Insights into the Price Puzzle: The Impact of Main Refinancing Operations (MRO) Rate and Unconventional Monetary Policy.

di Georgios Garafas

Abstract

This paper utilizes a Structural Vector Autoregressive (SVAR) model to explore the intricacies of monetary policy and inflation dynamics in the Eurozone. When examining conventional monetary policy, impulse reactions reveal a positive price response to positive interest rate innovations, contrary to theory, thus indicating a "price puzzle." However, the inclusion of commodity prices and exchange rates in the model appears to effectively mitigate this puzzle. Given the European Central Bank's (ECB) extensive use of unconventional monetary policy tools, investigating the impact of external shocks on the ECB's total assets is of particular significance. Notably, when switching to a model where the external shock refers to the ECB's unconventional monetary policy, the inclusion of commodity prices and exchange rates does not appear to be crucial.

Sommario

Questo articolo utilizza un modello autoregressivo vettoriale strutturale (SVAR) per esplorare le complessità della politica monetaria e delle dinamiche di inflazione nell'Eurozona. Quando si esamina la politica monetaria convenzionale, le reazioni impulsive rivelano una risposta positiva dei prezzi alle innovazioni positive dei tassi di interesse, contrariamente alla teoria, indicando così un "puzzle dei prezzi". Tuttavia, l'inclusione dei prezzi delle materie prime e dei tassi di cambio nel modello sembra mitigare efficacemente questo enigma. Dato l'ampio utilizzo da parte della Banca Centrale Europea (BCE) di strumenti di politica monetaria non convenzionali, indagare l'impatto degli shock esterni sulle attività totali della BCE è di particolare importanza. In particolare, quando si passa a un modello in cui lo shock esterno si riferisce alla politica monetaria non convenzionale della BCE, l'inclusione dei prezzi delle materie prime e dei tassi di cambio non sembra essere cruciale.

1. Introduction

This study aims to examine the relationship between monetary policy and inflation in the Eurosystem. It investigates both conventional monetary policies, focusing on the impact of the policy interest rate, and non-conventional measures, particularly the effect of the ECB's balance sheet innovations. To achieve this, the study draws upon the empirical model proposed by Sims (1992).

The influential work of Sims focuses on understanding the relationship between monetary policy and macroeconomic variables. Sims refers to "*the range of our ignorance*" as the dichotomy among macroeconomists regarding whether monetary policy can control nominal interest rates and, consequently, the level of output. He points out that while ISLM theory supports this link, proponents of the real business cycle (RBC) school mainly apply real variables in their models as they believe that nominal aggregate demand and monetary policy do not play a significant role. The primary idea behind ISLM models is that an expansionary monetary policy will raise the money stock and shift the LM curve, thereby lowering interest rates and increasing output. Similarly, a tighter monetary policy appears to precede a recession. However, there are numerous gaps. The evidence may, in many situations, validate the theory, but as Sims (1992, p. 977) notes "*simple co-movements could in principle easily be accounted for a passive response of money demand to changes in the level of activity not generated by monetary policy*".

Sims (1992) employs both a six- and a four-variable VAR model for five countries (France, Germany, Japan, the U.K., and the U.S.) assuming a recursive ordering. He uses monthly data for each country, and to build his six-variable VAR model, he includes the following variables: a short interest rate, a variant of M1, a consumer price index, an industrial production index, a foreign exchange value index, and an international commodity price index common to all countries. The output variable is placed last in his model, while the policy variable is placed first. This ordering is equivalent to the assumption that nominal interest rate innovations impact all other variables contemporaneously, while changes in industrial production, serving as a proxy for output, are affected by all other variables but do not affect any other variable contemporaneously.

Based on the impulse responses extracted from the six-variable VAR model, Sims finds, for all countries, a negative and persistent response of the money stock and output to positive interest rate innovations. Moreover, impulse responses show that in the cases of France and Japan, the price responses to interest rate innovations were strongly positive, a finding that does not fit the monetary/ISLM explanation. This pattern where in VAR models prices appear to react upward to monetary tightening, has been dubbed by Eichenbaum (1992) as a "price puzzle". However, Sims had initially tested a four-variable model without including exchange rates and commodities prices. According to this initial model, the positive and sustained impact of interest rate innovations on price levels appears to occur in all countries and to a greater extent. Hence, the addition of commodity prices and exchange rates ends up giving the model a better fit and significantly addresses the "price puzzle".

After the pioneering work of Sims, many researchers such as Christino et al. (1996) and Sims and Zha (2006) tackled the puzzle by applying commodity price indices to their models. To further explore the effect of interest rate shocks on prices, Rusnak et al. (2013) performed a meta-analysis. Through their quantitative review of impulse responses from 70 articles encompassing 31 countries, they concluded that the puzzle could be attributed to model misspecification, particularly the omission of commodity prices, neglect of potential output, and reliance on recursive identification.

In addition, Estrella (2015) proposes identification restrictions to deal with the puzzle, while Krusec (2010) suggests replacing Cholesky's identification with long-run restrictions. Giordani (2004) attributes the existence of the puzzle to the exclusion of the potential output. Hanson (2004) challenges the "conventional wisdom" that commodity prices can solve the price puzzle in the U.S. He examines alternative indicators but finds a limited correlation between their predictive ability and their ability to resolve the price puzzle. Furthermore, he finds that the evidence of a price puzzle is mainly linked to the period from 1959 to 1979 when even commodity prices failed to resolve the puzzle. Similarly, Demiralp et al. (2014) find that the positive price response remains even with the inclusion of commodity prices and that the price puzzle was more evident before 1982 compared to the later period.

Although setting policy interest rates is the primary instrument of a central bank such as the European Central Bank (ECB), in the past decade, unconventional monetary policy instruments have also been employed. Consequently, there is a growing interest in the ways that the central bank's balance sheet may stimulate the economy (see, indicatively: Burriel & Galesi, 2018; Gambacorta et al., 2014; Garafas, 2024).

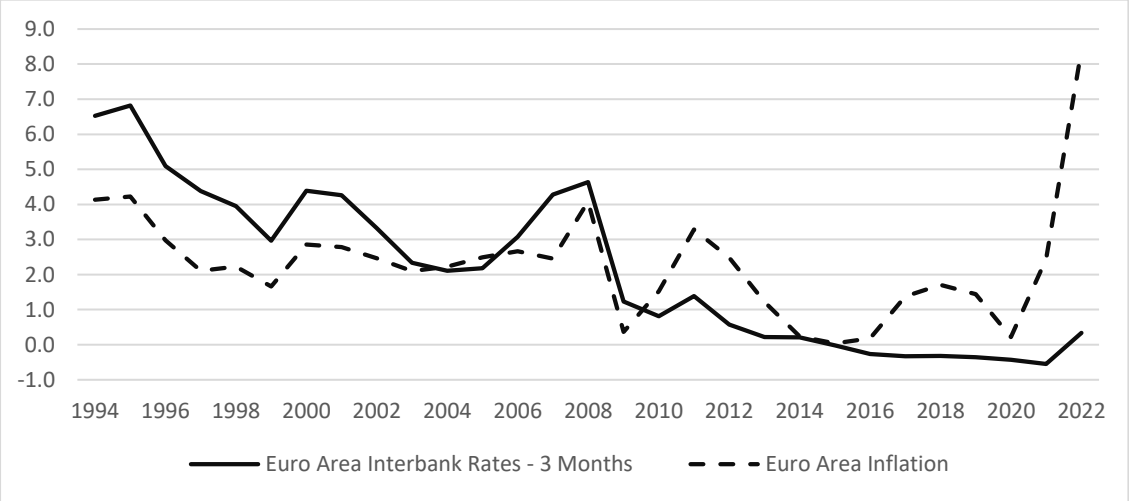
The primary objective of this research is to investigate the presence of the price puzzle in the eurozone. Initially, the influence of the policy rate is examined, based on Sims' (1992) model. The MRO rate holds significant importance as it serves as a vital liquidity injection into the banking sector. It stands as one of the key ECB rates, representing the interest rate at which banks borrow money from the ECB for a one-week period. Additionally, the prior model is modified to investigate the influence of unconventional monetary policy, focusing on the ECB's total assets.

In Section 2, the empirical analysis is outlined, and in Section 3, the main conclusions are presented.

2. Empirical Analysis

Empirical analysis commences by examining the correlation between short-term interest rates and inflation in the Eurozone, as observed in Figure 1.

Figure 1 Inflation and short rates.



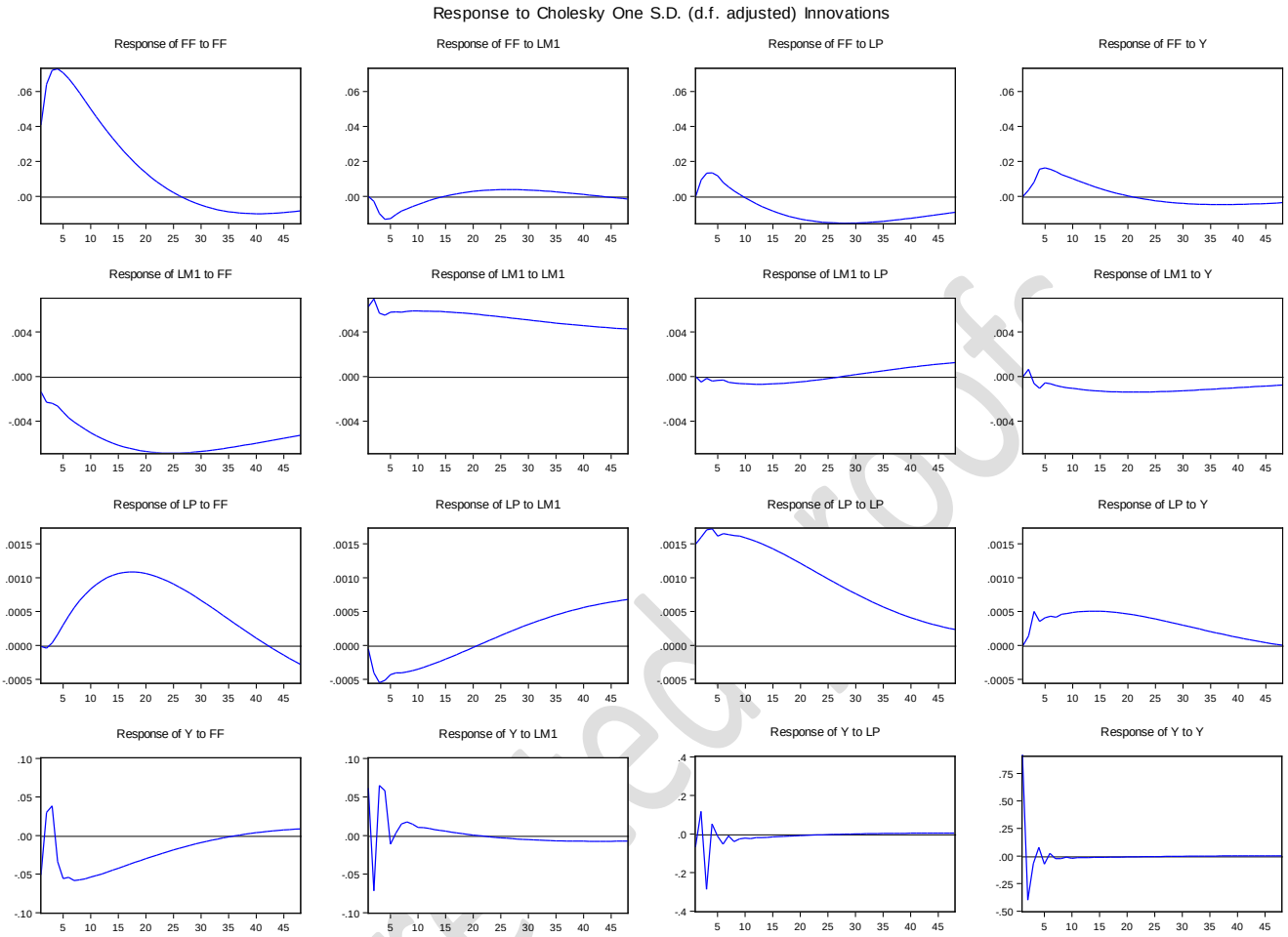
Sources: OECD (Interbank rates), World Bank (Inflation). Retrieved from FRED, Federal Reserve Bank of St. Louis

Monetary policy is endogenous—that is, it responds to changes in other variables—so concluding its effects appears to be difficult. To address this, we employ a Structural Vector Autoregressive (SVAR) model and apply impulse responses to isolate the variables' reactions to an exogenous shock, specifically interest rate innovations, which we assume represent conventional monetary policy.

Based on Sims (1992), we employ both a four- and a six-variable model, following a recursive ordering. The variables, retrieved from FRED (Federal Reserve Bank of St. Louis), comprise the following monthly data: 1) ECB Main Refinancing Operations Rate (ff), Source: ECB, 2) Total Manufacturing for the Euro Area (19 Countries), Growth Rate Previous Period (y), Source: OECD, 3) Consumer Price Index: All Items: Total for the Euro Area (19 Countries) (p), Source: OECD, 4) U.S. Dollars to Euro Spot Exchange Rate (xr), Source: Board of Governors of the Federal Reserve System (US), 5) Global Price Index of All Commodities: Index 2016 = 100 (cp), Source: IMF, 6) M1 for the Euro Area (19 Countries), Euro (m1), Source: OECD. For all variables, we applied logarithms except for interest rates and growth rate proxy for output, which are percentages. The dataset spans from January 2009 to January 2020.

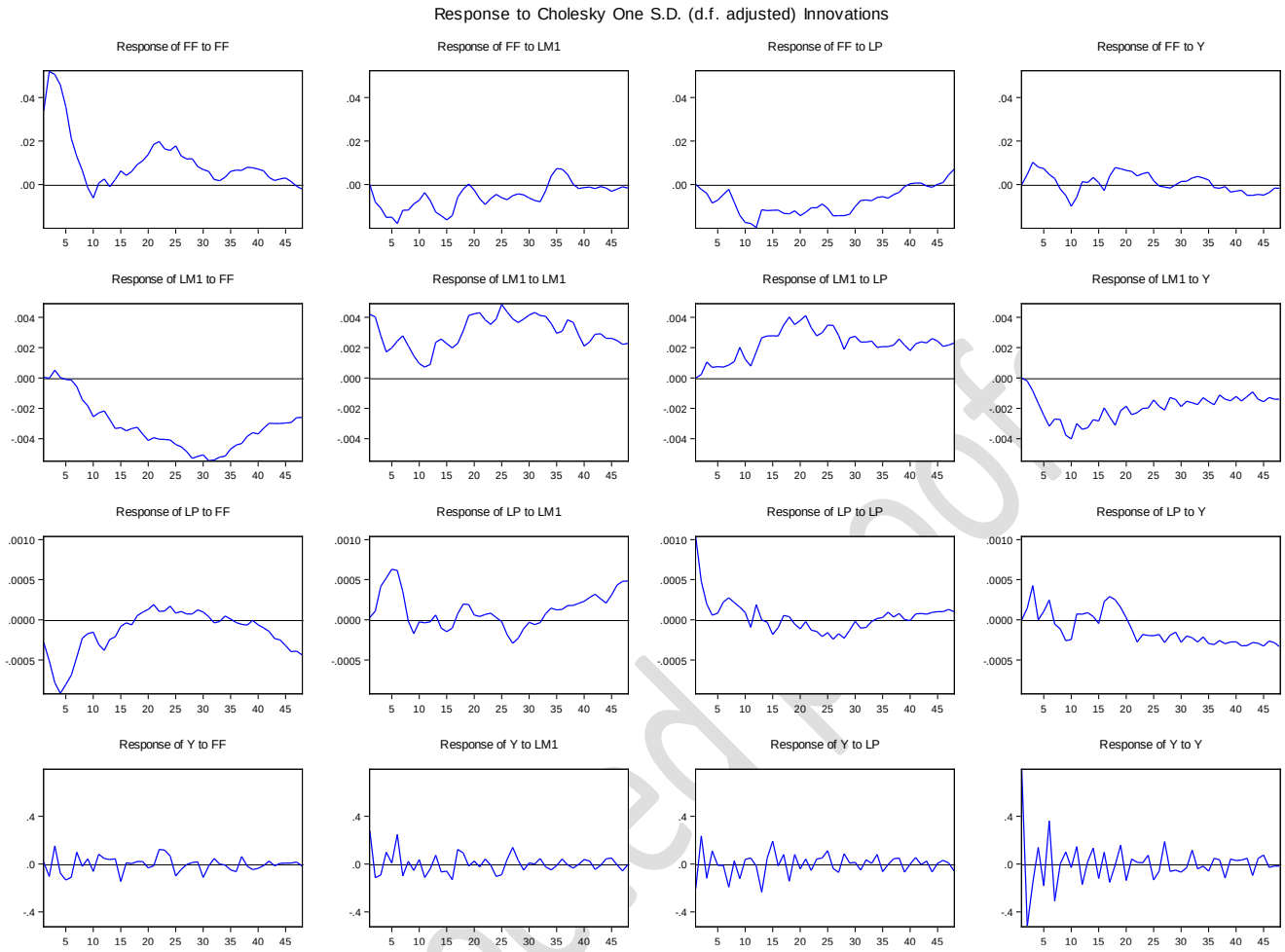
Initially, the four-variable SVAR model is applied, with exchange rates and commodities prices being excluded. The following recursive ordering applies to the model: ff, lm1, lp, y. Like Sims (1992) the output proxy is positioned last, signifying its dependence on other variables without contemporaneously affecting them. On the other hand, the ECB rate is placed first indicating that its innovations impact all other variables contemporaneously. Each variable entered each equation with 3 lags based on AIC criteria. The responses are presented over a 48-month period. Upon observing the impulse responses in Figure 2, we note a persistent negative response of the money stock to positive interest rate innovations and positive responses of prices to this monetary policy shock for at least 40 months. The latter reactions contradict the ISLM theory and suggest the existence of a price puzzle. The plot also illustrates that the responses of the growth rate of manufacturing do not appear persistent and become negative few months after the exogenous shock.

Figure 2 Impulse responses in 4-variable model, conventional monetary policy



We then employ the six-variable model, incorporating commodity prices and exchange rates. Each variable entered each equation with 13 lags based on AIC criteria. Examining the impulse responses (Figure 3) again for a period of 48 months, we observe that price response is closer to the expected, and to a significant extent the puzzle is solved since, especially in the first months the price change is negative. The reaction of money stock is still negative as expected, but the output response in the product is erratic and highly fluctuating.

Figure 3 Impulse responses in 6-variable model, conventional monetary policy

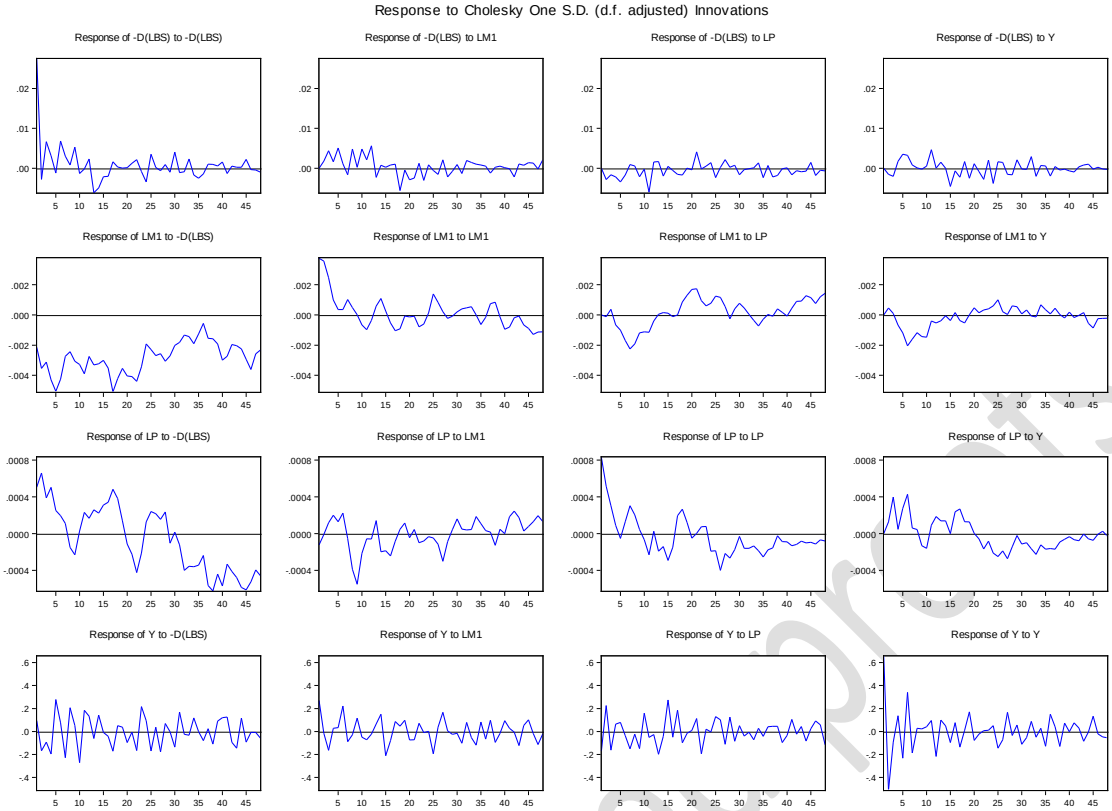


Next, the prior model is being modified by incorporating the log differences of the total assets of the ECB's balance sheet (bs), specifically $\log(bs_t)$- $\log(bs_{t-1})$. Total assets were sourced directly from the ECB. The interest rate is included in the analysis to consider the impact of unconventional monetary policy net of the conventional one. Additionally, a negative balance sheet innovation is assumed in order to assess contractionary shocks.

The seven-variable model employs the following recursive ordering: -dlbs, ff, lxr, lcp, lm1, lp, y. Each variable entered each aquation with 13 lags according to the AIC criteria.

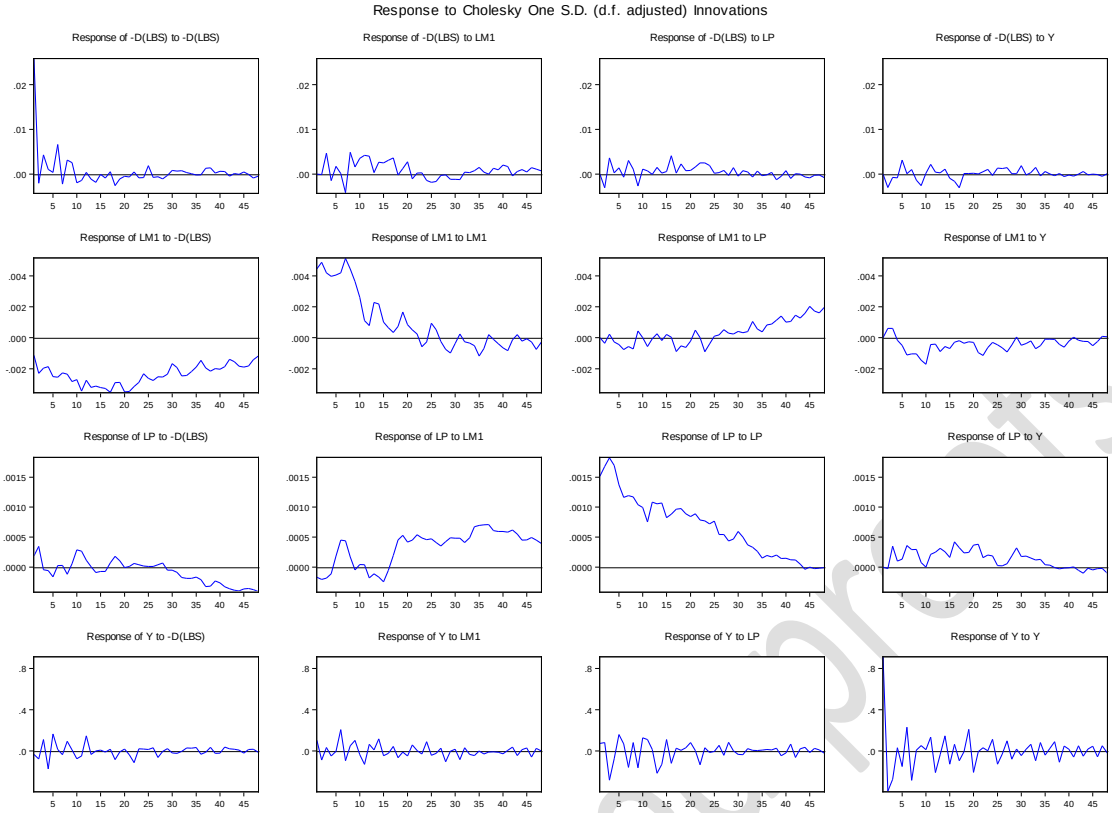
Observing the impulse responses (Figure 4), we notice that the money stock reacts negatively, whereas the output response is erratic and highly fluctuating. These reactions are similar to the results of the six-variable model for conventional monetary policy shock. On the other hand, the price response is highly volatile, becoming consistently negative only in the long run.

Figure 4 Impulse responses in 7-variable model, unconventional monetary policy



Interestingly, if we apply the model without including exchange rates and commodity prices, the impulse responses, as shown in Figure 5, yield almost the same results, with no significant differences in price response.

Figure 5 Impulse responses in 5-variable model, unconventional monetary policy



3. Conclusions

The end of the pandemic and the unexpected energy crisis that ensued caused a spike in inflation in the Eurozone, interrupting its previous declining trend. VAR models are extensively used in studies to understand the impact of monetary policy on prices. However, these models often encounter the so-called "price puzzle." Sims (1992) gives a plausible explanation, indicating that monetary authorities possess information about future inflation beyond what is reflected in historical data used in VAR models. Because they expect inflation to rise, they decide to raise interest rates. Prices may then continue to rise as expected, but not due to contractionary policy. Therefore, VAR models should include information about forthcoming inflation, such as commodity prices.

The empirical analysis undertaken in this study shed insights into the relationship between monetary policy and inflation trends in the Eurozone. The prolonged period of positive price response to monetary policy shocks contradicts conventional economic paradigms and highlights the intricate nature of inflation dynamics. The puzzle is mostly resolved by including exchange rates and commodities prices in the research. Switching to a model where the exogenous shock is the ECB's unconventional monetary policy yields similar results to some extent. However, the inclusion of commodity prices and exchange rates appears to have little effect on these outcomes.

In conclusion, this study contributes to an improved understanding of inflation dynamics using structural VAR models and examining both conventional and unconventional monetary policy. It also provides vital information for policymakers by pointing out the importance of correct model specification to ensure the required exogeneity of the shock.

References

Burriel, P., & Galesi, A. (2018). Uncovering the heterogeneous effects of ECB unconventional monetary policies across euro area countries. *European Economic Review*, *101*, 210-229.

Christiano, L. J., Eichenbaum, M. & Evans. C. (1996). The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds. Review of Economics and Statistics, 78,16—34.

Demiralp, S., Hoover, K. D., & Perez, S. J. (2014). Still puzzling: evaluating the price puzzle in an empirically identified structural vector autoregression. *Empirical Economics*, *46*, 701-731.

Eichenbaum, M. (1992). Interpreting the macroeconomic time series facts: The effects of monetary policy': by Christopher Sims, *European Economic Review*, 36, issue 5, p. 1001-1011.

Estrella, A. (2015). The price puzzle and var identification. *Macroeconomic Dynamics*, *19*(8), 1880-1887.

Gambacorta, L., Hofmann, B., & Peersman, G. (2014). The effectiveness of unconventional monetary policy at the zero lower bound: A cross-country analysis. *Journal of Money, Credit and Banking*, *46*(4), 615-642.

Garafas, G. (2024). Analyzing the balance sheet of the euro area NCBs and the ECB. The impact of securities on inflation and economic activity. *Actual Problems of Economics*, #1 (271), 66-76.

Giordani, P. (2004). An alternative explanation of the price puzzle. *Journal of Monetary Economics*, *51*(6), 1271-1296.

Hanson, M. S. (2004). The "price puzzle" reconsidered. *Journal of Monetary Economics*, *51*(7), 1385-1413.

Krusec, D. (2010). The "price puzzle" in the monetary transmission VARs with long-run restrictions. *Economics Letters*, *106*(3), 147-150.

Rusnák, M., Havranek, T., & Horváth, R. (2013). How to solve the price puzzle? A meta-analysis. *Journal of Money, Credit and Banking*, *45*(1), 37-70.

Sims, C.A. (1992). Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy. European Economic Review, 36, 975-1000.

Sims, C. A., & Zha, T. (2006). Does monetary policy generate recessions?. *Macroeconomic Dynamics*, *10*(2), 231-272.