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# Impact of Macroeconomic Shocks on Real Output Fluctuations in Croatia

***Nataša Erjavec*** *
***Boris Cota*** *
***Saša Jakšić*** *

***Abstract:*** The paper investigates the sources of real output variability in Croatia by assessing the impact of macroeconomic structural shocks on fluctuations in real output. The analysis is based on a structural vector autoregressive model (SVAR) where structural shocks (demand, supply and nominal) are identified using Blanchard-Quah long run restriction technique. The findings of the empirical analysis point out the dominant role of supply shocks in explaining real output fluctuations. In the same time the results reveal negligible effects of nominal and demand shocks on the variability of real output. To get a better insight in the dynamics of real output in the aftermath of the structural shocks we also analyse the impulse response functions. The results show that a positive supply shock leads to a permanent increase in real output. A nominal shock decreases the real output marginally although the effect is only temporary and fades out quickly. Surprisingly, the effect of a demand shock is insignificant both in the short run and in the long run.

***Keywords:*** real output, structural vector autoregression, variance decomposition, impulse response function, macroeconomic shocks

***JEL Classification:*** C32, E52

## Introduction

Output fluctuations and the sensitivity of the real economic activity to various exogenous shocks are of central interest for the policy makers in developed and emerging economies. Campbell and Mankiw (1987) question the conventional view that fluctuations in the output represent only temporary deviations from the trend and point out the importance of studying output fluctuations. The findings of their study

* Nataša Erjavec, Boris Cota and Saša Jakšić are at Faculty of Economics and Business, University of Zagreb, Zagreb, Croatia.

emphasise the important implications that unexpected changes in the real output have in forecasting the future levels of output. Taylor (1994) argues that the existence of trade-off between inflation and output variability is due to slow adjustment of prices. Lee (2002) analyses the trade-off between inflation and output variability as well. To account for structural instability the author employs GARCH model, and, once more, emphasises the role of the output fluctuations in the economy.

There is a degree of consensus in the economic theory regarding the long run effects of structural shocks on the real output. That is, aggregate supply shocks have permanent effects on the real output, while nominal and aggregate demand shocks have only temporary (short-run) effects which means that they are neutral in the long run with respect to real output. Therefore, the long run properties are established to a certain degree. On the other hand, the economic theory is less confident on the short run effects and dynamics of the real output in response to the structural shocks.

In order to examine the influence of money supply, money demand, real spending and supply shocks for short-run real output fluctuations, Rapach (1998) estimates a SVAR model. The identification of the shocks is achieved with Blanchard-Quah (1989) long-run restriction scheme. The main contribution of the study is a more general specification which allows for nonstationarity of certain variables as opposed to other studies that restrict these variables to be stationary. For instance, Keating (1992) restricts money growth to be stationary while Gali (1992) specifies a stationary real interest rate. Rapach (1998) uses quarterly, seasonally adjusted data from 1959 to 1994 and finds that fluctuations in the real output are mainly attributed to spending and supply shocks. Surprisingly, the influence of monetary policy shocks is unimportant for output variability, as they account for 6.27% or less of output variance at all reported horizons. In the short run, spending shocks explain most of the output variability, while in the long run, supply shocks are the most important for explaining the output variability.

Mirdala (2009) investigates the impact of three exogenous structural shocks on real output fluctuations in the new EMU (European Monetary Union) member countries (Slovenia, Cyprus, Malta and the Slovak Republic) and compares the findings with the results for the euro area. The author employs SVAR approach over the period from 1999 to 2008. The use of quarterly data restricts the analysis to just 40 observations which casts doubt on the results and conclusions of the paper. The results indicate that, in all countries, the variability of the real output is mainly attributed to the supply shocks. In the long run, supply shocks account for 80 to 90% of the real output variability. However, in the short run, results are mixed. In Cyprus, Slovenia and Slovakia, supply shocks are a dominant source of fluctuations in the short run, while in Malta the demand shock and in the euro area the nominal shock are the main sources of fluctuations.

The focus of this research is on the sources of fluctuations of real economic activity in Croatia. On 30th of June 2011 the European Commission declared the closure of accession negotiations and announced that Croatia will join the European Union on 1st July 2013. Obligation of all new European Union member states upon accession is to participate in the Exchange Rate Mechanism II (ERM II) and, when they eventually meet the convergence criteria set by European Commission, to adopt euro as their currency. As Croatia is about to become a new member state of the European Union, one of the challenges its policy makers will face is the ability to meet the convergence criteria. The insight into the sources of fluctuations of the real output could be very helpful for that purpose, as the sensitivity of the real economic activity to exogenous shocks plays an important role in assessing the ability of the economy to meet the convergence criteria. A suitable framework for assessing the relative significance of the structural shocks is a SVAR model. Identification scheme employed to identify these structural shocks is the Blanchard-Quah (1989) long run structural restriction technique. The main advantage of the strategy is that the shocks are identified by imposing long run restrictions without *a priori* restrictions on the short-run dynamics of the model. The importance of the disturbances is measured using the impulse response functions and the variance decompositions. The impact of three structural shocks on the real economic activity is then compared with the results for the new EMU member states.

The remainder of the paper is organized as follows. In the next section we introduce the Blanchard-Quah (1989) long run structural restriction technique. Section 3 describes the data employed in the empirical analysis and the sources from which they are obtained. Section 4 contains the most important results of the empirical analysis including the forecasting error variance decomposition and the impulse response analysis. Finally, the last section concludes.

## SVAR framework

The usual starting point in the analysis of output fluctuations is a structural moving average model which can be written as[1]:

$$\Delta x_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + ... = A(L)\varepsilon_t, \quad (1)$$

where $\Delta$ denotes the difference operator, $x_t = [y_t, q_t, p_t]'$ is a vector of the relevant endogenous variables, $\varepsilon_t = [\varepsilon_{st}, \varepsilon_{dt}, \varepsilon_{nt}]$ is a vector of structural disturbances and $A(L) = A_0 + A_1L + A_2L^2 + ...$ is a matrix polynomial in the lag operator[2] L. By definition, structural shocks ($\varepsilon_t$) are serially uncorrelated and mutually orthogonal and $E[\varepsilon_t\varepsilon_t']$ is normalised to the identity matrix, *i.e*.

[1] Deterministic components are left out due to notation simplicity.

[2] The lag polynomials are assumed to have absolutely summable coefficients.

$$E[\varepsilon_t]=0,\ E[\varepsilon_t\varepsilon_t']=\Sigma_\varepsilon=I \text{ and } E[\varepsilon_s\varepsilon_t']=[0],\quad \forall s\neq t. \tag{2}$$

The vector moving average (VMA) representation of the standard VAR model is given by

$$\Delta x_t=u_t+C_1u_{t-1}+C_2u_{t-2}+...=C(L)u_t \tag{3}$$

where $C(L)=I+C_1L+C_2L^2+...$, and $u_t=[u_{st},u_{dt},u_{nt}]'$ is a vector of reduced form disturbances that are serially uncorrelated but can be contemporaneously correlated with each other, *i.e*.

$$E(u_t)=0,\ E[u_tu_t']=\Omega \text{ and } E[u_su_t]=[0],\quad \forall s\neq t \tag{4}$$

Suppose that there exists a non singular matrix S such that $u_t = S\varepsilon_t$. Comparing equations (1) and (3) reveals that

$$u_t=A_0\varepsilon_t, \tag{5}$$

with variance-covariance matrix of the reduced form disturbances

$$\Omega=E[u_tu_t']=A_0A'_0. \tag{6}$$

As model (3) is underidentified, we need additional restrictions to obtain estimates of $A_0$ (and thus structural shocks $\varepsilon_t$) from the estimated model (3). Since $A_0$ is a 3x3 matrix, we need nine parameters to recover the structural residuals $\varepsilon_t$ (original shocks that drive the behaviour of the endogenous variables) from the reduced form residuals $u_t$. Of nine parameters, six are given by the elements of $\hat{\Omega}$ (three estimated variances and three estimated covariances of the VAR residuals). Therefore, three additional restrictions are needed to exactly identify the system. Additional restrictions are made by making further assumptions about the structural shocks. According to Clarida and Gali (1994), three constraints are imposed on the long run multipliers while the short run dynamics are left unconstrained. These three restrictions are as follows: only supply shocks ($\varepsilon_{st}$) are expected to influence economic growth in the long run, while both the supply shocks ($\varepsilon_{st}$) and demand shocks ($\varepsilon_{dt}$) are expected to influence the real exchange rate in the long run. Nominal shocks ($\varepsilon_{nt}$) are only short run phenomenon and for that reason they are expected to have no long run impact on either economic growth or the real exchange rate. The structural shocks are defined according to their impact on the variables in the VAR and do not necessarily coincide with the true demand, supply and nominal shocks as they are defined by the economic theory. Nevertheless, the assumptions are consistent with most existing macroeconomic theories. Furthermore, the approach avoids using contemporaneous restrictions which are often considered to be controversial.

Specially, letting $A(1)=A_0+A_1+A_2+\dots$, the long run representation of our structural moving average model (1) can be written as follows:

$$\begin{pmatrix}\Delta y_t\\ \Delta q_t\\ \Delta p_t\end{pmatrix}=\begin{pmatrix}A_{11}(1) & A_{12}(1) & A_{13}(1)\\ A_{21}(1) & A_{22}(1) & A_{23}(1)\\ A_{31}(1) & A_{32}(1) & A_{33}(1)\end{pmatrix}\begin{pmatrix}\varepsilon_{st}\\ \varepsilon_{dt}\\ \varepsilon_{nt}\end{pmatrix}, \tag{7}$$

where $A(1)$ is a matrix of the long-run effects of $\varepsilon_t$ on $\Delta x_t$.

The restrictions that neither nominal nor demand shocks ($\varepsilon_{nt}$ and $\varepsilon_{dt}$) influence economic growth in the long run are:

$$A_{12}(1)=A_{13}(1)=0. \tag{8}$$

Similarly, the restriction that nominal shocks ($\varepsilon_{nt}$) do not influence the real exchange rate in the long run requires that:

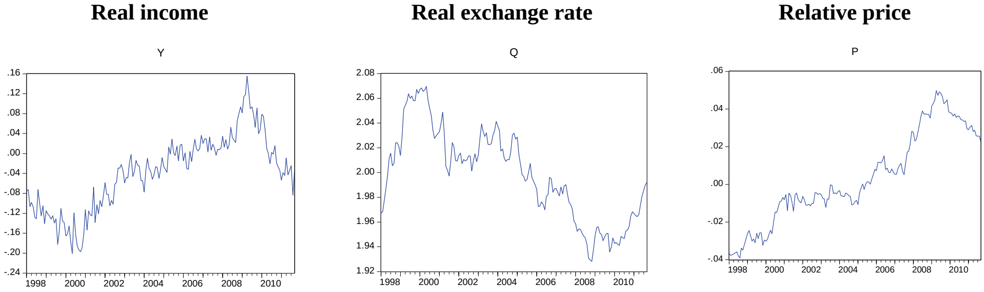
$$A_{23}(1)=0. \tag{9}$$

These three restrictions make the $A(1)$ matrix triangular and the system is exactly identified.

## Data description

In order to assess the relative importance of supply, demand and nominal shocks, a three variable VAR model for Croatia is estimated. The variables employed in the model are: real relative output ($y_t=y_t^h-y_t^f$) defined as the difference between the real income in Croatia ($y_t^h$) and the real income in EU27 ($y_t^f$); $q_t$ is the real exchange rate of kuna against the euro, *i.e.* $q_t=s_t-p_t$ where $s_t$ is the nominal exchange rate (the price of euro in units of domestic currency) and $p_t$ is the relative price level ($p_t=p_t^h-p_t^f$), *i.e.* the difference between the domestic price level ($p_t^h$) and the price level in the EU27 ($p_t^f$). All variables are in logarithms and multiplied by 100 so that their differences can be interpreted as the percentage change in the underlying variable. We use seasonally adjusted monthly data starting from January 1998 to September 2011. The indices of industrial production serve as proxies of real income variables. The price level is measured by the Harmonized Index of Consumer Prices (HICP). HICP is also used as a deflator in turning nominal variables into real terms. Data sets are obtained from the following sources: data on HICP and industrial production indices for Croatia and the EU 27 are from EUROSTAT and the source for nominal exchange rate is the Croatian National Bank. The dynamics of the series in the period under study are presented in Figure 1.

Figure 1: Variables: period from 1998/M1 to 2011/M9




*Source*: EUROSTAT and Croatian National Bank

Additionally, a dummy variable is included in the model to account for changes in the methodology used for calculating the exchange rate. Namely, it reflects the new Croatian National Bank act that came into force in April 2001 and according to which the Croatian National Bank may not extend credit to the Republic of Croatia (Croatian National Bank, 2011) [3].

The theoretical model employed in this paper corresponds to the Clarida and Gali (1994) stochastic setup of the open economy macroeconomic model developed by Obstfeld (1985). The main requirement of Clarida and Gali (1994) theoretical model is that all variables have to be nonstationary in levels but stationary in the first differences. Therefore, prior to model estimation and imposing Blanchard and Quah (1989) identification restrictions the order of integration of the analysed time series data is assessed and the variables are tested for a possible cointegration.

To determine the order of integration we apply two unit root tests, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). Visual inspection of the series (in levels) suggests the possibility that analysed series contain a linear trend, Figure 1. Hence, we perform the tests both with and without including a trend component in the test equation. The lag length in the ADF test equation was selected using Schwartz Information Criterion (for a maximum of 12 lags). In the Phillips-Perron test, the Newey-West bandwidth criterion and the Bartlett Kernel estimation method was applied. The reported results of the ADF tests (Table 1) applied to levels and differences of the variables indicate that all variables have a unit root in levels and are stationary in the first differences, *i.e.* all variables are integrated of order one, $I(1)$.

[3] We also experimented with several dummy variables to account for possible structural breaks such as changes in the economic and financial structure of the Croatian economy or the impact of financial and economic crisis. However, all of those variables turned out to be statistically insignificant and hence were not included in the final specification of the model.

Table 1: Unit root tests results

| Variable | ADF test | | | Phillips-Perron test | | |
|---|---|---|---|---|---|---|
| | **Deterministic components** | **test statistic** | **p-value** | **Deterministic components** | **test statistic** | **p-value** |
| **y** | c | -1.539 (1) | 0.5116 | c,t | -2.993 (4) | 0.1374 |
| **q** | c,t | -3.769 (1) | 0.0206 | c,t | -3.364 (2) | 0.0600 |
| **p** | c | -1.721 (0) | 0.7378 | c | -1.458 (4) | 0.5522 |
| **Δy** | c | -18.475 (0) | 0.0000 | c | -19.735 (21) | 0.0000 |
| **Δq** | c | -9.686 (0) | 0.0000 | c | -9.478 (5) | 0.0000 |
| **Δp** | c | -13.863 (0) | 0.0000 | c | -13.815 (4) | 0.0000 |

*Note*: Critical values used are from MacKinnon (1996). Figures in the square bracket indicate chosen lag length for ADF test and Bandwidth for the Phillip-Perron test. c denotes a constant and t denotes a trend, deterministic components included in the unit root test equation.

*Source*: authors´ calculations

When all variables are *I*(1) (as indicated by the ADF and PP tests) than there is a possibility that the variables are cointegrated which would require the estimation of a structural vector error correction model (VECM) instead of structural VAR model. To check for possible cointegration between the variables in their levels we apply the Johansen Cointegration test. The results are reported in Table 2. Both the Trace and Maximum Eigenvalue statistics suggest that we cannot reject any of the null hypotheses, which implies that there is no cointegration among variables, *i.e.* variables follow different stochastic trends in the long run. Thus, it is appropriate to use the first differences of the variables in our SVAR model.

Table 2: Johansen test for the number of cointegrating vectors

| Test | Null | Alternative | Eigenvalue | Test Statistics | 5% Critical Value | p-values |
|---|---|---|---|---|---|---|
| **Trace** | r = 0* | r > 0 | 0.126382 | 31.62801 | 42.91525 | 0.4087 |
| | r ≤ 1 | r > 1 | 0.049866 | 9.739875 | 25.87211 | 0.9356 |
| | r ≤ 2 | r > 2 | 0.008931 | 1.453254 | 12.51798 | 0.9922 |
| **Maximum Eigenvalue** | r = 0* | r = 1 | 0.126382 | 21.88814 | 25.82321 | 0.1522 |
| | r = 1 | r = 2 | 0.049866 | 8.286621 | 19.38704 | 0.7951 |
| | r = 2 | r = 3 | 0.008931 | 1.453254 | 12.51798 | 0.9922 |

*Note*: * denotes rejection of the hypothesis at the 0.05 level. p-values are based on MacKinnon-Haug-Michelis (1999).

*Source*: authors´ calculations

After analysing the basic properties of the variables, we estimate the VAR model in the first differences. A lag length of k=2 is determined by several criteria, namely; sequential modified LR test statistic (at 5% level), Final prediction error (FPE), Hannan-Quinn (HQ) and Akaike (AIC) information criteria. The underlying VAR model includes an intercept and a dummy variable. The model is stable, *i.e.* all its roots lay within the unit circle. Hence, the formal requirements for the use of the Blanchard and Quah (1989) identification scheme are satisfied.

## Empirical results

The model is estimated over the period from January 1998 to September 2011, which gives a total of 165 observations. On the basis of the estimated VAR model and three structural shocks identified as described in the second section, variance decomposition and impulse response analysis are carried out in order to measure the importance of the shocks in explaining the output fluctuations.

The results of the forecast error variance decomposition at various horizons (up to 12 months) are reported in Table 3.

Table 3: Variance decomposition of the rate of change in the real output

| | **1 month** | **6 months** | **1 year** |
|---|---|---|---|
| **Supply shock** | 98.608 | 94.582 | 94.577 |
| **Demand shock** | 0.198 | 0.320 | 0.320 |
| **Nominal shock** | 1.194 | 5.097 | 5.103 |

*Source*: authors´ calculations

Variance decomposition assesses the relative importance of analysed shocks. The results imply that the supply shocks account for the majority of the output variability, both in the long-run (by construction) and in the short-run. Demand shocks have a marginal influence in explaining the variation in output at all horizons. Nominal shocks also have a limited role. They account for up to 5% of output variability at all reported horizons.

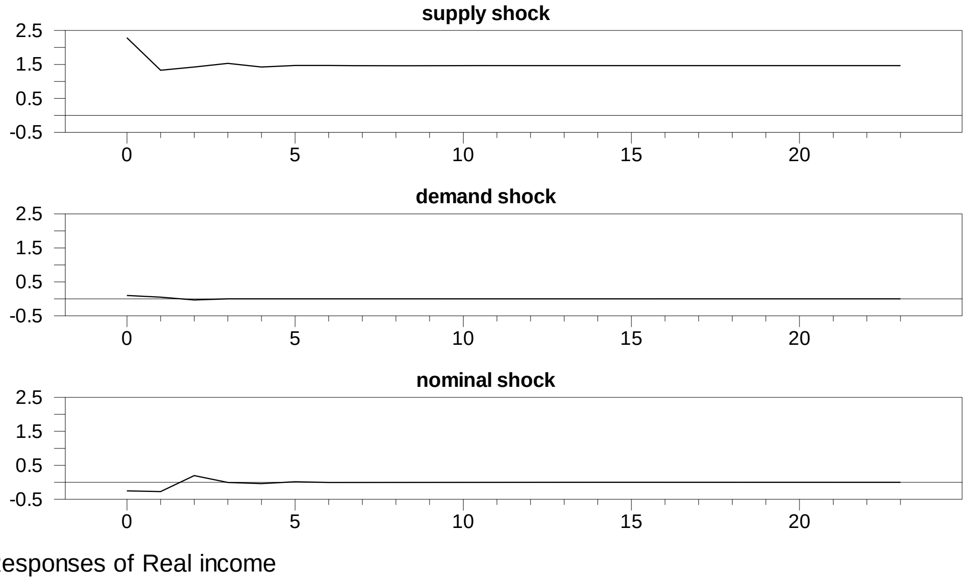
In comparison with the findings obtained by Mirdala (2009), regarding the dominant role of the supply shocks in explaining the short-run fluctuations in the real output, the results for Croatia are similar to those obtained for Cyprus, Slovenia and the Slovak republic. Negligible role of the demand shocks, at all horizons, is also observed for the EMU countries.

After identifying the shocks according to their long-run properties, the short-run dynamics of the model are freely estimated. If the identification scheme is correctly specified, the impulse response functions should exhibit the following pattern:

- A positive supply shock leads to an increase in the real output.
- In response to a positive demand shock, real output increases. Eventually, prices increase, and in the long run, the real output returns to its initial level.
- In response to a positive nominal shock, real output increases. However, the effect is temporary and finally real output returns to its initial value.

The results of the impulse response analysis to each of the structural shocks for Croatian real output are given in Figure 2.

Figure 2: Impulse response functions (responses to one standard deviation shock)




Note: The figure shows the estimated accumulated responses of differenced variable to a given shock which corresponds to the estimated responses of the level variable

*Source*: authors´ calculations

As it can be seen from the estimated responses in Figure 2, one standard deviation supply shock increases the real output both in the short and in the long run. On impact the real output rises by 2%. The following month it increases by about 1.5% after which the effect becomes permanent. A demand shock increases the real output instantaneously, although the effect is only temporary and much smaller in comparison to the supply shock. Overall, demand shocks have a negligible impact on the real output. On impact, nominal shocks decrease real output by 0.25%. However, very soon the effect becomes positive and dies out within the following two months.

The obtained impulse responses results are in accordance with the standard explanations of the effects of the shocks on the real output, drawn from the theoretical model. This provides evidence that the analysed shocks are identified in a correct way and the inference based on the data is valid.

## Conclusion

The empirical analysis is based on a SVAR model which is used to analyse the responses of the real economic activity to demand, supply and nominal structural shocks. Furthermore, the SVAR model assesses the degree to which each shock accounts for short-run variability in the output. The performed analysis illustrates that the supply shocks are the main source of fluctuations in the Croatian real output. Apart from indicating the importance of supply shocks in accounting for the variability of the real output the variance decomposition also reveals a negligible role of the nominal and demand shocks for the variability in the real output.

In addition to the variance decomposition, the impulse response functions are estimated to assess if the pattern of the responses corresponds to the Clarida and Gali (1994) theoretical model employed in the paper. The responses of all variables to structural shocks are in accordance with standard economic theory which points to the conclusion that the structural shocks have been identified in proper way. To be more precise, one standard deviation supply shock permanently increases the real output at about 1.5 percent. Furthermore, the short-run output responses to supply shocks are considerably bigger compared to responses to nominal and demand shocks. On the other hand, output responses to the nominal and demand shocks are negligible, both in the short-run and in the long run.

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