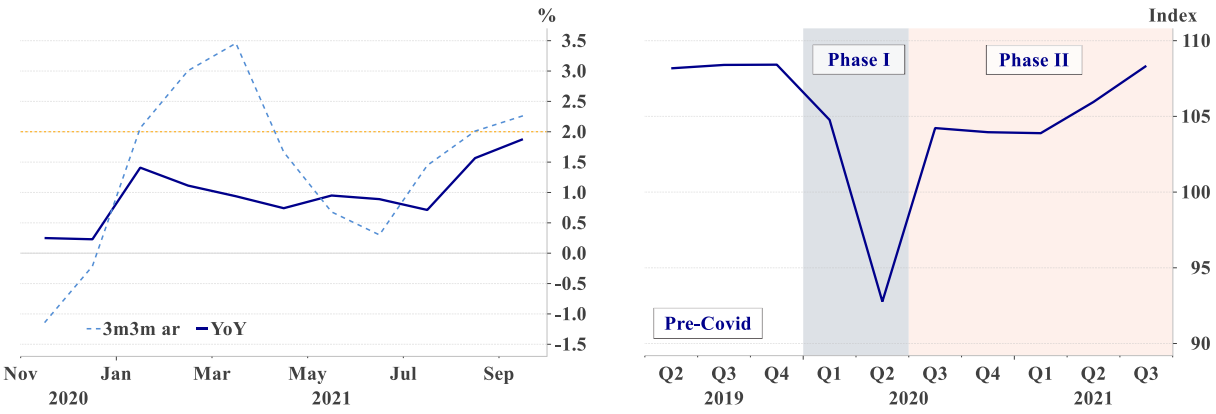

Figure 3. Left panel: Euro Area Core HICP; Right panel: Euro Area real GDP (index)

In terms of the AS-AD diagram, aggregate demand expanded and, at least in some dimensions, went beyond the pre-Covid level (D' to D''). Aggregate supply recovered but remained constrained in several dimensions (S' to S''). The economy moved from

[3] The 3m/3m shown in all figures of this note are calculated on seasonally adjusted data (Census X-13) using the US national accounts way, that is chaining the rolling quarters.

E' to E'', a point associated with output drifting to pre-Covid levels, but with higher inflation.

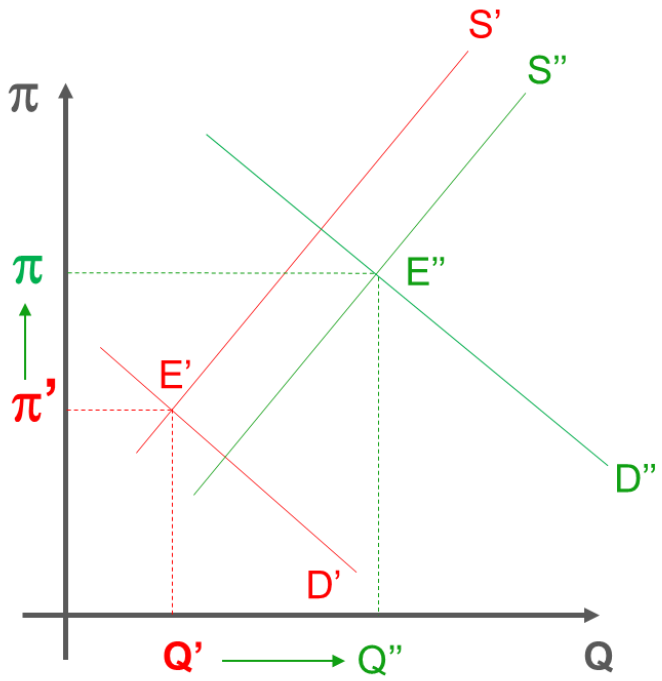

Figure 4. Phase II: The Re-opening

2.3 Phase III: the Post-Reopening

The post-reopening phase experienced an additional negative supply shock and a positive aggregate demand shock, resulting in further price pressures. In phase III, global supply chains recovered and the economies reopened further (i.e., Oxford stringency index close to zero). Households raised their consumption in mid 2022 as a result of pent-up demand and extra savings (as in the US, households' saving rate in phase I and II was almost twice its historical average). On the other hand, firms exhibited a similar pent-up demand, as the positive effect of the easing of the bottlenecks in global supply chain was counterbalanced by the need to replenish the stock of inventories that firms depleted in coping with the demand increase in phase II.[4]

In phase III the Euro Area experienced a region-specific shock. Starting in late 2021, aggregate supply in the Euro Area was hit again by a negative shock, although of a different kind this time: a sharp increase in energy prices. This large shock followed a period of acceleration in global commodity prices. As a reminder, the International Monetary Fund (IMF) global price index of all commodities more than doubled from the trough in April 2020 to October 2021, that is before natural

[4] The inventory cycle led to a strong acceleration in stock building already starting in 2021, possibly reflecting a "bullwhip effect", to prevent further damages from possible future further supply bottlenecks. Given the uncertainty about the supply of inputs, manufacturing firms increase orders of inputs to precautionary pile up inventories.

gas prices started to increase. Then, from February 2022 the Ukraine war led to a further acceleration of energy prices, which hit the Euro Area particularly strongly. The labor market remained tight in the Euro Area, the ratio of vacancies to unemployed increased, and many firms experienced labor shortages, signaling that the supply side of the economy, net of the energy shock, was still somewhat recovering but trudging to keep the pace of demand.

In order to sustain the economy and offset the energy shock, government consumption remained elevated and several governments announced fiscal measures to address the energy bills. In the US, support mainly took place through transfers to households, while the increase in direct government spending net of transfers in the Euro Area in 2021 and 2022 was higher than the one experienced in the U.S (see Figure 5).Aggregate demand today is close to its pre-Covid trend.[5] While the PEPP was discontinued in March 2022, net asset purchases in APP remained positive till July 2022, when the ECB started a steep hiking cycle bringing the main refinancing rate from 0 to 2.5% in December 2022, which ended up being reflected in the dynamics of the real rates.

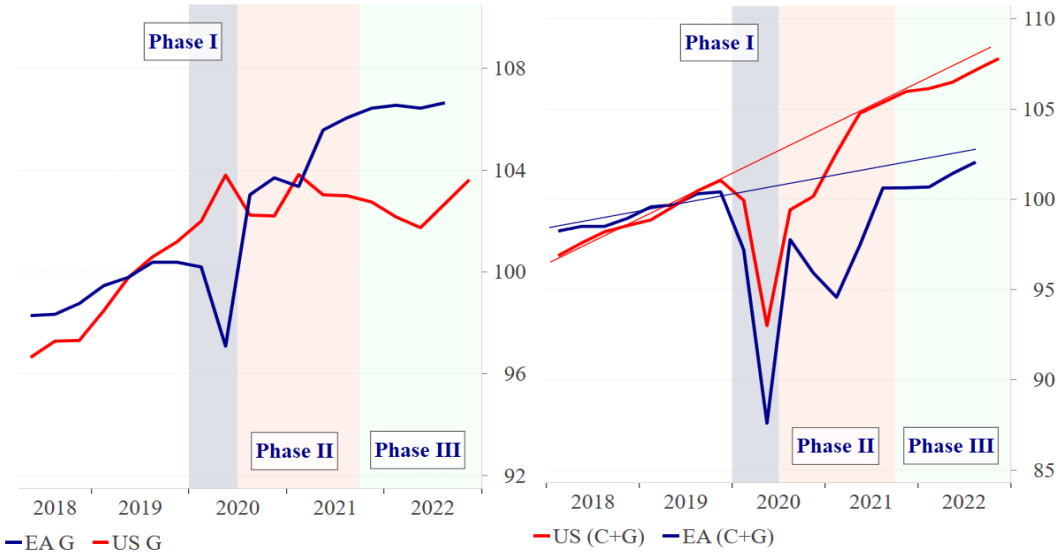

Figure 5. Government (G) and private expenditure (C) indexes (2019=100)

Overall, during phase III output went above the pre-Covid level and inflation accelerated. The level of real GDP at the end of phase III is above pre-Covid (output gap close to zero). The 3m/3m (ar) of core inflation accelerated from 2.1% to 6.1%, and the YoY from 1.9% to 5.2% (see Figure 6).

[5] Aggregate demand in Figure 5 is defined as the sum of government and households' consumption ("G" plus "C" in the GDP formula). Figure 5 shows a linear "trend" interpolating the 2018-2019 quarters. Needless to say, a more appropriate analysis should estimate the "gap", that is the deviation from potential output (which is model sensitive by definition). The latest WEO of the IMF estimates the output gap of both US and EA close to zero at the end of 2022, confirming the evidence from Figure 5.

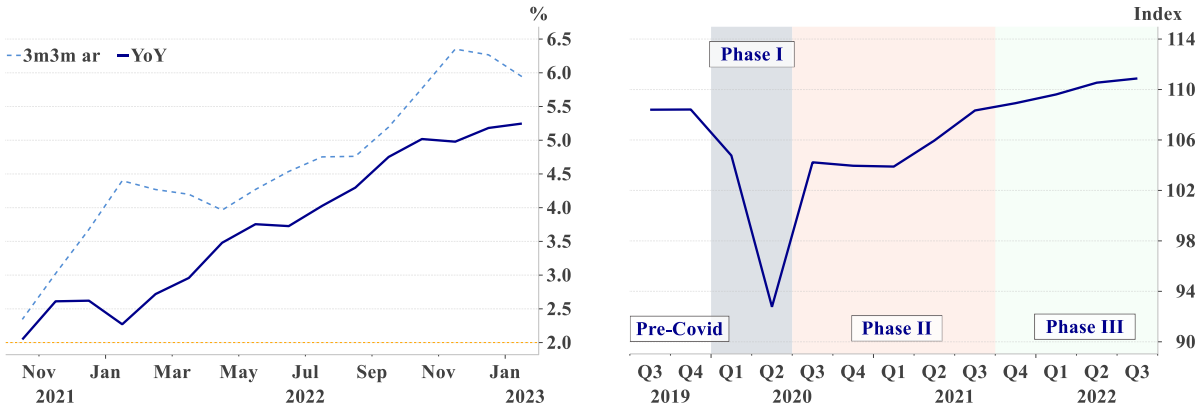

Figure 6. Left panel: Euro Area Core HICP; Right panel: Euro Area real GDP (QoQ ar)

In terms of the AS-AD model, aggregate demand remained solid and expanded from D'' to D'''. Aggregate supply moved up to the left (from S'' to S''') due to the negative energy shock. Overall, the economy moved from E'' to E''', a point with output similar to pre-Covid but with much higher inflation.

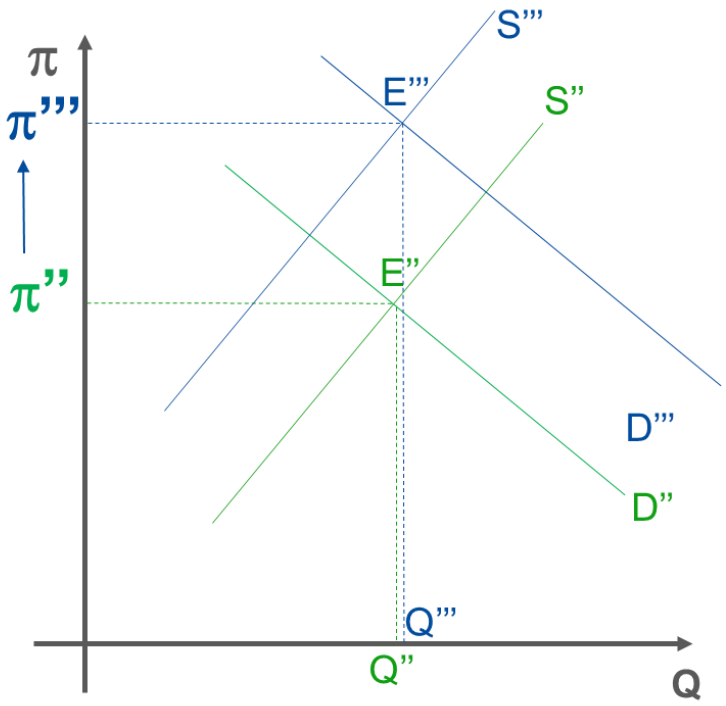

Figure 7. Phase III: The Energy Shock

To sum up, according to our analysis the current inflationary episode is driven by both, demand and supply-side factors. In phase I, the deflationary pressures were demand-driven. In phase II and III, both supply and demand contributed to the surge in inflation. Table 1 below summarizes the three phases and the contributions of demand and supply in each phase.

Table 1. Contributions of demand and supply-side shocks in each phase

Phase		Demand shock		Supply shock		Inflation (eop)
Phase I		Negative (L)		**Negative (L)**	↓	0.2% / -1.7%
Phase II		**Positive (L)**		Positive (S)	↑	1.9% / 2.1%
Phase III		**Positive (M)**		**Negative (M/L)**	↑	6.1% / 5.2%

Note: "eop" stands for "end of period". The column inflation shows the 3m/3m ar (left) and the YoY (right) at the end of the period. A red color indicates the inflationary shocks, a green color the deflationary shocks. The arrows indicate the direction of inflation (decreasing/increasing) in each phase. "L", "M", and "S" indicate the size of the shock (large, medium, and small, respectively).

3. Inflation dynamics in the data

The movements of price changes distributions are consistent with the narrative of our textbook analysis, including the rise and broadening of price increases. Figures 8 and 9 show the distribution of price changes estimated on disaggregated price index series underlying the HICP (COICOP) for headline and core items, respectively. Because the raw series are non-seasonally adjusted, we remove seasonality using the standard Census X-13 method. While each seasonal adjustment procedure delivers a slightly different result, the message of our analysis is unaffected.

Euro area inflation started to increase and broaden in the second half of 2021. It then broadened further in 2022, going well above the 2% target. There are three main takeaways from Figures 8 and 9. First, in H1:2021(the second part of phase II) the distributions of both headline and core inflation were already shifted compared to pre-Covid (when HICP prices run consistently below target) but remained nicely centered around the 2% target with low dispersion. For instance, the average MoM (at annual rate) in H1:2021 was 2.2% for core items. Second, in H2:2021 both distributions started to show signs of broadening, although the shift in core inflation was still limited. In terms of sub-categories (not shown for brevity), in 2021 we observe higher dynamics for durable goods prices and some services, as a reflection of continued supply chain issues and reopening effects. Finally, the last takeaway is that the shift that started in 2021 continued and broadened last year. For headline and core items, the 2022 distributions show an upward shift and an upward tail; the median of price changes increased significantly (to about 7% for headline and 4% for core), as well the price dispersion. As we show in the next section, the shift can be attributed to supply-side factors as well as demand-related shocks.

The evidence of the distributions suggest that the euro area is now facing an episode of persistent inflation. As discussed above, the entire distribution of price changes has shifted upward and it is much more dispersed than pre-Covid. The good news is that in recent months (not shown for brevity), there are tentative signs of stabilization, although the mean/median remain well above target. The recent drop in energy prices is expected to provide some relief to headline inflation. However, unless the distribution of core inflation will start traveling back towards target (ideally with a lower variance around its mean/median) the risk of elevated core inflation in the medium-term is non-negligible anymore.

This Section highlights the importance of monitoring and analyzing the distribution of price changes in real-time. As a reminder, at the beginning of phase III, the policy debate was still about the persistence of this inflation surge with a focus on commodity prices rather than broad based inflationary pressures. In January 2022, DNB staff published an analysis[6] similar to Wolman (2021) using 199 HICP COICOP-series and found that inflation in the Netherlands had become more broad-based since the summer of 2021.[7] This is also the case for inflation in the euro area.

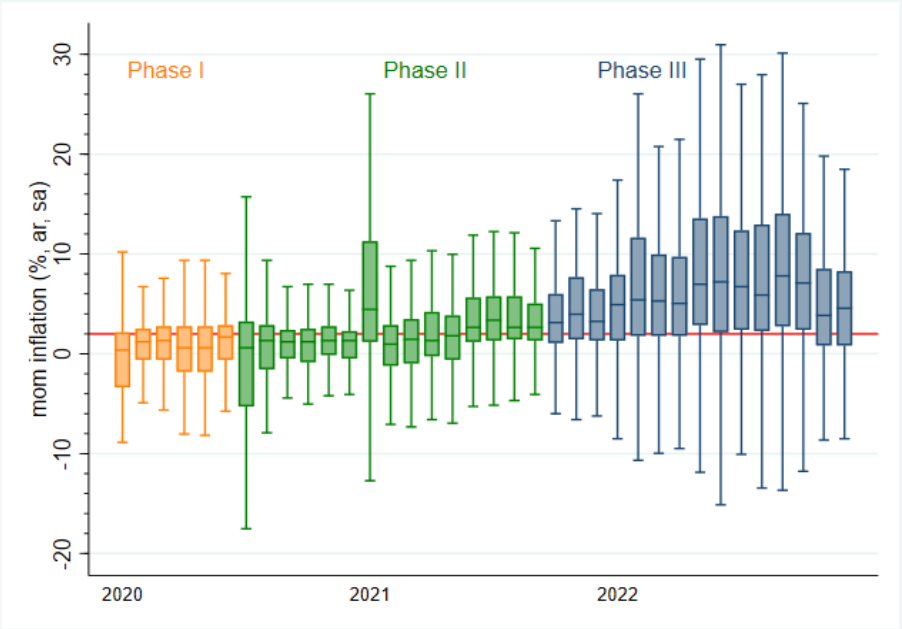

Figure 8. Box plots – headline HICP

Note: the figure shows boxplots of the distribution of MoM (at annual rate) price changes across headline HICP items (for a total of 283 COICOP-series). For each month the box shows the range between the 25th and 75th percentile with the horizontal line indicating the (weighted) median MoM price change. The whiskers show the upper and lower adjacent values at 1.5 times the interquartile range. The spikes in

[6] Inflatie sinds augustus hoger over een breed front - ESB
[7] Wolman (2021) "How Broad-Based Is the Recent High Inflation? (richmondfed.org)" analyzed the distribution of price changes in the US studying the contributions to inflation of items with the largest price changes. Wolman (2021) showed that this contribution was actually decreasing from March to July concluding that *"price increases in July — when inflation fell but was still above the Fed's target — were relatively broad-based."*

variance/mean in July 2020 and January 2021 were driven by the decrease and subsequent increase of the VAT in Germany.

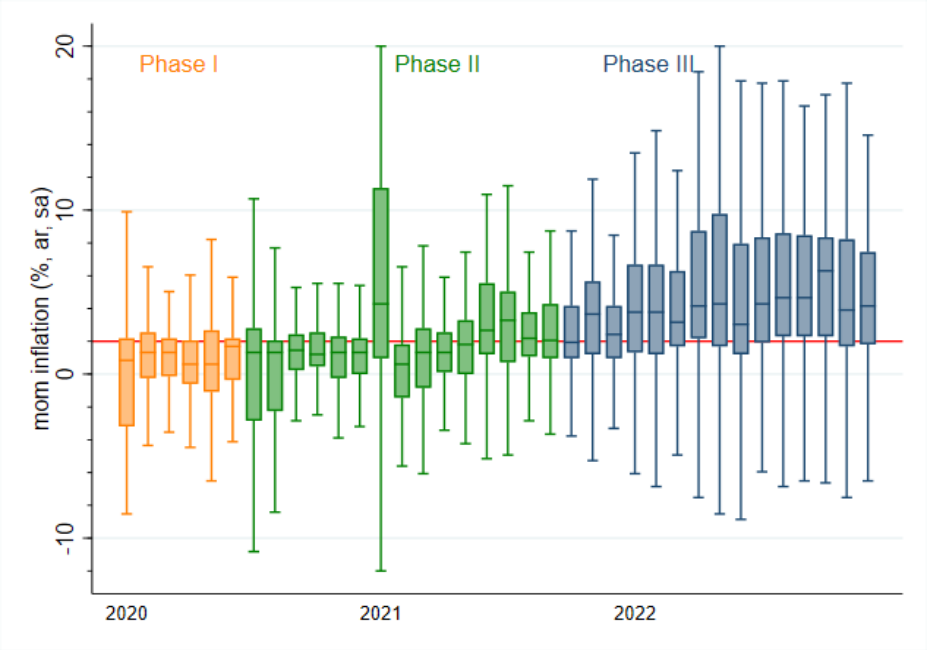

Figure 9. Box plots – core HICP

Note: the figure shows boxplots of the distribution of MoM (at annual rate) price changes across core HICP items (for a total of 199 COICOP-series). For each month the box shows the range between the 25th and 75th percentile with the horizontal line indicating the (weighted) median MoM price change. The whiskers show the upper and lower adjacent values at 1.5 times the interquartile range. The spikes in variance/mean in July 2020 and January 2021 were driven by the decrease and subsequent increase of the VAT in Germany.

4. Inflation dynamics drivers: The role of supply and demand through the lens of a Vector Autoregressive model

We quantify the role of supply and demand in the three phases described in Section 2 using a Vector Autoregressive model (VAR). This approach gives econometric support to the narrative told using the AS-AD framework. The VAR contains 4 variables: inflation (measured as the monthly change in headline HICP), the industrial production index as a proxy for output, the 2 year overnight index swap, and HICP

energy.[8] We use conventional sign restrictions to identify supply and demand shocks: the former move inflation and output in opposite directions while the latter move them in the same direction. Among the supply factors, we also identify an energy shock, that is an exogenous pressure specific to the HICP energy component. The model is estimated using Bayesian methods on data from January 2001 until November 2022 (see Appendix for technical details).

In order to isolate the role of supply and demand factors, we rely on the model forecast errors. The idea is as follows: run the model till time "t", produce the forecast until "t+k", and then compute the forecast error using realized values. Conditional on the information set at time "t", the model forecast errors are generated by unexpected shocks that can be decomposed in demand and supply-driven, according to the relative movements of output and inflation.[9] In this way, for a specific time period, we identify the most important economic drivers that explain the unexpected movements of the variables considered in the VAR.

The results for phase I are reported in Figure 10. Our analysis confirms that the first few months of the pandemic can be interpreted as a combination of negative supply and negative demand shocks (the blue and light blue bars in Figure 10, respectively). A small energy shock also contributes to lower output and higher inflation (the yellow bars in Figure 10). Output contracts as a result of all these drivers, while inflation drops as the demand side more than offsets the supply side shock.

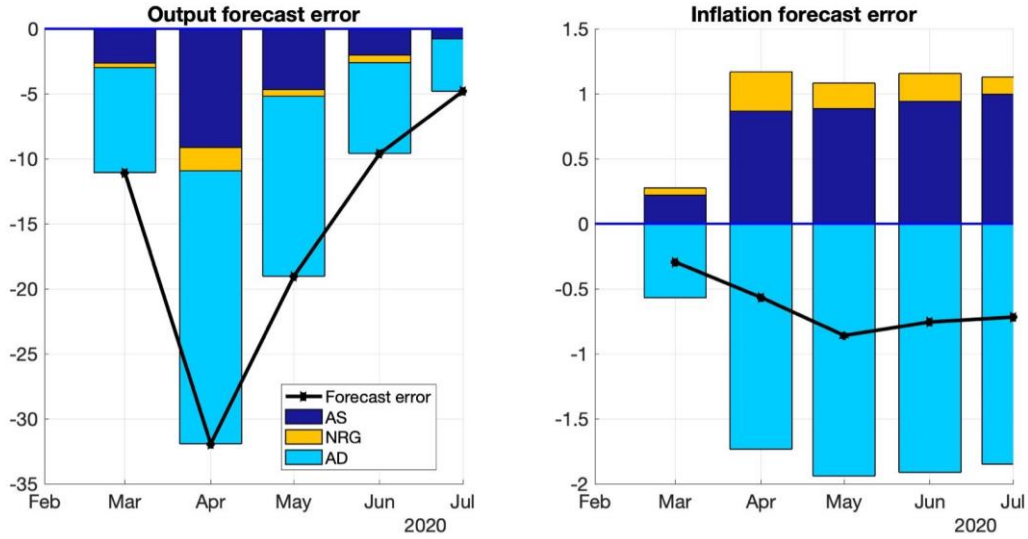

Figure 10. Output and inflation forecast error decomposition, phase I

Figure 11 shows the forecast error decompositions for Phase II. According to the model, the re-opening phase is characterized by positive pressure from demand and

[8] All the variables are expressed at monthly frequency. The movements in the 2 year OIS capture the effects of unconventional monetary policy better than the respective rates at shorter horizon. The inclusion of HICP energy allows us to identify also the specific role of energy shocks.
[9] Since the identification is based on the joint movements in inflation and output, we are going to concentrate on these two variables.

a partial recovery of supply. As described in Section 2, demand factors are estimated to have a strong impact, especially from the beginning of 2021 onwards. Supply recovers but not enough, so that the excess demand puts upper pressure on consumers' prices. Energy prices start putting upward pressure on inflation at the end of Phase II.

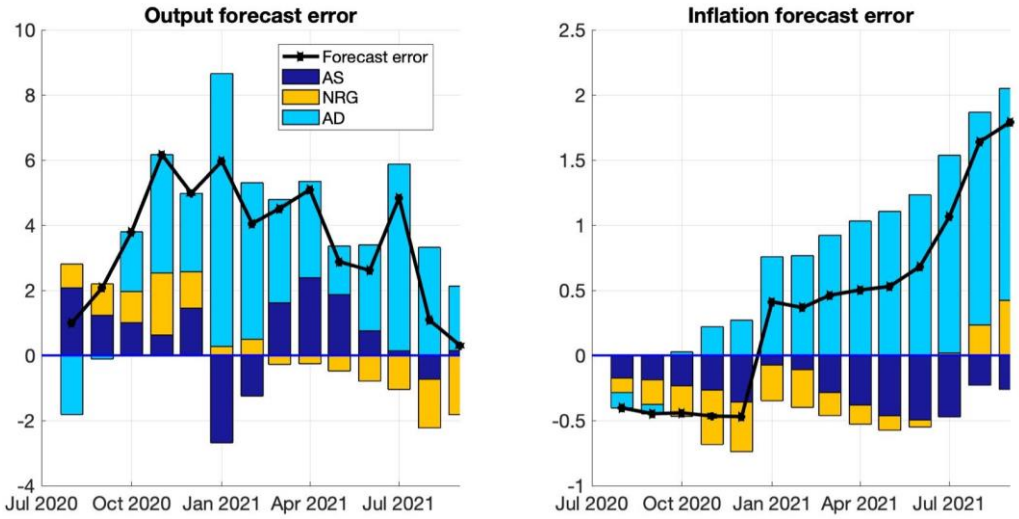

Figure 11. Output and inflation forecast error decomposition, phase II

The VAR shock decomposition of Phase III is shown in Figure 12. The model estimates a positive demand shock, and a negative supply shock with an important contribution of energy. According to the model, net of the demand side, the negative supply shocks would have resulted in a sharp contraction of output (industrial production about 10% lower than observed). The combination of negative supply and positive demand shocks explains why inflation has surprised so much on the upside in phase III.

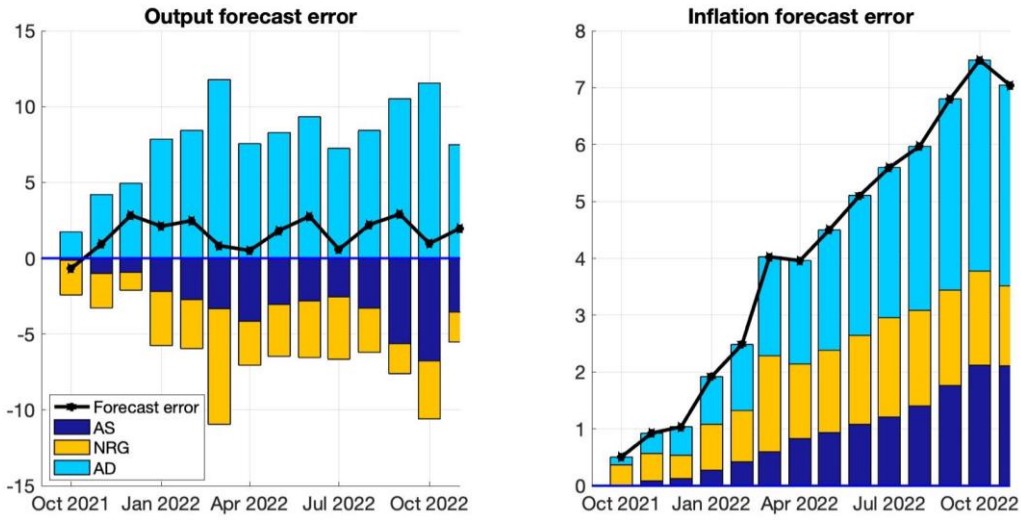

Figure 12. Output and inflation forecast error decomposition, phase III.

The ex-post evidence provides a different perspective on the real-time policy debate which was dominated by the idea that the inflation dynamics were entirely supply-driven and that monetary policy should have looked through temporary supply shocks. The absence of a sharp drop in economic activity suggests that the negative impact of supply shocks was at least partially offset by positive demand developments. The BVAR analysis described above suggests that a major role is played by demand, also in the revision of the forecasts by the model using new data information from July to December 2021. We find that demand factors accounted for 60% of the inflation gap. As the next Section shows, a number of other studies are supportive of the same conclusion.

5. Literature review

Recent literature argues that euro area inflation dynamics are similar to the United States: demand factors are a significant driver, and inflation is broad-based. Starting with Shapiro (2022a), several papers have estimated the contributions of supply and demand factors in the current inflationary episode. The main result of the literature is that the runup in inflation across the Atlantic is more similar than generally perceived. Indeed, demand-side factors have been a relevant driver in both the United States and in the euro area.

The original methodology of Shapiro (2022a and 2022b) is based on standard theory about the slopes of the supply and demand curves. Shifts in demand move both prices and quantities in the same direction along the upward-sloping supply curve, while shifts in supply move prices and quantities in opposite directions along the downward-sloping demand curve. Implementing this concept empirically entails the use of sign-restrictions. According to the latest data, demand-driven factors are contributing as much as supply-driven factors to US inflation, with the former a bit higher in core inflation and the latter unsurprisingly stronger in headline inflation.[10]

The methodology of Shapiro (2022a and 2022b) has been applied to other regions, including euro area countries. For instance, OECD (2022) finds that in France supply and demand factors have contributed equally to headline inflation in 2022 (with similar results for the United Kingdom, Canada, and Australia). ECB staff Gonçalves and Koester (2022) argue that the increase in euro area core inflation starting in the third quarter of 2021 was initially mainly supply-driven, but the importance of demand factors has gradually increased. Over recent months, according to Gonçalves and Koester (2022), supply and demand factors have played broadly similar roles. Furthermore, Andersson et al. (2022) show that while the importance of demand as a driver of core inflation in the euro area has increased more gradually than in the United States, the relative contribution is now higher in the old continent, that is demand factors contribute proportionally more to core inflation.

[10] See San Francisco Fed website for latest data, available here: https://www.frbsf.org/economic-research/indicators-data/supply-and-demand-driven-pce-inflation .

Other studies, using different methodologies have come to similar conclusions. For instance, Eickmeier and Hofmann (2022) employ a structural factor model and a large number of inflation and real activity measures to disentangle the contribution of demand and supply. The estimates of Eickmeier and Hofmann (2022) indicate that the inflation surge since mid-2021 has been driven by a combination of extraordinarily expansionary demand and tight supply conditions in both the US and in the euro area. Cascaldi-Garcia et al. (2023) using a dynamic factor model show that core inflation in the euro area (as well as in other countries) is driven by a "common component" across items, as opposed to idiosyncratic item-specific shocks. They also show that more than half of core items are running above an annual rate of 3% with no signs of disinflation. Finally, Binici et al. (2022) argue that the relative importance of global factors in explaining domestic inflation in the euro area has not increased after the pandemic. Instead, Binici et al. (2022) find that domestic developments have become influential in determining inflation dynamics with greater persistence across the board. In other words, the evolution of aggregate demand at home - they argue - matters more than ever for domestic inflation dynamics.

6. Conclusions

This brief note provides a narrative of the recent inflation surge in the Euro Area, based on a simple textbook AS-AD diagram, backed by empirical evidence.

Inflation was sparked by the reopening of the economy and by supply side constraints. Then, the commodity cycle first, and the Ukraine war afterwards, added to the supply side: a cost-push shock (i.e., increase in energy prices) that firms passed to consumers by increasing prices to preserve their margins. The main take away from our analysis is that this was possible because demand remained sustained for the whole period after re-opening. Pent-up household demand together with fiscal and monetary accommodation resulted in a strong GDP performance but ended up contributing as well to the inflation runup. After all, what happened is nothing but the textbook policy trade-off between growth and inflation generated by a negative supply shock. Having said so, the reader shall not interpret this note as a critique of economic policy at the time. Doing economic policy in real-time is a very difficult task, and, only with the benefit of ex-post insight, it is easy to convey a narrative. Uncertainty was very high at the time, with no clear horizon on how the pandemic would develop; let alone the incidence of the Russian invasion of Ukraine early 2022 and the subsequent energy crisis. Moreover, policy-makers also had to weigh other socio-economic factors. The Euro Area was recovering from a terrifying pandemic that led to unprecedented losses in real activity, households' incomes, and human lives. It was far from clear that the economy would have rebounded so quickly, as well as the fact that such a quick rebound would catch the supply side unprepared. Moreover, the initial surge in commodity prices could have well been transitory without the Ukraine war, such that the debate in the winter of 2021 between the so-

called "camp permanent and camp transitory" made sense, given the renewed constraints driven by the Omicron variant.[11]

What's next? As we write, the January flash HICP report confirms that core inflation is growing at a very robust pace (5.2% at annual rate). January is the 19th consecutive month in which the 3Months-over-3Months (at annual rate) runs above the Year-over-Year (YoY), suggesting there is still some room for the YoY to tick up in the coming months.[12] As for headline inflation, the risks are skewed to the downside, given the fall in energy prices.

In our view, core inflation dynamics risk being persistent. This is no time for complacency for monetary policy. We think the narrative in this note convincingly indicates that it would be a mistake to only focus on the headline numbers. In the next few months, headline inflation will likely moderate due to base effects and lower energy prices. Now, it is time to tackle core inflation, a much harder task, and to push back against excessive second round effects (in terms of inflation expectations and wages dynamics). The distribution of price changes indicates that core inflation is currently centered well above target and that price dispersion is very high. Going forward, convincing signs of disinflation must include a downward shift of the entire distribution and a much lower dispersion around well centered mean/median. Until then, any soft reading driven by a movement of the left tail without a shift of the entire distribution should be interpreted with caution.[13]

[11] See for example, https://www.bruegel.org/comment/inflation-ideology-camp-permanent-or-camp-temporary.
[12] The 3m/3m at annual rate are chained, that is calculated as in the BEA US national accounts statistics.
[13] See also Speech Klaas Knot - "Staying the course" (dnb.nl)

References

Andersson, M., Doleschel, J., Gomez-Salvador, R., Gonçalves, González Pardo, B., E., Koester, G., and Lebastard, L., (2022). " Inflation developments in the euro area and the United States" Economic Bulletin Boxes, European Central Bank, vol. 8. https://www.ecb.europa.eu/pub/economic-bulletin/focus/2023/html/ecb.ebbox202208_01~c11d09d5fd.en.html#:~:text=Published%20as%20part%20of%20the,euro%20area%20since%20July%202022

Arias, J. E., Rubio-Ramírez, J. F., & Waggoner, D. F. (2018). "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications", Econometrica, 86(2), 685–720.

Binici, M., Centorrino, S., Cevik, S., and Gwon, G. (2022). "Here Comes the Change: The Role of Global and Domestic Factors in Post-Pandemic Inflation in Europe", IMF Working Papers, 2022(241), https://www.elibrary.imf.org/view/journals/001/2022/241/article-A001-en.xml

Cascaldi-Garcia, D., Musa O., and Zina S. (2023). "Drivers of Post-pandemic Inflation in Selected Advanced Economies and Implications for the Outlook," FEDS Notes. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/2380-7172.3232

Eickmeier, S. and Hofmann B. (2022). "What drives inflation? Disentangling demand and supply factors" BIS Working Papers, No 1047, November. https://www.bis.org/publ/work1047.pdf

Gomez-Salvador, R., Koester, G., and Ricarte, S. C., (2022). "Recent inflation developments in the United States and the euro area – an update," Economic Bulletin Boxes, European Central Bank, vol. 1. https://www.ecb.europa.eu/pub/economic-bulletin/focus/2022/html/ecb.ebbox202201_01~4bb2c93b96.en.html#:~:text=Looking%20ahead%2C%20the%20degree%20of,2022%20and%201.6%25%20in%202023.

Gonçalves, E. and Koester, G., (2022). "The role of demand and supply in underlying inflation – decomposing HICPX inflation into components," Economic Bulletin Boxes, European Central Bank, vol. 7. https://www.ecb.europa.eu/pub/economic-bulletin/focus/2022/html/ecb.ebbox202207_07~8b71edbfcf.en.html

Heijden, M. van der, Hoeberichts, M., Rutgers, W. and Ascari, G. (2022). "Inflation higher and broad based since August (in Dutch)", ESB 107(4805) Inflatie sinds augustus hoger over een breed front - ESB

Knot, K. (2023), keynote speech at MNI Market News Speech Klaas Knot - "Staying the course" (dnb.nl)

Koester, G., Nordeman, J., and Soudan, M. (2021). "Comparing recent inflation developments in the United States and the euro area," Economic Bulletin Boxes, European Central Bank, vol. 6. https://www.ecb.europa.eu/pub/economic-bulletin/focus/2021/html/ecb.ebbox202106_01~11705a988e.en.html

OECD (2022), OECD Economic Outlook, Volume 2022 Issue 2, OECD Publishing, Paris, https://doi.org/10.1787/f6da2159-en

Shapiro, A.H., "How Much Do Supply and Demand Drive Inflation?" (2022a), FRBSF Economic Letters, No 2022-15, Federal Reserve Bank of San Francisco, June 2022, https://www.frbsf.org/economic-research/publications/economic-letter/2022/june/how-much-do-supply-and-demand-drive-inflation/

Shapiro, A.H., "Decomposing Supply and Demand Driven Inflation", (2022b) Working Papers, No 2022-18, Federal Reserve Bank of San Francisco, October 2022, https://www.frbsf.org/economic-research/publications/working-papers/2022/18/

Villani, M. (2009), "Steady-state priors for vector autoregressions", Journal of Applied Econometrics, Vol. 24, No.4

Wolman, A. L. (2021), "How Broad-Based Is the Recent High Inflation?", Richmond Fed Economic Brief, 21(30), https://www.richmondfed.org/publications/research/economic_brief/2021/eb_21-30

Appendix - The monthly Bayesian VAR

The model

We specify a VAR at monthly frequency for 4 variables: HICP inflation, the industrial production index, the 2 year overnight index swap, and HICP energy. Define Y_t as the vector with the observed variables at time t, and ${Y_t}^E$ as the vector with the corresponding equilibrium values. Then:

$$A(L)\left(Y_t - {Y_t}^E\right) = B\varepsilon_t \quad \varepsilon_t \sim N(0, I)$$

where $A(L)$ is a polynomial in the lag operator L restricted to ensure stable dynamics (we assume 6 lags). Vector ${Y_t}^E$ contains the counterfactual values of Y_t when there are no shocks ε_t hitting the economy.[14] We assume that the equilibrium values are constant steady states for all the variables, except the industrial production index for which we specify a linear trend.

Estimation

Our sample goes from January 2001 until November 2022. The model parameters are jointly estimated using Bayesian methods. We specify a Minnesota type prior distribution for the parameters in $A(L)$ with hyperparameters equal to 0.2 for the overall tightness, 1 for the cross-variable tightness and lag length decay. The prior for the variance covariance matrix is uninformative, and the parameters in B are set-identified imposing zero and sign restrictions using the method by Arias et. al (2018). The prior distributions for the constant steady states are centered around the respective sample mean, with the exception of the inflation rate for which we use a tight prior around the 2% target. Finally, the parameters of the linear trend have a prior distribution centered around the OLS estimate of a linear trend in a simple univariate model.

[14] This approach has been originally proposed by Villani (2009).

Identification

We identify 4 shocks using a combination of zero and sign restrictions as reported in Table A1. All restrictions are imposed on impact.

Table A1: Identification restrictions

	AD		AS	NRG
	Shock 1	**Shock 2**	**Shock 3**	**Shock 4**
HICP	+	+	+	+
Industrial production	+	+	-	-
Interest rate	+	-		
HICPenergy		0	0	+

Shock 1 and Shock 2 move output and inflation in the same direction, so they can be interpreted as demand factors. The main difference between these two disturbances is the response of the interest rate: Shock 2 can be interpreted as a monetary policy shock. However, because during this period monetary policy is conducted with both conventional and unconventional tools, and the exact identification of these effects goes beyond the purposes of this work, we aggregate Shock 1 and Shock 2 under a common "Aggregate Demand"(AD) shock. Shock 3 and Shock 4 move output and inflation in opposite directions, so they represent supply disturbances. The energy cost push (NRG) affects HICP on impact. All the other supply shocks are aggregated as "Aggregate Supply" (AS).