Assessing the Effectiveness of Unconventional Monetary Policy in the Euro Area

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Abstract

This paper assesses the macroeconomic effects of Unconventional Monetary Policy by estimating a Structural Vector AutoRegression model with monthly data from the Euro-Area. The analysis is carried out over a sample spanning the period since the onset of Quantitative Easing until the beginning of the COVID crisis (2014 - 2019). Our work aims to contribute to the growing literature on this topic, extending the work of other authors by applying their model to contemporary data and checking that the results they found in the past are still valid in our context. We find that an exogenous increase in the Central Bank balance sheet leads to macroeconomics effects which are consistent with the ones assessed by Gambacorta et al.[1] in their analysis: a temporary spike in economic activity and a slightly more persistent rise in price level. We finally check the robustness of our findings by evaluating the same model with different instrumental variables to proxy the output, i.e. Retail Sales and Industrial Production.

1 Introduction

For several decades the main tool used to conduct monetary policy has been the interest rate, a rate that the monetary authority sets for the purpose of influencing other variables of interest in the economy. In response to the Global Financial Crisis of 2008, central banks had to drastically lower the interest rates, reaching near-zero levels, in order to avoid the collapse of the whole system.

When interest rates are extremely low an economy falls into a situation that we commonly refer to as *Liquidity Trap*, where investments stop and people prefer to keep their money liquid due to the low expected Return On Investment. In a regular recession, the central bank would boost the economy by lowering interest rates (Conventional Monetary Policy), so that private banks would have the incentive to lend more money, effectively increasing spending; but when deep recessions happens and interest rates are already at the Zero Lower Bound[1], decreasing them even more does not actually achieve any positive effect on the economy.

In this setting, interest rates became ineffective as a tool to control the economy, leaving the space to different unconventional tools.

[1]We know that in the Euro-Area, interest rates became even negative for a brief period.

In this analysis we analyze the macroeconomics effects of Quantitative Easing, which can be defined as the purchase of assets and securities from the open-market by the European Central Bank. This kind of operations have always been part of the Central Bank conventional approach; what has been unconventional in the recent years is:

- The volume of the acquired assets, which has massively increased since the onset of QE.
- The actual composition of the balance sheet, that includes mortgage-backed securities and long-term Treasury bonds along with other conventional items.
- The announcement of an extended Asset Purchase Program [2] influencing investors' expectations, in particular expected inflation.

As we can see in Figure 1, the balance sheet of the ECB drastically increased since 2014 while its composition changed, mainly due to the increase of *securities of euro area residents denominated in euro*.

In this paper we are interested in assessing the effect of QE shocks on the following macroeconomics variables, collected specifically for the Euro Area:

1. **Output**: we will proxy output with Real GDP in the main analysis and with both Retail Sales and Industrial Production in the robustness check.
2. **Prices**: Harmonised Index of Consumer Prices.
3. **Market Volatility**: we will proxy the volatility with the VSTOXX index, which is designed to reflect the investor sentiment and overall economic uncertainty by measuring the 30-day implied volatility of the EURO STOXX 50.
4. **Unconventional Monetary Policy**: we will use the assets of the European Central Bank balance sheet.

These variables can be seen in Figure 2 where we show the raw data before any transformation. In Section 2 we extensively describe both our dataset and the transformations we applied in order to correctly evaluate the econometric model.

As stated by Gambacorta et al.[1] in their paper:

> "The models that were estimated over pre-crisis period [...] are not suitable for studying the effectiveness of monetary policy in the aftermath of the crisis."

For this reason economists developed different alternative models that can help us analyze the effects of these new monetary policy tools.
In this paper we evaluate a Structural Vector AutoRegression model, as proposed by Gambacorta et al.[1], on a sample starting from 2014, right before ECB officially began Quantitative Easing, and ending in 2019, right before the onset of COVID crisis.

The main issue we need to deal with in our analysis is the disentanglement of the endogenous reactions of the ECB balance sheet from the exogenous monetary policy shifts, which happen as an automatic response to spikes in market volatility. We will identify Unconventional Monetary Policy shocks by using a combination of sign and zero restrictions on the responses of macroeconomic variables to shocks in Central Bank Balance Sheet; this approach is discussed in details in section 2.

We find that our results are similar to the ones reported in Gambacorta et al.[1]; specifically an UMP shock leads to a firm but temporary rise in both Output and Prices. From a more accurate analysis of the results, which are shown in Figure 4, we observe that, while the effect on Prices resets after a little more than two years, the rise in Output is more volatile and fades after one year; finally market volatility drops immediately as expected by the sign restrictions, and fully resets after less than two years.

When compared to Gambacorta et al.[1] IRFs, shown in Figure 5, we assess that our results confirm their findings and our expectations, even if the length of our shocks is slightly higher for what it concerns Prices, Market Volatility and Monetary Policy shocks.

In order to confirm our results we perform two robustness checks in which we use Retail Sales and Industrial Production as a proxy for output instead of Real GDP. The results, shown in Figure 7 and 8, are still aligned with our main findings: we clearly see that the three variables that are kept fixed perform exactly as in our main analysis, while both Retail Sales and Industrial Production show strong spikes after a lagged period which fade away in one to two years.

From these results we can conclude that both our expectations and the findings of other authors can be confirmed in this recent scenario. Unconventional Monetary Policy can easily boost the economy but its effects do not last long, and for this reason it should be considered as a temporary patch to apply in unconventional settings while more in-depth and long-term approaches are to be made in order to maintain and stabilize growth.

2 Methods and Data

Measuring the causal effect of a policy requires monitoring changes in the economic fundamentals to which the policy responds endogenously. Moreover, by using sign restrictions and zero contemporaneous effect restrictions, we can go further because we are able to "refine" these shocks identification. The use of a Structuralized Vector AutoRegression model is intended to correctly identify causal relationships among the regressors. Finally, we can measure and analyse the effects of these shocks through the impulse response functions.

When studying the effects of a monetary policy shock on a particular variable over time, it is necessary to take into account any other fundamental economic factor that could also have an impact on that variable: the VAR approach allows us to control these effects. The second argument in favour of using a VAR model is that we can better understand how our variables of interest, in this case Real GDP and CPI, are affected. In other words, we can explore the effects in a dynamic way, thus identifying the main intermediaries to the responses.

In order to understand the intuition of SVAR models, let's consider a set of n endogenous variables following a VAR model (1) of the type:

$$y_t = Ay_{t-1} + \varepsilon_t \tag{1}$$

where

- y_t is a $n \times 1$ vector of endogenous variables.
- A is a $n \times n$ matrix of coefficients.
- ε_t corresponds to the error term which is a $n \times 1$ vector of stochastic components with zero mean, zero autocorrelation, and constant variance.

In this setting, the variance-covariance matrix of the error-term is:

$$\Sigma = \mathbb{E}[\varepsilon_t \varepsilon_t'] \tag{2}$$

The representation above corresponds to the reduced form representation of a VAR model.
In this kind of model all variables could be endogenous and dependent on each other; this situation, however, present a serious drawback: we are not able to explain how endogenous variables react to each other in the system; in other words, we can not identify a causal relationship between the variables.
In a simpler model, in which the shocks ε_t between the equations of the system are orthogonal, we would easily interpret causal dynamics; but in this more complex case, the reduced-form shocks are cross-correlated.

It is clear that macroeconomic and financial variables are inherently endogenous between them; nevertheless this representation does not allow us to model the contemporary relationships between them. This therefore motivates the use of a structural VAR framework (SVAR).

The structural form of our VAR model, with contemporaneous dependencies, can be rewritten as:

$$Y_t = B_0 Y_t + B_1 Y_{t-1} + \varepsilon_t \tag{3}$$

In which we identify, with the matrix B_0, the contemporaneous effects that our variables have on each other.
We can retrieve its reduced form as follow:

$$\begin{aligned} (I - B_0 Y_t) &= B_1 Y_{t-1} + \varepsilon_t \\ B_0^* Y_t &= B_1 Y_{t-1} + \varepsilon_t \\ Y_t &= B_0^{*-1} B_1 Y_{t-1} + B_0^{*-1} \varepsilon_t \\ Y_t &= A Y_{t-1} + \mu_t \end{aligned} \tag{4}$$

where $B_0^* = I - B_0$, $A = B_0^{*-1} B_1$ and $\mu_t = B_0^{*-1} \varepsilon_t$

In this case the variance-covariance matrix becomes:

$$\Sigma_\mu = \mathbb{E}[\mu_t \mu_t'] = B_0^{*-1} \mathbb{E}[\varepsilon_t \varepsilon_t'] B_0^{*-1'} = B_0^{*-1} B_0^{*-1'} \tag{5}$$

The definition of the structural parameters B_0^*, B_1 and ε_t could be computed in two different ways:

1. Using a *Cholesky decomposition* of the reduced form variance-covariance matrix Σ_u[1].
2. Imposing specific short-run or long-run restrictions derived from theory [2].

To better understand the way in which the algorithm we used impose sign restrictions, let us start by writing a reduced form VAR (1) in its moving average representation:

$$Y_t = \sum_{i=0}^{\infty} \phi_i u_{t-i} \tag{6}$$

where ϕ captures the impulse responses, $\phi_0 = I$ and $\phi_i = \sum_{j=1}^{i} \phi_{i-j} A_j$.

Using a *Cholesky decomposition* we can find a matrix P such that $\Sigma_u = PP'$, and we can rewrite (6) as :

$$Y_t = \sum_{i=0}^{\infty} \phi_i P P^{-1} u_{t-1} = \sum_{i=0}^{\infty} \psi_i P^{-1} u_{t-1} \tag{7}$$

where $\psi_i = \phi_i P$.

Computing the structural variance-covariance matrix we find:

$$\begin{aligned} \Sigma_\varepsilon = P^{-1} E(u_t u_t^{'}) P^{-1'} &= \\ P^{-1} \Sigma_u P^{-1} &= \\ P^{-1} P P^{'} P^{-1'} &= I \end{aligned} \tag{8}$$

[1] Originally suggested by Sims, (1980)[6]
[2] See e.g. Blanchard and Quah, 1989 [7]; Galì, 1992 [3]

While the *Cholesky decomposition* imposes a recursive structure in the VAR, in our case we want to impose specific restrictions on the signs of ψ_i over a specific horizon i in order to identify structural shocks; hence we do not proceed to exactly identify the matrix B_0^*, because different orthogonalizations of the reduced form models could potentially be consistent with the required sign restrictions.
Note that in order to obtain different orthogonal representations of the impulse responses of our VAR model (6), we can multiply $\psi_i = \phi_i P$ by a random matrix Q such that $Q'Q = I$, since then it would still holds that:

$$\Sigma_\varepsilon = E(Q'P^{-1}u_t u_t^{'} P^{-1'} Q) = I \tag{9}$$

Given the theoretical framework explained above, the algorithm works by repeating the following steps a fixed number of times (in our case we computed 5000 draws):

1. Estimates the reduced form VAR.
2. Evaluates the orthogonal IR $\widetilde{\psi_i}$ by computing both P and a random Q to multiply the standard responses ϕ_i.
3. Check whether $\widetilde{\psi_i}$ fulfill the sign restrictions imposed and, if true, it saves the results.

At the end the results are aggregated in a statistical representation, with mean and confidence bands, as shown in Figure 4.

When both zero restrictions and sign restrictions are imposed, the identification algorithm we implement thanks to the *ZeroSignVAR* [4] library, follows Arias et al.(2018)[5] methods constructing the matrix Q recursively. The recursive construction of Q allows to obtain an orthonormal matrix which also ensures that the transformed impulse responses ($\widetilde{\psi_i} = \phi_i PQ$) are zero where required.

Moving now to the data, as mentioned above, the vector of endogenous variables $Y_{i,t}$ comprises four variables:

1. The log of seasonally adjusted real GDP for the Euro Area in differences.
2. The log of seasonally adjusted Harmonised Index of Consumer Prices for the Euro Area in differences.
3. The log of seasonally adjusted European Central Bank assets and liabilities in differences.
4. The levels of implied stock market volatility (VSTOXX[3]) of the EURO STOXX 50

All the series have been tested for the presence of a Unit Root and the null hypothesis has been rejected. The number of lags for the SVAR (1) was chosen through the Akaike Information Criterion.

The data have been gathered from the ECB Statistical Data Warehouse[4] with the exception of VSTOXX that has been retrieved from its official source, the Eurex[5].

To maintain a fair level of interpretability of the model we chose to work with monthly observations; for this reason different transformations have been applied to the data in order to obtain a coherent dataset.

We calculated monthly Real GDP, from a quarterly time-series, through the *Chow-Lin temporal disaggregation method*, using Retail Sales and Industrial Production as references[6].
For what it concerns the VSTOXX, which is a daily index, we computed the standard deviation of the values within a month and divided it for the number of observations in that month (10), obtaining a monthly aggregated value.

$$VSTOXX(M_k) = \frac{STD(VSTOXX_{M_k})}{\#\, Days\, of\, M_k} \tag{10}$$

Lastly HICP and ECB balance sheet are already available as monthly data.

While the dynamics of aggregate output and prices are supposed to capture the macroeconomic dimension, the Central Bank assets represent our proxy for the (unconventional) monetary policy instrument: that is because they can be seen as an assessment of the overall "stock effect" of Central Bank Balance Sheet policies on the macroeconomy, as stated by Gambacorta et al. [1]:

> "With the reaching of the lower bound of policy rates and the widespread adoption of unconventional monetary policies, interest rate rules have implicitly been replaced by quantitative reaction functions in the spirit of McCallum (1988), where the main policy instrument is a quantitative aggregate."[7]

[3]This index is designed to reflect the market expectations of near-term up to long-term volatility by measuring the square root of the implied variance across all options of a given time to expiration.

[4]https://sdw.ecb.europa.eu

[5]https://www.eurex.com/ex-en/markets/vol/vstoxx

[6]link to Chow-Lin Method

[7]Gambacorta et al. (2012)[1]

Finally, we include the VSTOXX for its ability to be an indicator of financial market risk aversion and because it should also capture the shocks to uncertainty that are likely to be an important driver of macroeconomic dynamics.

Failing to take into account the endogenous reaction of Central Bank Balance Sheet to financial turbulence and economic uncertainty could seriously bias the estimation results. For example, our model could potentially attribute the fall in output and prices to the increase in central bank assets although it was driven by the rise in risk aversion and financial market instability.

As Gambacorta et al. (2012) [1] affirms, an Unconventional Monetary Policy shock is identified as an exogenous innovation to the central bank balance sheet. Isolating exogenous balance sheet shocks involves making identifying assumptions to estimate the parameters of the feedback rules which relate Central Bank actions to the state of the economy.

This leads us to the solution of the identification problem: we are going to impose zero and sign restrictions on our model.

1. We assume that there is a contemporaneous zero effect of shock to Central Bank Balance Sheet to both Output and Prices.
2. We assume that an expansionary Unconventional Monetary Policy shock does not increase stock market volatility.

Quoting from Gambacorta et al.[1]

> "This restriction is needed in order to disentangle exogenous innovations to the central bank balance sheet from their endogenous response to financial turmoil, and from financial market disturbances."

The sign restriction reflects the notion that unconventional monetary policies have the effect of mitigating concerns about financial and economic instability captured by stock market volatility. Indeed there is widespread agreement that unconventional monetary policy actions were crucial to mitigate the tail risks of a financial meltdown[8].

3 Results

Figure 4 shows the results we obtained from our SVAR model.

The impulse response function of UMP shows that the shock is defined by an increase of ECB balance sheet which ranges from at least 0.2% to 1.4% and which fades out after 20/25 months.
As expected from the imposed sign restrictions, VSTOXX falls immediately by a minimum of 1% to 6% before resetting after almost 15/20 months.
The responses of both Output and Prices indicate that Unconventional Monetary Policy measures are effective in supporting the macroeconomy by displaying a significant increase: Prices increase by a minimum of 0.005% to a maximum of 0.01%, completely fading out after about three years while Real GDP shows a small peak of a minimum of 0.0005% to 0.005% after a couple of months which fades after just one year.

When compared to our benchmark, the findings of Gambacorta et al. [1] shown in Figure 5, we can see that our results actually confirms their analysis and our expectations.

One of the main differences between unconventional and conventional monetary policies that Gambacorta et al. [1] spotted in their analysis was the temporal impact on prices: while existing evidence on the transmission of conventional monetary policy shocks on price level is found to be very sluggish with a peak only after about two years (or even later), their study found a temporary significant effect with a peak coinciding with that of the output response. Nevertheless, they were reluctant to affirm that without further studies evidences:

> "At this stage, it is not possible to pin down whether this difference is the result of the relatively short sample period of our analysis."

From figure 4 we can clearly observe how the peaks of prices and output in our analysis are indeed contemporaneous too, hence adding little evidences to the state of the art of Unconventional Monetary Policy.

The main difference that can be found, instead, is represented by the magnitude of the shocks of Output which are smaller[8] by a factor of almost 10^{-2}. We suppose this could be explained by the uniqueness of the Euro Area and its heterogeneity of responses among nations, a difference that could have been significantly brought down the figures. This is of course something that opens up the way to further needed research on the topic, as it would be interesting deepening in that.

[8] Gambacorta Y axis is already in percentage change. Our models' are not. They have to be multiplied $\times 100$ to be compared with Gambacorta's.

Noticeable enough is the fact that the massive expansion of Central Bank balance sheets did not represent an exogenous unconventional monetary policy shock.

As we can spot through the Forecast Error Variance Decomposition in figure 6, exogenous Central Bank Balance Sheet shocks account for less than half the variance decomposition of the balance sheet. Its fluctuations are in fact mainly linked to real economy shocks and financial turbulences in the stock market.

4 Robustness Analysis

As a robustness check, in order to confirm our findings, we evaluated two alternative models which use Retail Sales and Industrial Production in the Euro Area to proxy the Output instead of Real GDP; the raw and transformed data are shown in Figures 9 and 10. Figure 7 and 8 show the impulse response functions obtained from the novel models. Even if the confidence bands differ, the shocks are coherent with our main analysis in duration and timing.
For what it concerns Retail Sales, the magnitude is a little higher (it ranges from 0.02% to 0.04% compared to a peak of 0.005% of GDP) but still definitely comparable, while the duration seems more persistent fading out after almost 2 years instead of just 11 months. This difference can be easily explained by the fact that in this IRF the confidence bands are smaller than the ones reported in the main analysis, and this forces us to see the shock as more propagated in time.
On the other hand, the model which uses Industrial Production shows a magnitude of the shock which is almost identical to the Retail's one (with a slightly higher peak of almost 0.05%) while its persistence seems to be even smaller than GDP's, fading out after less than 10 months.

For the sake of completeness we showed all the other shocks as well, but they should actually be identical to the ones of the main model. The perceptible differences than can be spotted are simply caused by the fact that the different models' results are computed using a statistic aggregation of random draws as explained in Section 2.

5 Conclusions

The goal of this paper was to confirm the findings of Gambacorta et al. [1] by extending their analysis on a more recent dataset that includes actaul implementation of Quantitative Easing in the Euro Area. As discussed in Sections 3 and 4, all three of our models' IRFs are aligned with the expected results. These findings also confirm the idea of Quantitative Easing that we often find in the literature: this tool is effective in supporting macroeconomics in unconventional situations, and it is, for sure, the right response to address extraordinary crisis; however its effects are definitely temporary, fading after few months, and doping, with potentially severe backlashes.

In our sample we specifically excluded the latest period, characterized by the COVID crisis. Even if, in literature, there are already different ways to address this event in VAR models[9], we wanted to both avoid unnecessary exogenous shocks that could have interfered with our findings and maintain the same model of our benchmark, Gambacorta et al. [1], so that the results would be comparable without any doubt.

Further steps that could be taken in order to provide a more careful analysis on the topic are:

- Include in the sample the COVID period, addressing it properly, to further confirm the findings.
- Evaluate the model on a full sample from 2008 to 2021, including other relevant nations.
- Provide more robustness checks with different variables, like Private Banks Balance Sheets or Composite Indicator of Systemic Stress (CISS).

[9] How to estimate a VAR after March 2020, Lenza and Primiceri from ECB.

References

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[2] https://www.ecb.europa.eu/press/key/date/2012/html/sp120726.en.html.

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Figure 1: European Central Bank balance sheet composition.

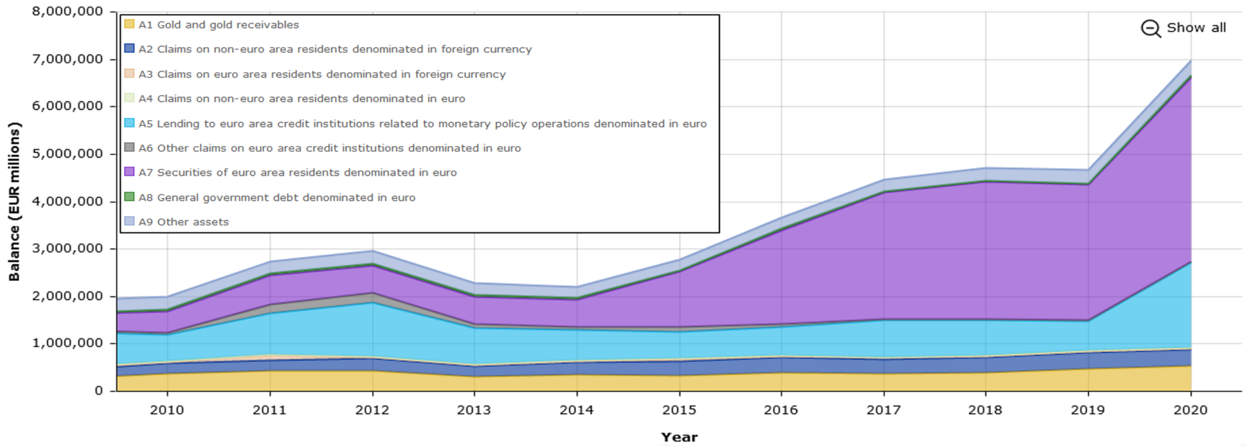

Figure 2: Raw data.

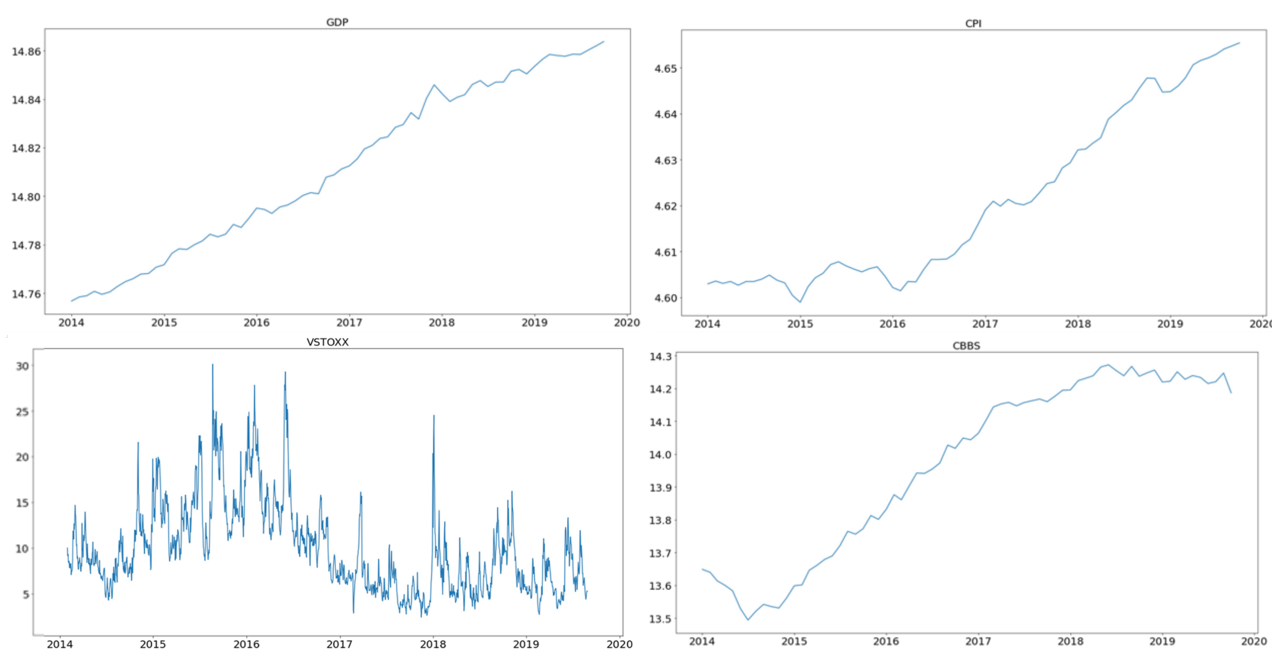

Figure 3: Transformed data.

Figure 4: Model results.

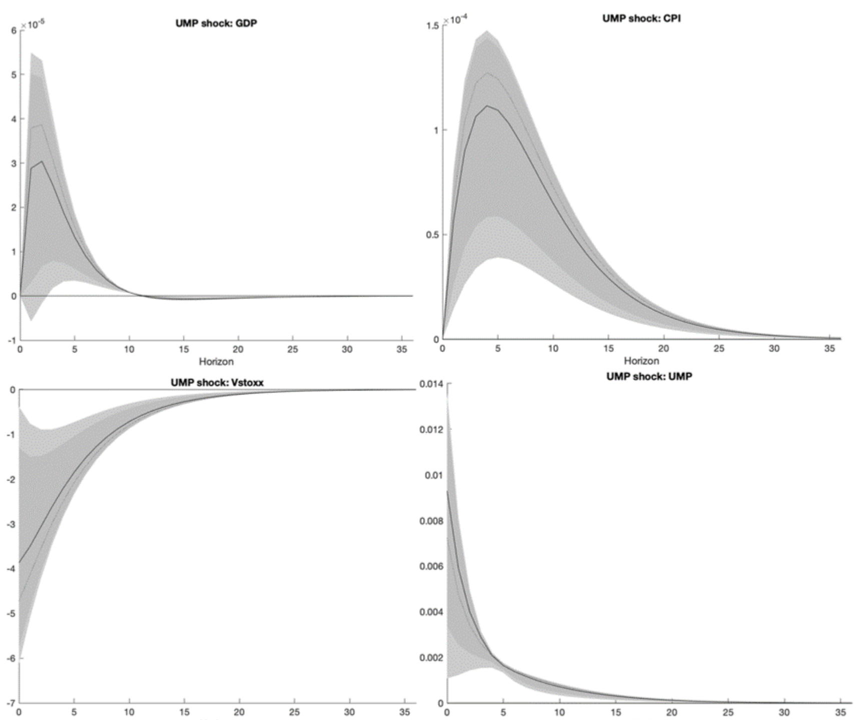

Figure 5: Results of Gambacorta et al.[1]

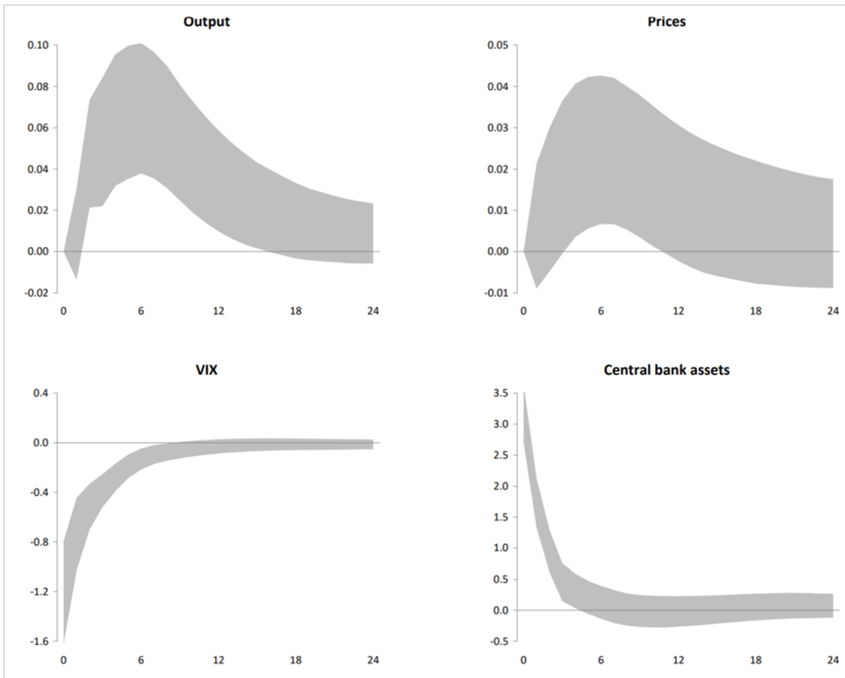

Figure 6: Forecast Error Variance Decomposition of CB balance sheet.

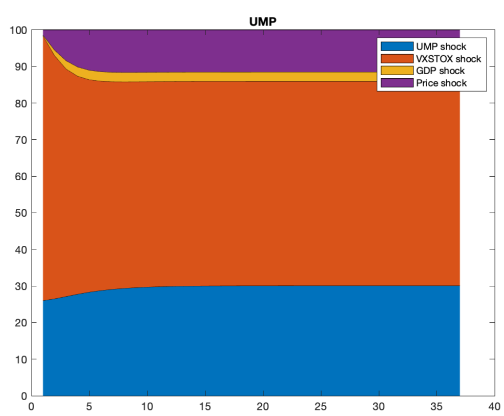

Figure 7: Retail Sales IRFs of MP shocks.

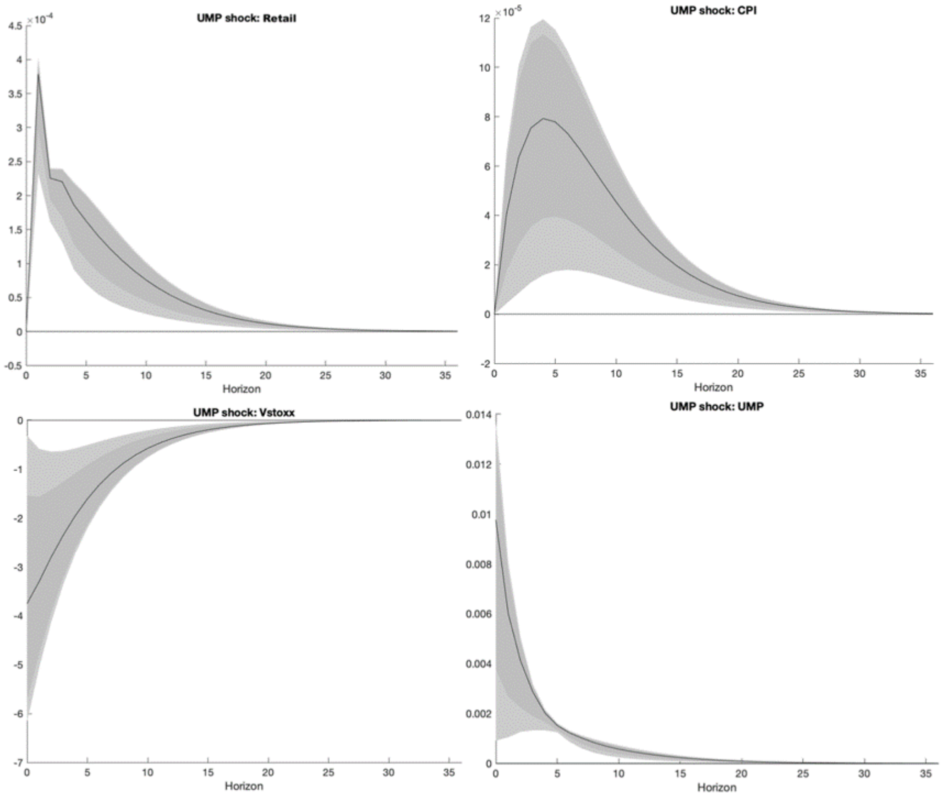

Figure 8: Industrial Production IRFs of MP shocks.

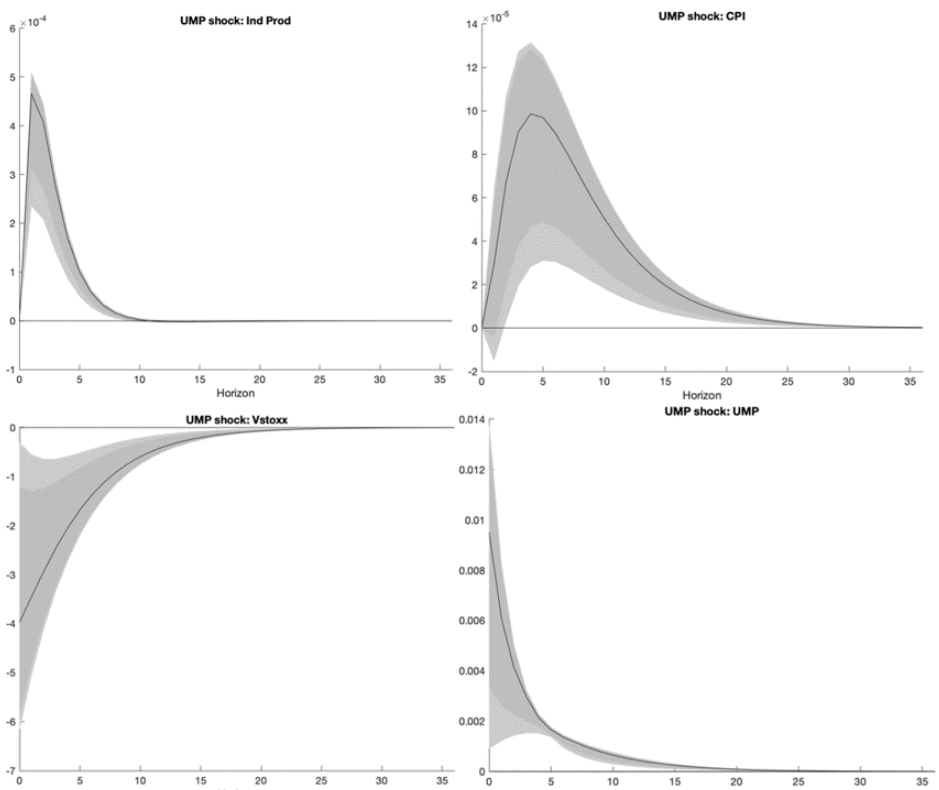

Figure 9: Robustness check data.

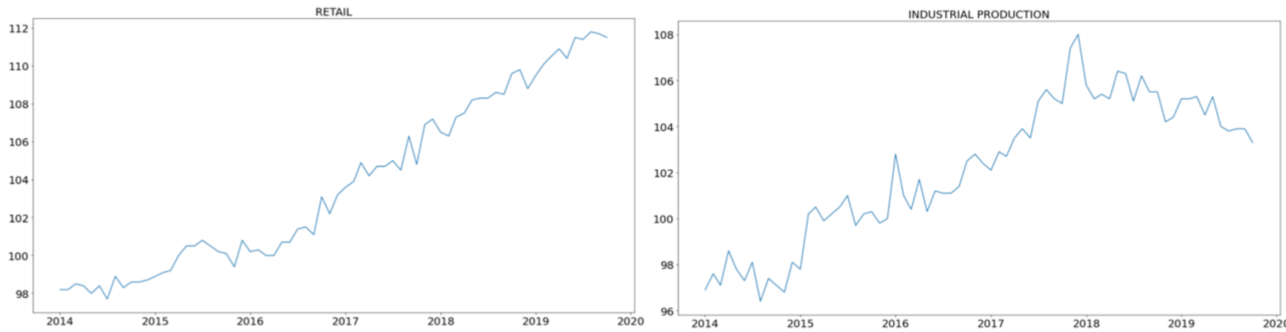

Figure 10: Robustness check transformed data.