Modelling Fiscal and Monetary Policy Interactions in Croatia Using Structural Vector Error Correction Model

RESEARCH PAPER

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Abstract

This paper investigates the interactions of fiscal policy, monetary policy and economic activity in Croatia. It employs a structural VECM in the identification of permanent and transitory shocks using monthly data on government expenditures, money aggregate M1 and the index of economic activity. The cointegrating properties of the data provide two restrictions on the transitory nature of fiscal and monetary policy shocks. An additional identifying restriction is provided by the assumption on contemporaneous interactions of the two policies. Impulse response functions and variance decompositions are used to study the effects of identified structural shocks. The results imply that an aggregate supply shock has a statistically significant permanent effect on all three observed variables in the long-run; secondly, fiscal and monetary policy move in the opposite direction, which indicates that they have been used as substitutes; finally, an unambiguous conclusion on the impact of the two policies on economic activity in the short- and medium-run can not be reached.

Keywords: fiscal policy, monetary policy, cointegration, structural VEC model, permanent shocks, transitory shocks, impulse response functions, Croatia

JEL classification: C32, E52, E62

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1 Introduction[1]

The basic objective of this paper is to analyse fiscal and monetary policy interactions in Croatia. In addition, the interdependence of fiscal and monetary policy with national output is examined. The analysis is performed within the VAR (Vector Autoregression) framework where all variables are considered endogenous. This allows insights into their impact on national output as well as the impact of national output on fiscal and monetary policy. Although empirical research is based on a very simple theoretical framework, in the future it can be extended by additional macroeconomic variables or policy instruments.

The questions of the proper intensity of fiscal and monetary stimulus have become especially important during the actual financial crisis. By understanding the impacts of fiscal and monetary policy shocks in the past, we can predict the outcomes of undertaken policy measures in the future. Consequently, this paper addresses the following issues: the effects of policy stimulus on national output, policy responses on changes in the national output and a complementary or substituting behaviour of monetary and fiscal policies in the overall macroeconomic management of the country.

Just like in any other exercise of this type, the recognition of data generating process provides good grounds for the analysis. Consequently, a large part of this paper tries to fit the data to the appropriate econometric model, although this is not enough to detect the underlying forces governing the behaviour of analysed variables. The next step is the identification of the structural form, using the structural VECM (Vector Error Correction Model). The novelty of this approach is that it provides additional statistical restrictions on the structural form, which results in a lesser degree of arbitrariness in the identification process.

In Croatia, fiscal and monetary policy have been analysed separately, but to the best knowledge of the author, there is no published paper which

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[1] *I would like to thank the two anonymous referees for their helpful and constructive comments. The paper is based on Rukelj (2009).*

analyses the interactions of these two policies. This paper focuses on the framework within which interactions can be analysed. Although fiscal and monetary shocks are quite broadly defined, this framework enables us to identify them and analyse their interactions.

The rest of the paper is organised as follows. Firstly, a review of the literature on fiscal and monetary policy identification is given in Section 2 along with the literature on methodology and a review of previous studies for Croatia. This is followed by Section 3 in which the outline of a simple theoretical framework serves as a basis for empirical analysis. Methodology is discussed in Section 4, while Section 5 provides an explanation of data sources and data compilation. The results are presented in Section 6, while Section 7 gives the summary and conclusions.

2 Literature Review

In the existing literature, monetary and fiscal policy are analysed with VAR models which enable the simultaneous modelling of relationships between policy instruments and selected macroeconomic variables. The tools employed to examine the relationships between policy instruments and macroeconomic variables are impulse response functions and variance decompositions. The identification procedure is the main challenge in this process. Early literature relied on the Cholesky decomposition, where the main problem was that different variable orderings, based on more or less provisional assumptions, yielded significantly different results.

New types of restrictions were introduced by Blanchard and Quah (1989) and King et al. (1991), who used integrating and cointegrating properties of the data in the identification process. In the former study, a long-run restriction was used in the identification of aggregate demand and supply disturbances. The latter study shows how to use the cointegrating properties of the data to supply additional restrictions in the identification process.

Three most relevant studies analysing fiscal and monetary policy within a VAR framework are Bernanke and Blinder (1992), Bernanke and Mihov (1998) and Blanchard and Perotti (2002). Bernanke and Blinder (1992) identify monetary policy with a set of assumptions regarding the non-existence of the contemporaneous impact of policy shocks on economic variables and vice versa followed by the application of the Cholesky decomposition.

Bernanke and Mihov (1998) use a more sophisticated methodology in which monetary policy instruments are represented by a vector of suspected instruments. Restrictions are then imposed on variables related to monetary policy instruments, while the relationships among macro variables are left unrestricted. Blanchard and Perotti (2002) examine the effect of fiscal policy within a structural VAR approach using institutional information about government revenues and expenditures for identification.

An overview of structural VECM, together with details on impulse response functions and variance decompositions, is given in Lütkepohl (2005) and Lütkepohl and Krätzig (2004). A detailed description of this methodology and estimation procedure can also be found in Vlaar (2004). A recent identification method of structural shocks is presented in Uhlig (2005) and Pagan and Pesaran (2008). In the former, identification is based on sign restrictions of the impulse responses of variables which are expected to react to monetary shocks, while the latter generalises the Blanchard-Quah type restrictions in the case of more than one permanent structural shock.

Different combinations of these methods have been used to identify fiscal and monetary shocks. For example, Dungey and Fry (2007) deal with the identification of fiscal and monetary shocks, using sign restrictions and permanent and temporary shock methodology for New Zealand. In the identification of fiscal shocks in the US, Caldara and Kamps (2008) employ recursive sign restrictions and an event study approach. Additionally, they also apply the methodology used by Blanchard and Perotti (2002). Other analyses use Bayesian VAR models and Markov-Switching models. Muscatelli, Tirelli and Trecroci (2002), for example, use the Bayesian

VAR model to investigate fiscal and monetary policy interactions in G7 countries. The Markov-Switching model is engaged by Semmler and Zhang (2004) to explore time-varying interactions of fiscal and monetary policy for selected Euro-area countries.

For Croatia, models of fiscal and monetary policy have been used by Benazić (2006) and Vizek (2006). Benazić (2006) employs the structural VECM in the examination of fiscal policy impacts on economic activity, while Vizek (2006) uses cointegration and VAR analysis of monetary transmission mechanisms. Transmission mechanisms of monetary policy have also been studied by Lang and Krznar (2004), who closely follow Bernanke and Mihov's (1998) approach. Cziraky and Gillman (2006) estimated money demand in Croatia. Fiscal and monetary policy have been analysed separately in the case of Croatia, but there is no study which considers both policies and studies their interactions.

3 Theoretical Framework

The main idea of this paper can be described by a simple theoretical model with three equations: output equation, fiscal policy equation and monetary policy equation. The output equation describes national output (y) as a function of fiscal and monetary policy variables g, m and an aggregate supply stochastic trend (θ_1), which is assumed to be non-stationary:

$$\begin{aligned} y_t &= \alpha_1 g_t + \alpha_2 m_t + \theta_{1,t}, \\ \theta_{1,t} &= \varphi_1 \theta_{1,t-1} + \varepsilon_t^y, \\ |\varphi_1| &= 1. \end{aligned} \tag{1}$$

The fiscal policy equation relates government expenditures to national output and a stationary stochastic component θ_2:

$$\begin{aligned} g_t &= \beta_1 y_t + \theta_{2,t}, \\ \theta_{2,t} &= \varphi_2 \theta_{2,t-1} + \varepsilon_t^g, \\ |\varphi_2| &< 1. \end{aligned} \tag{2}$$

Similarly, the monetary policy equation describes the relationship between money aggregate (m), national output, velocity of money (v) and a stationary stochastic component θ_3:

$$
\begin{aligned}
&m_t = \beta_2 y_t - \beta_3 v_t + \theta_{3,t}, \\
&\theta_{3,t} = \varphi_3 \theta_{3,t-1} + \varepsilon_t^m, \\
&|\varphi_3| < 1.
\end{aligned} \tag{3}
$$

All the variables are expressed in natural logarithms.

When expressed in terms of stochastic components, the system yields a solution:

$$
\begin{bmatrix} y_t \\ g_t \\ m_t \end{bmatrix} = \frac{1}{\gamma}\left(\begin{bmatrix} 1 \\ \beta_1 \\ \beta_2 \end{bmatrix} \theta_{1,t} + \begin{bmatrix} \alpha_1 \\ (\gamma + \alpha_1\beta_1) \\ \alpha_1\beta_2 \end{bmatrix} \theta_{2,t} + \begin{bmatrix} \alpha_2 \\ \alpha_2\beta_1 \\ (\gamma + \alpha_2\beta_2) \end{bmatrix} \theta_{3,t} - \begin{bmatrix} \alpha_2\beta_3 \\ \alpha_2\beta_1\beta_3 \\ \alpha_2\beta_2\beta_3 + \gamma\beta_3 \end{bmatrix} v_t \right) \tag{4}
$$

where, $\gamma = 1 - \alpha_1\beta_1 - \alpha_2\beta_2$.

The relations between variables represented by monetary policy equation have their theoretical foundations in the quantitative theory of money; consequently, velocity is modelled by a deterministic trend. For example, Cziraky and Gillman (2006) find that money velocity in Croatia decreased from the mid-1990s to 2003 and, therefore, a negative trend coefficient is expected. The reasoning for the relation established in the fiscal policy equation relies on the notion that government expenditures are in the long-run bounded by the national output.

There are several implications of this model. Firstly, all constant terms have been dropped out of the model to make notation clearer and, consequently, all variables can be considered demeaned. Secondly, the stationarity of stochastic terms in the second and third equation implies two cointegrating relationships, between national output and government expenditures, and between national output and money aggregate M1, where velocity is represented by deterministic trend included in the cointegrating space. Finally, Equation (4) shows that a non-stationary stochastic term θ_1 represents the only common stochastic trend which drives the whole system.

The terms ε^y, ε^g and ε^m represent orthogonal shocks of aggregate supply, fiscal policy and monetary policy. Fiscal and monetary policy shocks can also be referred to as aggregate demand shocks. Although fiscal and monetary policy shocks defined in this manner contain components other than pure policies, it can be argued that policy components dominate these shocks. The main task is to find the appropriate methodological framework which will facilitate the identification of these orthogonal structural disturbances.

4 Methodology

The general framework used in this paper is a three-dimensional VAR model in the structural form proposed by Sims (1980) with deterministic terms (C) and without exogenous variables:

$$\begin{bmatrix} y_t \\ g_t \\ m_t \end{bmatrix} = C + \begin{bmatrix} 0 & b_{11} & c_{11} \\ a_{21} & 0 & c_{21} \\ a_{31} & b_{31} & 0 \end{bmatrix} * \begin{bmatrix} y_t \\ g_t \\ m_t \end{bmatrix} + \ldots + \begin{bmatrix} a_{1p} & b_{1p} & c_{1p} \\ a_{2p} & b_{2p} & c_{2p} \\ a_{3p} & b_{3p} & c_{3p} \end{bmatrix} * \begin{bmatrix} y_{t-p} \\ g_{t-p} \\ m_{t-p} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \end{bmatrix}. \qquad (5)$$

The vector of structural shocks (e) represents white noise disturbances that are mutually uncorrelated. This system cannot be estimated by OLS (Ordinary Least Squares) because endogenous variables in individual equations are correlated with error terms. The structural form can be rewritten in the matrix form by grouping all the contemporaneous variables on the left side:

$$Bx_t = C + A_1 x_{t-1} + \ldots + A_p x_{t-p} + e, \qquad (6)$$

where x_t is a vector of endogenous variables.

As explained by Enders (2004), a reduced form VAR can be derived by multiplying the structural form of Equation (6) by the inverse of B matrix (B^{-1}). This results in a reduced form VAR with lagged variables on the right side and this system can be estimated by OLS:

$$\begin{bmatrix} y_t \\ g_t \\ m_t \end{bmatrix} = C^* + \begin{bmatrix} a_{11}^* & b_{11}^* & c_{11}^* \\ a_{21}^* & b_{21}^* & c_{21}^* \\ a_{31}^* & b_{31}^* & c_{31}^* \end{bmatrix} * \begin{bmatrix} y_{t-1} \\ g_{t-1} \\ m_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} a_{1p}^* & b_{1p}^* & c_{1p}^* \\ a_{2p}^* & b_{2p}^* & c_{2p}^* \\ a_{3p}^* & b_{3p}^* & c_{3p}^* \end{bmatrix} * \begin{bmatrix} y_{t-p} \\ g_{t-p} \\ m_{t-p} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \\ u_{2,t} \end{bmatrix}, \quad (7)$$

where errors $u=B^{-1}e$ are the composites of three shocks which are not autocorrelated but they might be mutually correlated. Structural shocks can be recovered from the OLS estimated residuals through the process of identification. The problem is a loss of information in the re-parameterisation of structural to reduced form VAR and additional restrictions must be imposed to achieve identification. In the three variable case, the first set of restrictions is given by $u=B^{-1}e$, where covariance matrices are symmetric. If variances of structural shocks are normalised to a one in three dimensional case, three more restrictions are needed.

If variables are non-stationary and cointegrated, statistically determined restrictions are available. In order to use these restrictions, firstly the VECM is estimated by the Johansen procedure:

$$\Delta x_t = \alpha\beta' x_{t-1} + \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_{p-1} \Delta x_{t-p+1} + u_t \ . \qquad (8)$$

As shown in Lütkepohl (2005), the multivariate Beveridge–Nelson representation of the VECM can be written:

$$x_t = \Xi \sum_{i=1}^{t} u_i + \sum_{j=0}^{\infty} \Xi_j^* u_{t-j} + x_0^*, \qquad (9)$$

where,

$$\Xi = \beta_\perp' \left[\alpha_\perp' \left(I_n - \sum_{i=1}^{p-1} \Gamma_i \right) \beta_\perp \right]^{-1} \alpha_\perp' \ , \qquad (10)$$

and x_t is a vector of y_t, g_t and m_t, while x^*_0 represents initial values. Matrix Ξ has the rank 3-r, where r is the number of cointegrating vectors. In this way, the multivariate process is decomposed in its stationary and non-stationary components. The non-stationary components are represented by the first term on the right side of Equation (9) as 3-r common stochastic trends, while stationary components are represented in the second term, where matrices Ξ^*_j converge to zero as j goes to infinity.

The B-model (Amisano and Giannini, 1997) will be used for identification purposes, where:

$$e_t \sim (0, I_k) \rightarrow \Sigma_u = BB' \tag{11}$$

As presented in Lütkepohl (2005), n^2 elements of matrix B have to be identified, where n represents the number of variables in the system. The symmetric structure and normalisation of Σ_u provide 0.5n(n+1) restrictions and a further 0.5n(n-1) are required for a unique identification. Transitory shocks provide r(n-r) independent restrictions and additional r(r-1)/2 restrictions are needed for transitory and (n-r)((n-r)-1)/2 restrictions for permanent shocks identification. By imposing these restrictions, the model is identified. If more restrictions are imposed, the model is overidentified and this over-identifying restrictions can be tested.

Once the VECM is estimated and its structural form has been recovered, the usual tools can be used in the analysis of interactions between variables: impulse response functions and forecast error variance decompositions. The complex nature of inter-relations in the VECM prevent the simple interpretation of estimated coefficients. Impulse response functions make it possible to study the impact of exogenous shocks on the variables of interest. In the context of the structural VECM, it is especially interesting to observe the impulse response functions of permanent and transitory shocks and to see whether they have characteristics implied by the presented theoretical framework.

Confidence intervals of impulse responses are calculated by a bootstrap method to assess the statistical significance of impulse responses. Efron (1985) and Hall (1988) confidence intervals are used. Variance decomposition is helpful in determining the proportion of variable fluctuations explained by individual structural shocks. One would expect the increasing explanatory power of permanent shocks and decreasing explanatory power of transitory shocks with an increasing time horizon.

5 Data

Variables used in this paper include: index of economic activity, government expenditures and money aggregate M1. The data are available from public sources, or are constructed from publicly available series. The data frequency is monthly and the time span covers the period from January 1997 to December 2008. All the variables are used in real terms, rebased to 1997 as a base year and transformed to natural logarithms. Since all the variables contain a strong seasonal component, variables were seasonally adjusted by the Census X12 method. Variables are plotted in their original and seasonally adjusted form in Figures 1 to 3.

An index of economic activity is constructed as a proxy of national output since GDP data is available only on a quarterly basis. The following series were used in the construction of the index: index of industrial production, real retail trade turnover index, construction work index and the number of tourist nights. The index is calculated as a weighted average of these components, where weights are their shares in gross value added. The total share of these activities in GDP is around 60 percent. It should be taken into account that gross value added categories are more broadly defined than individual indices used to represent them. The Central Bureau of Statistics of the Republic of Croatia (CBS) is the source of all data series used in the construction of the index of economic activity.[2]

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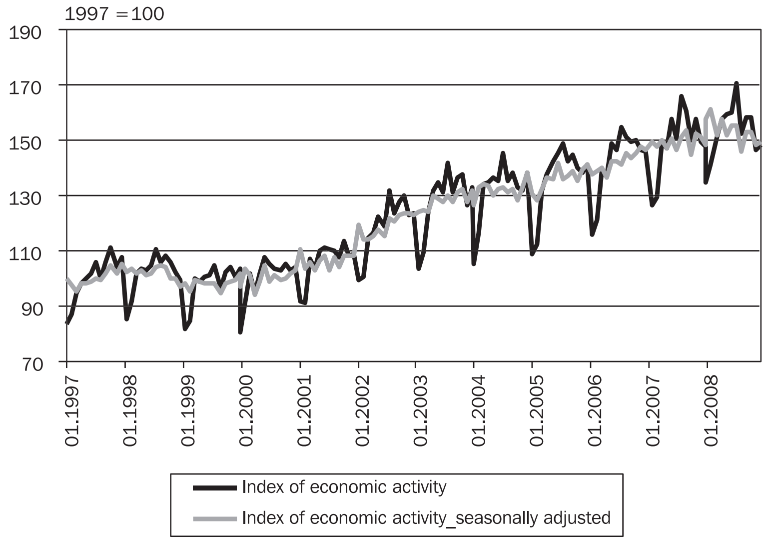
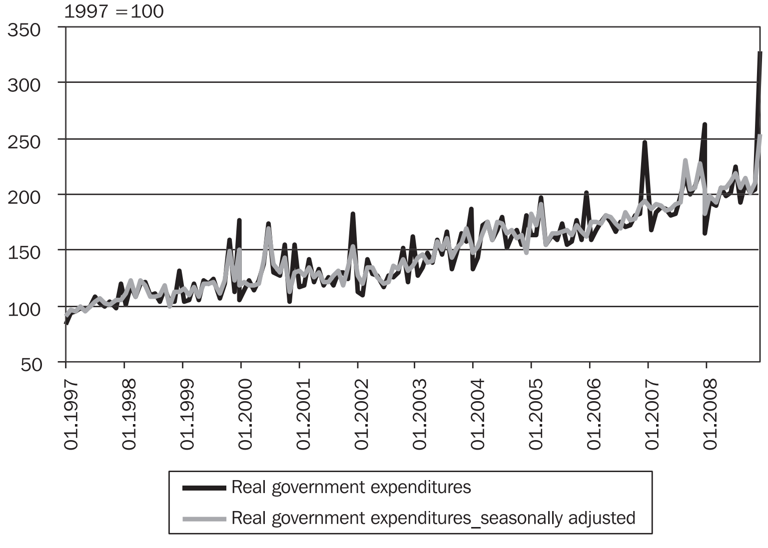
[2] *http://www.dzs.hr.*

Figure 1 **Index of Economic Activity**



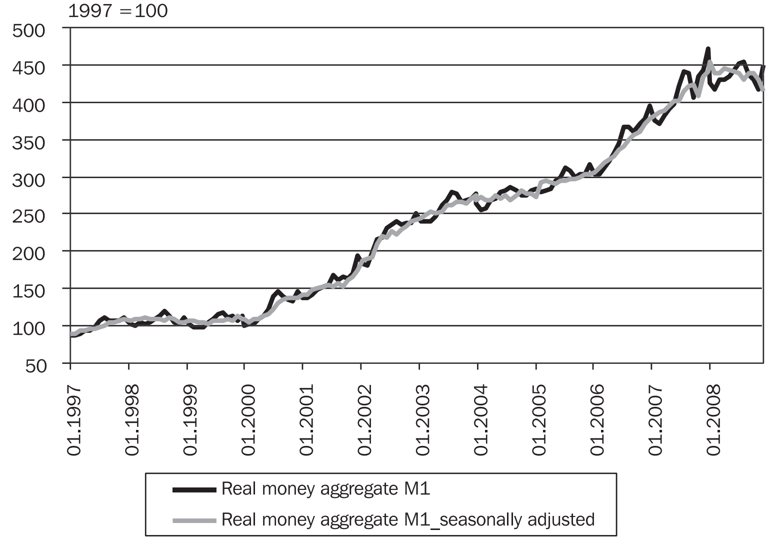
Source for original data: Central Bureau of Statistics of the Republic of Croatia.

Figure 2 **Government Expenditures**



Source for original data: Ministry of Finance of the Republic of Croatia.

Figure 3 **Money Aggregate M1**



Source for original data: Croatian National Bank.

The main problem with data on government expenditures was that the reporting standard changed from the GFS (Government Finance Statistics) 1986 to GFS 2001 in mid 2004. Therefore, all the data prior to this point needed to be reclassified from the GFS 1986 to GFS 2001 methodology to obtain a consistent time series.[3] According to the GFS 2001 methodology, the sum of categories Expense (2) and Acquisition of non-financial assets (3.1.1) was used as the government expenditures variable. The broadest coverage that could be achieved on a monthly basis is the consolidated central government because the consolidated general government data are available only quarterly. The CPI (Consumer Price Index) was used as a deflator of government expenditures. The source of government statistics is the Ministry of Finance[4], and for the CPI, the CBS.[5]

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[3] *See IMF (1986, 2001).*

[4] *http://www.mfin.hr.*

[5] *http://www.dzs.hr.*

The money aggregate M1 comprises of currency outside banks, deposits with the Croatian National Bank by other banking institutions and other domestic sectors, as well as banks' demand deposits.[6] This aggregate was chosen because in the situation where foreign exchange interventions are the main channel of money creation, it reflects changes in monetary policy. The Croatian National Bank is the source of the money aggregate M1[7], which is also deflated by the CPI.

6 Results

6.1 VECM Estimation

In the first step, trend properties of the data are examined by the augmented Dickey-Fuller unit root test. The number of lags has been automatically selected by the Schwarz criteria. The included deterministic components are trend and intercept, and the results are presented in Table 1. The null hypothesis that the monetary aggregate M1 and the index of economic activity have a unit root can not be rejected, even at a 10 percent significance level, while their first differences turn out to be stationary at a 1 percent significance level. The results of the test indicate that government expenditures are trend stationary. Inspection of the graphic representation of the series suggests non-stationary properties around the trend. Also, even a light smoothing of a series changes the results of the test in favour of unit root. This is indicative because smoothing of the series decreases the irregular component and reveals trend properties. Therefore, in the rest of the paper, government expenditures will be treated as a unit root process around a deterministic trend.

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[6] *See methodological explanations in Croatian National Bank (2009).*

[7] *http://www.hnb.hr.*

Table 1 **Unit Root Tests**

Null hypothesis:	**m has a unit root**	**D(m) has a unit root**	**g has a unit root**	**D(g) has a unit root**	**y has a unit root**	**D(y) has a unit root**
Exogenous:	Constant, linear trend	Constant, linear trend	Constant, linear trend	Constant, linear trend	Constant, linear trend	Constant, linear trend
Lag length*:	0	0	0	1	2	1
ADF test statistic:						
t-statistic	-0.984	-11.675	-8.380	-12.838	-1.765	-17.210
Prob.**	0.942	0.000	0.000	0.000	0.717	0.000

*Notes: *Lag Length: Automatic based on SIC, MAXLAG=13. **MacKinnon (1996) one-sided p-values.*
Source: Author's calculations.

The next step is the Johansen cointegration test, where linear trend and constant are deterministic terms included in the cointegrating equation. The number of lags in VAR, according to the Schwarz criteria, is four, and according to the Akaike information criteria, two. The maximum eigenvalue and trace tests suggest two cointegrating vectors at a 1 percent significance level in a system of first differences, with three lags included. The results of both tests are given in Table 2. Because of the presence of the residual autocorrelations in the VECM with three lags, results based on the VECM with six lags are reported. The trace test for the model with six lags suggests two cointegrating vectors at a 5 percent significance level.

Table 2 **Johansen Cointegration Test**

Unrestricted cointegration rank test (trace)				
Hypothesised no. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None*	0.191	62.207	42.915	0.000
At most 1*	0.163	31.609	25.872	0.009
At most 2	0.041	5.975	12.518	0.464
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesised no. of CE(s)	Eigenvalue	Max-eigenvalue statistic	0.05 critical value	Prob.**
None*	0.191	30.599	25.823	0.011
At most 1*	0.163	25.633	19.387	0.005
At most 2	0.041	5.975	12.518	0.464

*Notes: Max-eigenvalue test and trace test indicate 2 cointegrating eqn(s) at the 0.05 level. *Denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values.*
Source: Author's calculations.

An appropriate VECM with two cointegrating vectors is estimated in a two stage estimation procedure, with the Johansen approach in the first and OLS in the second step. Initially, the estimated model is over-parameterized, so statistically insignificant lags are dropped out. Also, three impulse dummy variables are included to account for outliers in October and December 1999 and December 2008 in fiscal policy equation. The estimated model is given in Table 3.

Table 3 **Estimated VEC Model**

Estimated cointegration relations:					**Lagged endogenous term:**			
	Ec1(t-1)	Ec2(t-1)				d(m)	d(g)	d(y)
					d(m)(t-1)	-	0.71	-
m(t-1)	1.00	-				-	[3.12]	-
	-	-			d(g)(t-1)	-	-0.55	-0.14
g(t-1)	-	1.00				-	[-6.66]	[-3.99]
	-	-			d(y)(t-1)	-	-0.48	-0.36
y(t-1)	-1.18	-1.93				-	[-2.06]	[-4.01]
	[-2.88]	[-4.51]			d(m)(t-2)	0.13	-	-
Const.	5.45	9.00				[1.70]	-	-
	[2.82]	[4.46]			d(g)(t-2)	-	-0.33	-0.12
TR.(t-1)	-0.01	0.00				-	[-3.89]	[-3.24]
	[-3.15]	[2.61]			d(y)(t-2)	0.14	-0.46	-0.18
						[2.23]	[-1.62]	[-2.45]
Loading coefficients:					d(m)(t-3)	-	-0.59	-
						-	[-2.56]	-
	d(m)	d(g)	d(y)		d(g)(t-3)	-	-0.22	-0.08
						-	[-2.52]	[-2.32]
Ec1(t-1)	-0.05	-	0.17		d(y)(t-3)	-	-0.69	-
	[-1.93]	-	[5.49]			-	[-2.56]	-
Ec2(t-1)	-	-0.27	0.11		d(m)(t-4)	0.28	0.31	0.25
	-	[-4.49]	[4.32]			[3.50]	[1.25]	[2.80]
					d(g)(t-4)	-	-0.24	-0.10
Deterministic terms:						-	[-2.83]	[-3.65]
					d(y)(t-4)	-	-0.38	-0.07
	d(m)	d(g)	d(y)			-	[-1.44]	[-1.19]
					d(m)(t-5)	0.35	0.43	-0.17
IMP1	-	0.24	-			[4.06]	[1.65]	[-1.92]
	-	[4.34]	-		d(g)(t-5)	-0.06	-0.34	-
IMP2	-	0.22	-			[-2.23]	[-3.99]	-
	-	[3.81]	-		d(y)(t-5)	-	-0.60	-
IMP3	-	0.26	-			-	[-2.44]	-
	-	[4.67]	-		d(m)(t-6)	-	-	-
						-	-	-
					d(g)(t-6)	-	-0.26	-
						-	[-3.97]	-
					d(y)(t-6)	-	-0.52	-
						-	[-2.60]	-

Note: t-statistic in brackets.
Source: Author's calculations.

Based on Equations (2) and (3), cointegrating vectors are identified between the index of economic activity and monetary aggregate M1, and the index of economic activity and government expenditures. As expected, estimated coefficients suggest a positive relation of money aggregate and the index of economic activity. Deterministic trend included in the first cointegrating equation is highly significant and negative. It turns out that there is also a deterministic trend in the second cointegrating equation which is highly significant and positive.

Estimated coefficients within the cointegrating vectors are statistically significant, while loading coefficients of the second cointegrating vector in the money equation and the first cointegrating vector in the government expenditures equation are not significantly different from zero. The loading coefficient of the first cointegrating vector in the money equation is negative as well as the loading coefficient of the second cointegrating vector in the government expenditures equation, just as it is expected in error correction models.

The results of diagnostic tests of the estimated VECM are shown in Table 4. The Portmanteau test does not reject the null hypothesis of no autocorrelation in the first 16 lags. As indicated by the Jarque-Bera test, there are normality issues with residuals from the second equation, but the Doornik-Hansen multivariate test does not reject normality at 1 percent significance level. ARCH (Autoregressive Conditional Heteroscedasticity) and multivariate ARCH LM tests do not imply problems with heteroscedasticity.

Table 4 **Diagnostic Tests**

	Test statistic	P-value
Portmanteau test with 16 lags, dof: 110:	98.484	0.776
Nonnormality test, (Doornik and Hansen, 1994), dof: 6	14.152	0.028
Jarque-Bera test:		
u1	1.153	0.562
u2	12.113	0.002
u3	0.731	0.694
ARCH-LM test with 16 lags:		
u1	22.876	0.117
u2	8.005	0.949
u3	14.208	0.583
Multivariate ARCH-LM test with 16 lags, dof : 576:	606.667	0.182

Source: Author's calculations.

6.2 Structural VECM Estimation

The two cointegrating relationships in the system imply one permanent and two transitory shocks. In this situation, the permanent shock is identified without further restrictions and only one restriction is needed to identify transitory shocks. Three cases were considered: a fiscal policy shock has no contemporaneous effect on the money aggregate M1; a monetary policy shock has no contemporaneous impact on government expenditures; and the case with two restrictions, zero contemporaneous effect of a monetary policy shock to government expenditures and zero contemporaneous effect of a fiscal policy shock to economic activity which yields an overidentified system. The method of estimation is maximum likelihood with the Amisano and Giannini scoring algorithm and the software used was JMulti, which comes as a freeware with the Lütkepohl and Krätzig (2004) textbook.

The first case with no contemporaneous impact of fiscal policy shocks on the money aggregate M1 implies the following restrictions on B matrix and the long-run impact matrix ΞB:

$$B = \begin{bmatrix} * & 0 & * \\ * & * & * \\ * & * & * \end{bmatrix}, \quad \Xi B = \begin{bmatrix} 0 & 0 & * \\ 0 & 0 & * \\ 0 & 0 & * \end{bmatrix}; \tag{12}$$

the second case with a restriction of zero contemporaneous effect of a monetary policy shock to government expenditures:

$$B = \begin{bmatrix} * & * & * \\ 0 & * & * \\ * & * & * \end{bmatrix}, \quad \Xi B = \begin{bmatrix} 0 & 0 & * \\ 0 & 0 & * \\ 0 & 0 & * \end{bmatrix}; \tag{13}$$

and the third case with overidentifying restrictions:

$$B = \begin{bmatrix} * & * & * \\ 0 & * & * \\ * & 0 & * \end{bmatrix}, \quad \Xi B = \begin{bmatrix} 0 & 0 & * \\ 0 & 0 & * \\ 0 & 0 & * \end{bmatrix}, \tag{14}$$

where * represents unrestricted elements to be estimated. Restrictions of the first two columns in the long-run impact matrix are provided by cointegrating properties of the system and are the same in all three observed cases. Their implication is that there is no long-run effect of temporary shocks on variables in the system. T-values are calculated on the basis of standard deviations of estimates obtained by the bootstrap method with 1,000 replications.

Estimated coefficients, together with their t-values for all three cases, are presented in Table 5.

Table 5 **Estimated B-models with Long-run Restrictions**

Model I				**Model II**				**Model III**			
Long-run restrictions: 2				Long-run restrictions: 2				Long-run restrictions: 2			
Contemp. restrictions: 1				Contemp. restrictions: 1				Contemp. restrictions: 2			
Convergence: 9 iterations				Convergence: 13 iterations				Convergence: 8 iterations			
Log likelihood: 1,249.68				Log likelihood: 1,249.68				Log likelihood: 1,248.92			
								LR test prob: 0.2188			
Estimated B matrix:				**Estimated B matrix:**				**Estimated B matrix:**			
	m	g	y		m	g	y		m	g	y
m	0.007	0.000	0.021	m	0.006	-0.005	0.021	m	0.006	-0.005	0.021
	[2.55]		[2.89]		[2.41]	[-2.47]	[3.22]		[2.30]	[-2.28]	[11.68]
g	-0.030	0.035	0.033	g	0.000	0.046	0.033	g	0.000	0.046	0.033
	[-3.40]	[5.31]	[2.71]			[6.94]	[2.93]			[6.95]	[4.85]
y	-0.014	-0.015	0.005	y	-0.020	-0.002	0.005	y	-0.020	0.000	0.005
	[-4.47]	[-5.86]	[2.16]		[-6.42]	[-0.82]	[2.27]		[-14.17]		[2.35]
Estimated long-run impact matrix:				**Estimated long-run impact matrix:**				**Estimated long-run impact matrix:**			
	m	g	y		m	g	y		m	g	y
m	0.000	0.000	0.018	m	0.000	0.000	0.018	m	0.000	0.000	0.018
			[1.71]				[1.87]				[2.88]
g	0.000	0.000	0.029	g	0.000	0.000	0.029	g	0.000	0.000	0.029
			[1.71]				[1.87]				[2.88]
y	0.000	0.000	0.015	y	0.000	0.000	0.015	y	0.000	0.000	0.015
			[1.71]				[1.87]				[2.88]

Note: t-statistic in brackets.
Source: Author's calculations.

These coefficients describe only contemporaneous interactions between variables and impulse responses might offer a significantly different picture of the short-run dynamics due to six lags included in the model and the monthly frequency of data. All the t-values indicate coefficients different than zero, except the coefficient of contemporaneous effect of a fiscal policy shock to economic activity in the second case. The overidentifying restriction that this coefficient is not equal to zero cannot be rejected at a 10 percent significance level by the likelihood ratio test and, therefore, this case is also included in the further analysis. As expected, coefficients in the estimated long-run impact matrix are all significantly positive.

6.3 Analysis of Impulse Responses and Variance Decompositions

Impulse response functions and variance decompositions for the length of 100 periods for all three cases were considered. The size of the shocks in impulse response functions is one standard deviation. Both Hall and Efron 90 percent confidence intervals were plotted with impulse responses. These confidence intervals are calculated by bootstrap method with 1,000 replications. The impulse response functions of individual variables to the identified monetary policy, fiscal policy and aggregate supply structural shocks in all three cases are presented in Figures 4, 6 and 8. The impacts of individual orthogonal shocks are observed in the columns of charts; so the first column, for example, shows the impulse response functions of all the three variables to the structural positive monetary policy shock of one standard deviation. The forecast error variance decomposition is used to assess the relative importance of individual shocks in explaining forecast error variances of the observed variables. Forecast error variance decompositions are presented in Figures 5, 7 and 9.

The basic features of the impulse responses are very similar in all three cases. The analysis is based on the common patterns across the cases rather than on the detailed examination of some differences that occurred in the certain periods. Point estimates, as well as the confidence intervals, indicate a positive reaction of the money aggregate M1 to the positive monetary policy shock and a negative reaction to the fiscal policy shock in the short-run. Transitory nature of these aggregate demand shocks leads to the zero effect in the long-run. On the other hand, the positive aggregate supply shock has a positive and statistically significant permanent effect on the level of the money aggregate M1 variable. The common feature of all three observed cases is that the biggest part of money aggregate M1 variations in the short-run, or the first year, is explained by the aggregate supply shock. The part explained by the permanent shock slightly grows with an increasing time horizon.

The reaction of government expenditures to the positive monetary policy shock is the initial ripple around zero, followed by a protracted mildly positive effect before the disappearance in the long-run. The picture is even more blurred by confidence intervals which point to the periods where reactions are not significantly different from zero. In order to see the total impact of the monetary policy shock to government expenditures, the accumulated impulse response was checked, which indicated a statistically significant negative response in all three cases. Government expenditures reaction to the positive fiscal policy shock is statistically significant and positive in the short-run. As expected, response to the aggregate supply shock is significantly positive and permanent. In the short-run, government expenditures variations are to the largest extent explained by the fiscal policy shock, but this changes swiftly with an increasing time horizon, and in the long-run aggregate supply shocks explain more than 80 percent variations in government expenditures.

The analysis of the index of economic activity reaction to transitory shocks is not so conclusive. Initially, there is a strong and statistically significant negative impact of positive monetary policy shock on the index of economic activity, which then becomes positive for a certain period of time. Confidence intervals suggest a statistical significance of the initial negative impact, but a positive reaction of government expenditures in the following periods seems to be statistically insignificant. The response to the fiscal policy shock is dependent on the contemporaneous restrictions imposed. In the first case, there is a significant initial impact, while in the other two cases, the pattern shows the initial ripple, followed by a number of negative periods. It should be noted, though, that responses in the cases two and three seem statistically insignificant. Once again, the positive aggregate supply shock has significantly positive permanent effect on the index of economic activity. In the short-run, fiscal and monetary policy shocks have some role in explaining variations in the index of economic activity, but in the long-run, more than 90 percent of variations are explained by aggregate supply shocks.

6.4 Interpretation of the Results

Basic assumptions of the theoretical framework which were confirmed by the estimated VECM were that policy instruments and national output are cointegrated. The existence of deterministic trend in the first cointegrating vector was anticipated to account for the velocity of money. It turned out that there is also a significant deterministic trend in the second cointegrating vector which was not specified in the theoretical framework. One plausible explanation of the second cointegrating relation are different elasticities of government expenditures with respect to the cyclical component of national output and the long-term trend of national output. This can be seen if the second cointegrating equation is rewritten in the form:

$$g_t = -3.5 + 1.9\left[y_t - \left(0.003775t + 4.7\right)\right] + 0.75\left(0.003775t + 4.7\right) \ . \tag{15}$$

Namely, 0.003775t+4.7 represents a separately estimated trend component of national output which can be viewed as a proxy of potential output $\overline{y}$. If an appropriate restriction is imposed on the constant term, which was not rejected by the Wald test at a 10 percent significance level, then the cointegrating relationship becomes:

$$g_t = 1.9\left(y_t - \overline{y_t}\right) + 0.75\overline{y_t} \ . \tag{16}$$

These cointegrating relationships are the same as saying that the level of government expenditures and money aggregate M1 are bound by the level of national output in the long-run, which makes sense in the real world. Although government expenditures can be financed from sources other than the national output, such as privatisation receipts or borrowing, eventually this will lead to an unsustainable debt burden or exhausted national wealth. Also, the above offered interpretation with different elasticities of government expenditures gives interesting implications. Namely, the coefficient in front of the cyclical component of national output suggests procyclical fiscal policy in Croatia which is on the track of Ilzetzki and Vegh (2008) findings on procyclical fiscal policy in developing countries. The amount of money in the economy also cannot increase endlessly. This is especially the case for the country with such an exchange rate regime as in Croatia, where foreign exchange interventions make the main channel of money creation.

In this context, fiscal and monetary policies were defined as shocks to government expenditures and the monetary aggregate M1, which cannot be explained by the level of national output. In the case of fiscal policy, an example of one such positive shock might be increased government spending financed by privatisation receipts. Significant foreign capital inflow or outflow not related to the national output, which will induce foreign exchange intervention and consequently increase money in the system, is an example of a monetary policy shock. In the long-run, though, both shocks are expected to disappear. The only permanent shock in the system is an aggregate supply shock which has a permanent impact on all three observed variables.

The variance decompositions and impulse responses of variables to these identified structural shocks can be summarised as follows. Firstly, positive fiscal shocks have a predominantly negative impact on the money aggregate M1 no matter which contemporaneous restrictions are imposed. Although not as clear, the effects of positive monetary policy shocks on government expenditures were predominantly negative. Therefore, it seems that two policies acted as substitutes. Secondly, the overall impact of transitory aggregate demand shocks on the index of economic activity is not clear due to statistically insignificant impulse responses and the dependence of responses on contemporaneous restrictions imposed. Thirdly, positive permanent aggregate supply shocks increase economic activity, government expenditures and the money aggregate M1 in the long-run and the biggest part of the variations in all three variables in the medium and long-run are explained by aggregate supply shocks.

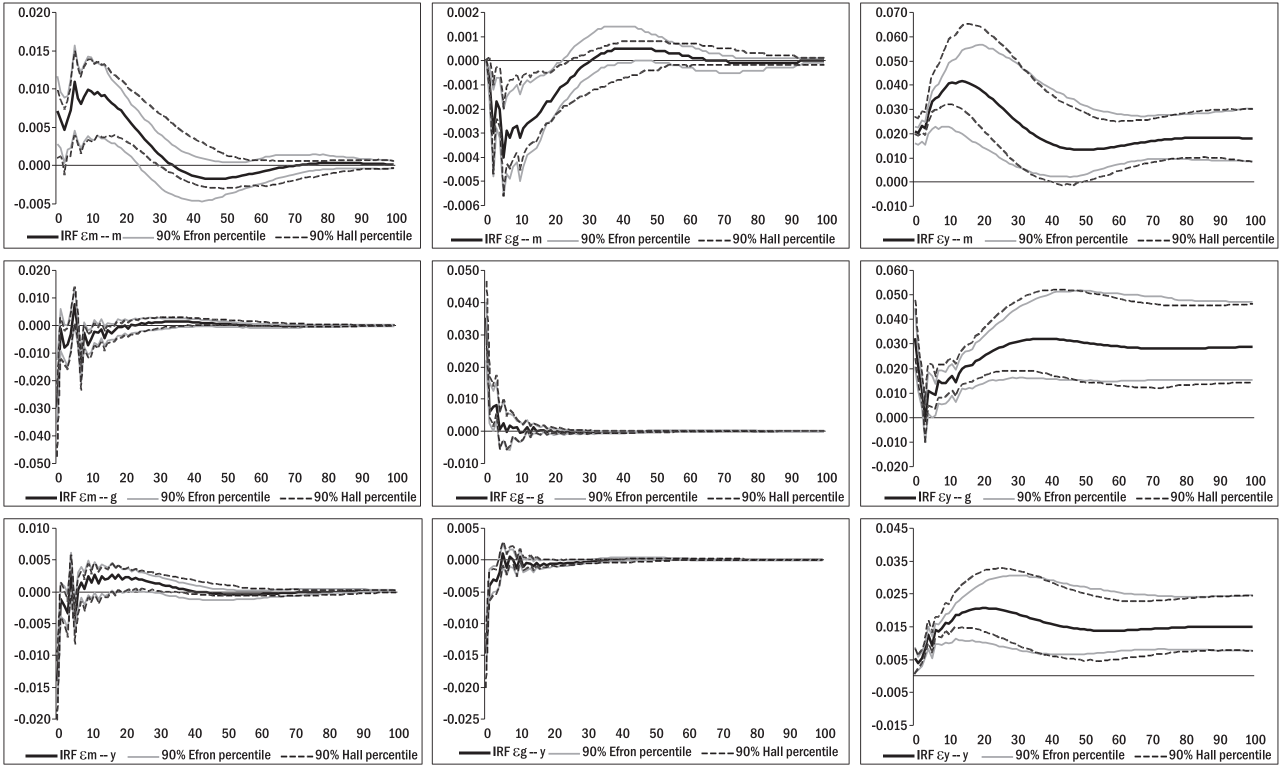
7 Summary and Conclusion

The main purpose of this paper was to analyse the interactions among fiscal policy, monetary policy and economic activity in Croatia. In this respect, a simple theoretical framework was developed which served as a basis for the empirical analysis. As a part of this framework, structural fiscal and monetary policy shocks and structural aggregate supply shocks were defined. The structural VECM methodology served the purpose of structural shocks identification. The effects of these shocks on the behaviour of variables of interests were examined by impulse response functions and variance decompositions.

The results lead to the following conclusions. The effects of fiscal policy shocks on the money aggregate M1 are negative and the effects of monetary policy shocks on government expenditures are also negative, which implies that two policies behaved as substitutes. Furthermore, clear conclusions on the effects of transitory shocks to the index of economic activity could not be reached. Also, monetary and fiscal policy have a dominant effect on economic activity only in the short-run, while in the medium and long-run economic activity is dominated by its own dynamics. Finally, positive permanent aggregate supply shocks have significant positive effects on all the three observed variables in the long-run.

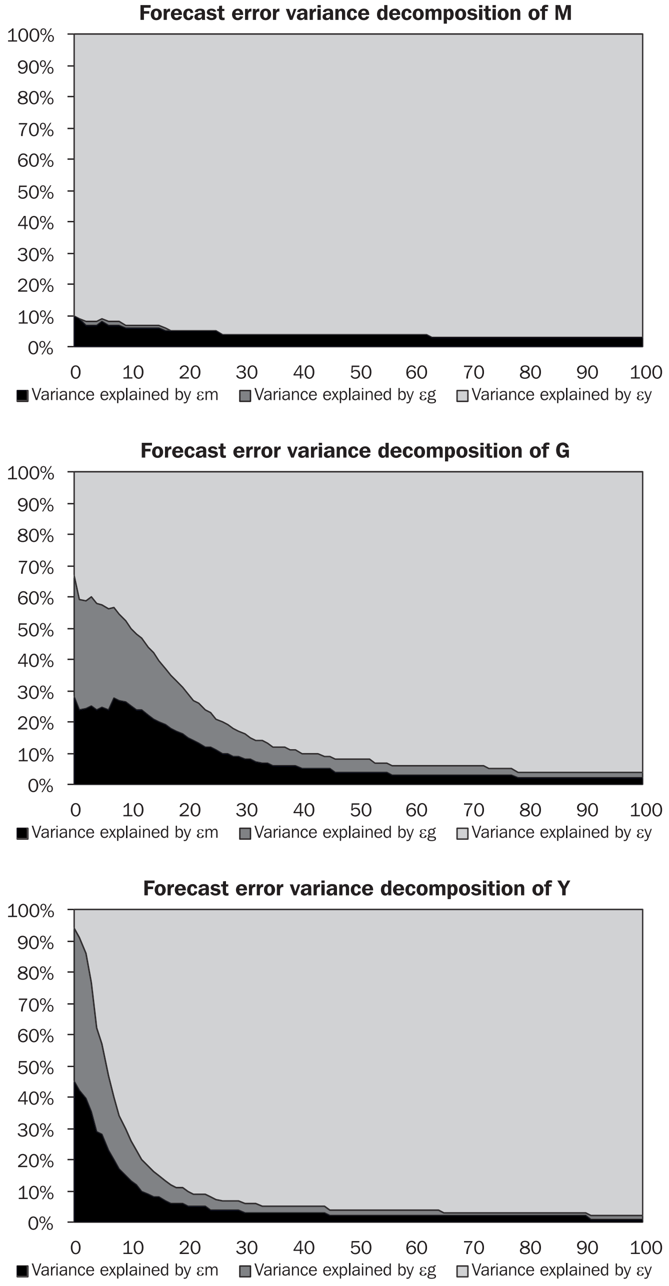
Future work on this topic could give a more precise definition of fiscal and monetary policy shocks. While here only general shocks are observed, for policy purposes, a more sophisticated model is needed with additional variables, including the exchange rate, government revenues and interest rates. Such a model would reach a high enough level of sophistication needed to engage in the applied formulation of the policies.

Figure 4 **Impulse Responses (Based on the Restrictions from Table 5, Model I)**



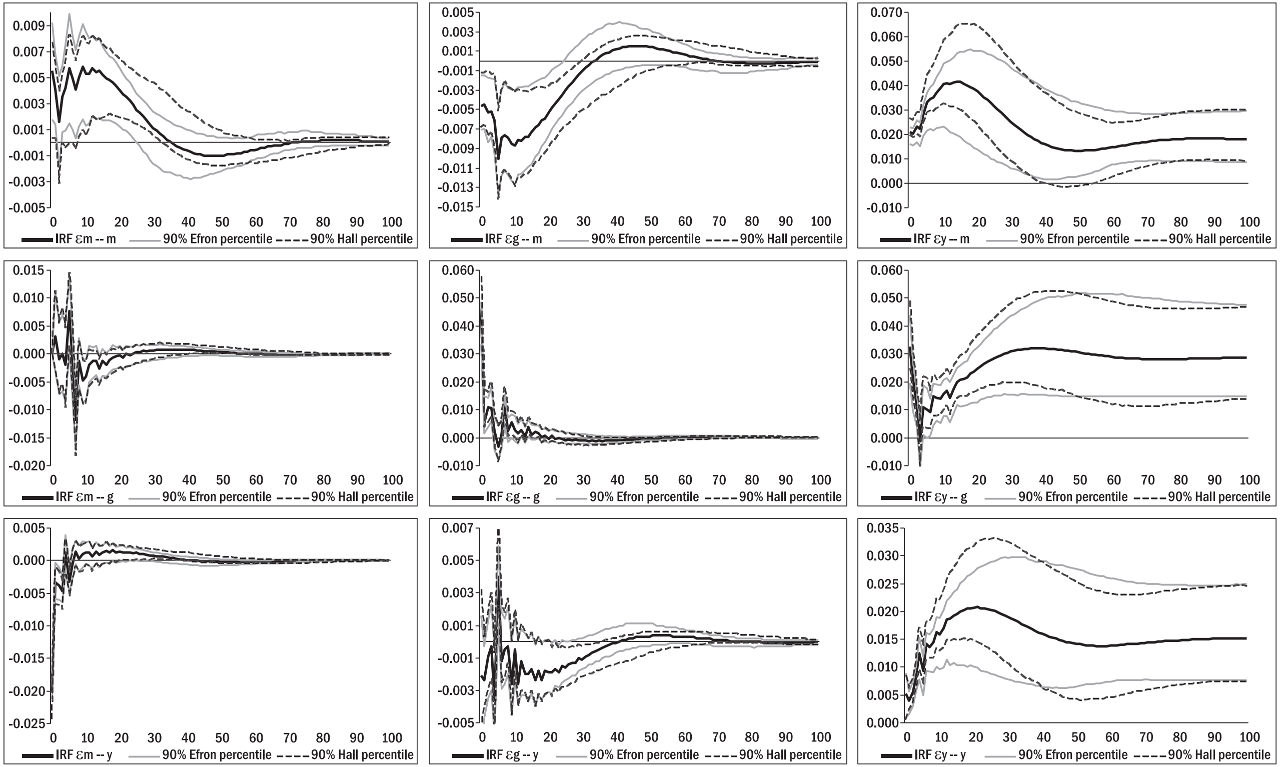
Source: Author's calculations.

Figure 5 **Forecast Error Variance Decompositions (Based on the Restrictions from Table 5, Model I)**



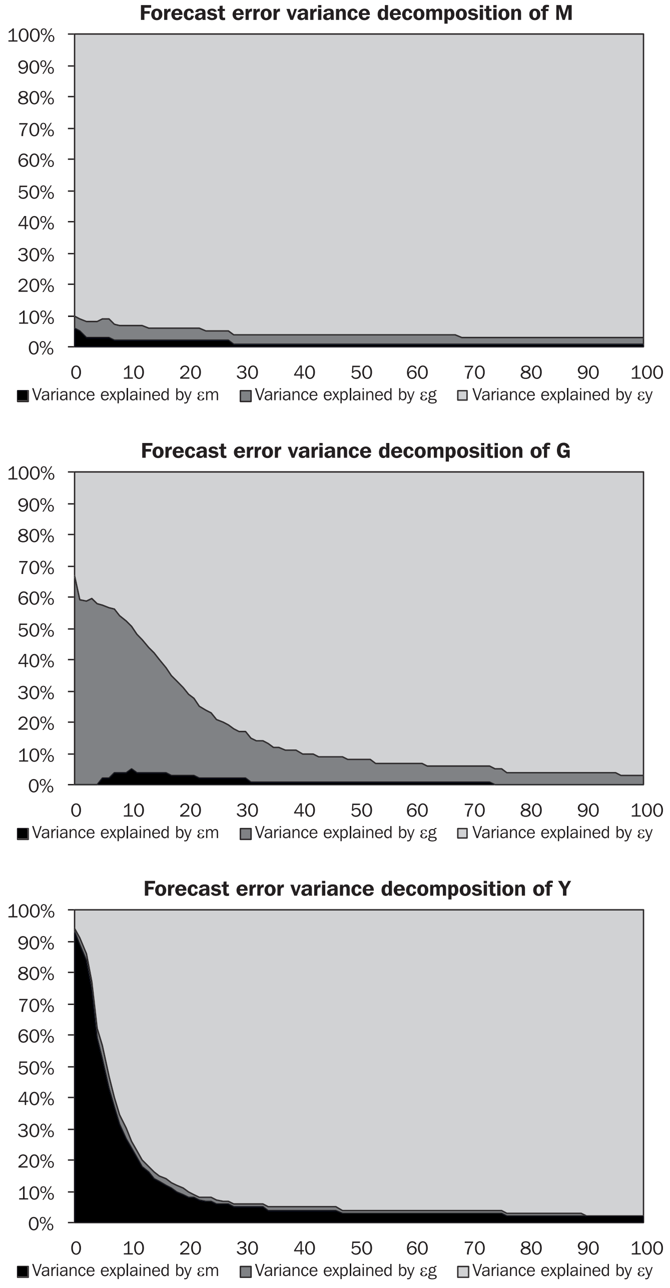
Source: Author's calculations.

Figure 6 **Impulse Responses (Based on the Restrictions from Table 5, Model II)**



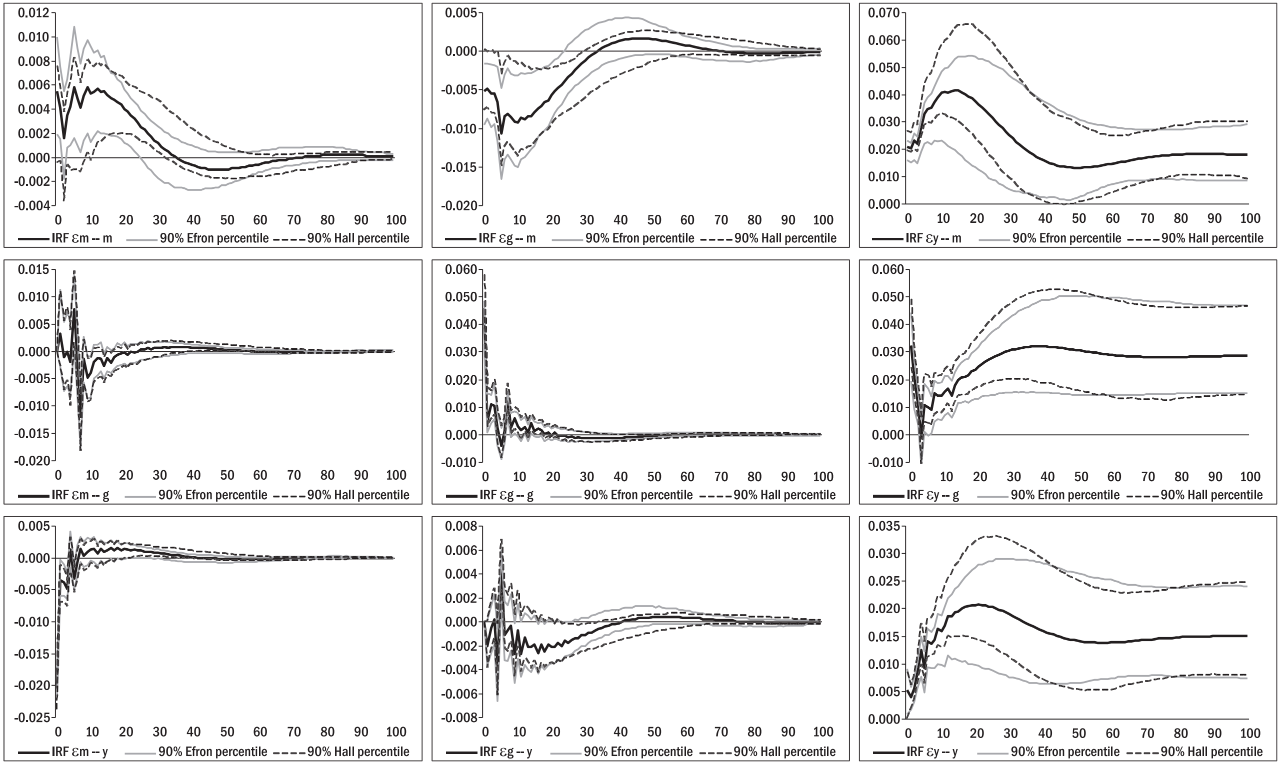
Source: Author's calculations.

Figure 7 **Forecast Error Variance Decompositions (Based on the Restrictions from Table 5, Model II)**



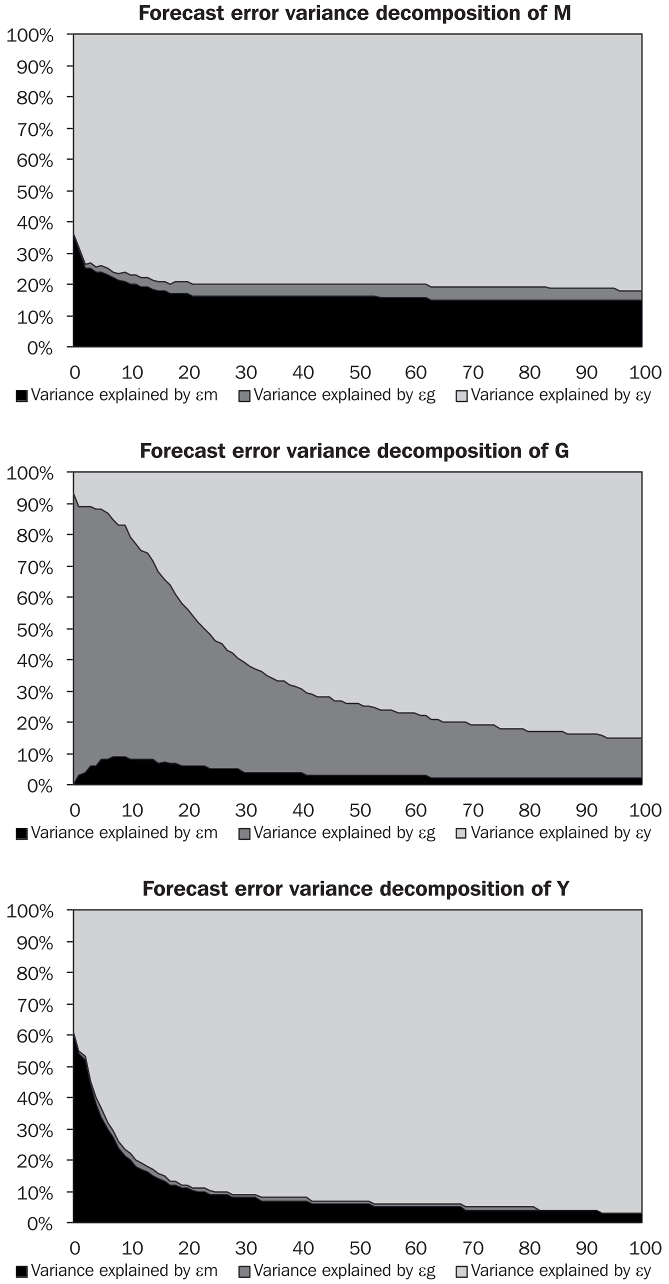
Source: Author's calculations.

Figure 8 **Impulse Responses (Based on the Restrictions from Table 5, Model III)**



Source: Author's calculations.

Figure 9 **Forecast Error Variance Decompositions (Based on the Restrictions from Table 5, Model III)**



Source: Author's calculations.

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