THE ANALYSIS OF MONETARY TRANSMISSION MECHANISM IN CROATIA USING COINTEGRATION APPROACH

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Abstract

In this paper, authors analyze monetary transmission in Croatia from 1998 to 2009 including the impact of euro area income using cointegration approach. Direct channel, interest rate channel and exchange rate channel are discussed. The analysis of interest rate, exchange rate, money supply, income in Croatia as well as euro area income time series is conducted. ADF tests show the stationarity of time series in first differences, thus cointegration approach is used to examine effects of mentioned variables on Croatian income. Cointegrating relations are found among selected variables and income. The innovation analysis, i.e. variance decomposition and impulse response function analysis is done. Cointegration analysis has shown that mentioned monetary transmission channels are significant in the long run, as well as the effect of euro area income on Croatian income. The article concludes by the comparison of monetary transmission in Croatia with empirical findings and theoretical background.

Key words: *cointegration approach, innovation analysis, monetary transmission, euro area impact*

1. INTRODUCTION

Impacts of monetary policy on real economic activity have been widely discussed for decades. While there are different views about monetary transmission effects in developed countries, monetary transmission effects are even more uncertain in transition countries. As more central banks of Central and Eastern Europe prepare themselves for the entrance in the European Monetary Union, the knowledge of monetary policy

transmission mechanisms becomes crucial for the appropriate design and implementation of the monetary policy (Čenić, 2004). In this paper, three monetary transmission channels are analyzed: interest rate channel, exchange rate channel and money supply channel. In addition, in context of accession into EU and EMU, the impact of euro area income on Croatian income is analyzed. Vector autoregression methodology, namely cointegration approach is used in analyzing mentioned channels and euro zone impact on Croatian income.

Interest rate channel is the oldest known in the literature of monetary policy transmission mechanisms. Its basis is presented in Keynesian IS-LM model. Expansive monetary policy leads to fall in real interest rates lowering the cost of capital and leading to growth of investment and output. Although Keynes originally talked about the importance of decisions about investment, interest rate mechanism is important in households' investment and durables demand (Žigman, Lovrinčević, 2005). Exchange rate channel during a monetary expansion leads to a decrease of domestic interest rates, relative to the foreign ones, followed by currency depreciation. This causes a rise in net exports and hence output. Direct monetary transmission is related to money supply. An increase in money supply results in surplus of cash balances and over time in an expansion in aggregate spending. Direct transmission could also be viewed as a part of real balances effect which connects the monetary with the commodity sector (Čenić, 2004).

Vector autoregression methodology is widely used in quantifying the impacts of monetary policy on the real economy. In the recent VAR literature in Croatia and the EU a huge amount of effort has been devoted to discover how the actions of Central bank affect output and inflation rate. Also, a lot of researches have tried to evaluate how will transition economies response on entering the EMU.

In Croatia, Benazić (2008), Vizek (2006), Lang and Krznar (2004), Erjavec, Cota, and Bahovec (1999) and Erjavec and Cota (2003) have used a VAR approach in analyzing monetary transmission mechanism. Benazić (2008) concluded that monetary transmission in Croatia has considerably weaker strength than in the EU. Conducted analysis indicated a relatively important role of the exchange rate, which is characteristic for transitional countries. Also, a significant effect of European Union interest rate and income on the Croatian economy was found. Vizek (2006) proved that monetary policy has significantly affected the real sector through exchange rate channel and direct channel, but not through interest rate channel. Lang and Krznar (2004) found that monetary policy in Croatia is procyclical and thus the exchange rate depreciation is positively correlated with monetary tightening. They also found an evidence of significance of bank lending channel and proved that monetary policy reacts to current account deficit. Erjavec and Cota (2003) used cointegration approach in investigating relationship between money, output, prices and exchange rate.

In Europe, a lot of researches have used a VAR approach in monetary transmission analysis : Cecioni, and Neri. (2010), Bartels (2009), Anzuini and Levy (2007), Arnoštová and Hurník (2005), Juselius, and Toro

(2005), Hericourt and Matei (2004), Lovrinović and Benazić (2004), Angeloni, Kasyap, Mojon and Terlizzese (2001), Peersman and Smets (2001), Mojon and Peersman (2001), McCoy and MacMahon (2000), Dedola and Lippi(2000). Bartels (2009) used VAR to research the impact of EU monetary policy on Austria and Germany. Lovrinović and Benazić (2004) researched interest rate channel in the EU and concluded that the interest rate influences only the industrial production and not retail prices, real exchange rate and M1. Peersman and Smets (2001) used synthetic euro area data and found that a temporary rise in the nominal and real short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output. The conclusion is that the results are very similar to those obtained for the US economy using similar methodologies. Dedola and Lippi (2000) made a detailed analysis of monetary impact on industry of five OECD countries. They found that monetary policy effects are stronger in the industries producing durable output, with a higher capital intensity of production and with smaller borrowing capacity (smaller leverage ratio).

2. EMPIRICAL ANALYISIS OF MONETARY TRANSMISSION IN CROATIA

2.1. Data and methods

In this part, the effect of money supply, interest rate, and exchange rate in Croatia, as well as income in euro zone, on Croatian income is examined using econometric analysis techniques. Firstly, the stationarity of mentioned variables is tested using Augmented Dickey- Fuller (ADF) Unit Root test. After testing the integration of variables, cointegration is tested using Johansen cointegration test. Error correction model is defined and the effects of one-unit shock in mentioned variables on Croatian income are analyzed using impulse response functions. Forecast error variance decomposition is done to show the proportion of the movements in a sequence due to its own shocks versus shocks to other variables (see Enders, 2010).

Data is collected form Croatian National Bank and Central Bureau of Statistics, Republic of Croatia. Variable money supply is approximated by monetary aggregate M1. This approximation is also used in Benazić, 2008, Vizek, 2006, Lovrinović and Benazić, 2004, Erjavec and Cota, 2003. For each central bank the most important information is the one about the funds that have transaction function, as they most potentially affect the price level change. This is about the most liquid forms of money which are usually found in the monetary aggregate M1, i.e. cash and demand deposits (Lovrinović, Ivanov, 2003).

Variable interest rate is represented by money market interest rate. In Croatia, significant part of the monetary transmission works through changes in interest rates on money market, which can be used as proxy / surrogate variable for the stance of monetary policy (IMF Report, 2004).This approximation is found

also in Monnet, Veber (2001), Vizek, (2006), Benazić (2008), Lang and Krznar (2004), McCoy and MacMahon (2000).

Exchange rate is represented by effective exchange rate indices, 2001=100 (see Dumičić, Čibarić, 2009, Benazić, 2008, Erjavec and Cota, 2003, Angeloni, Kasyap, Mojon and Terlizzese, 2001). Regarding income in Croatia, monthly data on Croatian national income or GDP is not available. Therefore, monthly industrial production indices, 2001=100 approximate domestic income. Foreign income, i.e. euro area income is approximated by total industrial production (excluding construction) indices in euro area[1], 2001=100. Industrial production indices are used as a proxy for income in Dumičić, Čibarić (2009), Čibarić (2009), Cota and Erjavec (2001), Vizek (2006), Lovrinović and Benazić (2004), Erjavec and Cota (2003), Dedola and Lippi (2000). Monthly time series data from February 1998 until August 2009 is used in this analysis. Monetary aggregate M1, money market interest rate and effective exchange rate indices time series are provided by Croatian National Bank statistics. Domestic industrial production indices and consumer price indices are found in Central Bureau of Statistics Monthly Reports. Euro zone industrial production indices are announced by Eurostat.

Data on monetary aggregate M1 and domestic industrial production indices in Croatia are deflated by consumer price indices, 2001=100 taken from Monthly Reports of the Central Bureau of Statistics, Republic of Croatia. Nominal money market interest rates are accounted for the effects of inflation. Inflation rate which is used to calculate real interest rates is also based on consumer price indices, 2001=100. Real effective exchange rate indices, 2001=100 are published by Croatian National Bank as a weighted geometric average of bilateral exchange rate indices adjusted by relative price indices, which are calculated as the ratio of consumer price indices in the partner countries and domestic prices. Regarding real industrial production indices in the euro area, real indices are calculated using consumer price indices, 2001=100 provided by Eurostat.

After deflating nominal data, logarithmic transformation was conducted. Logarithmic values of original data series are used to eliminate the problem of heteroskedasticity (see Čibarić, 2010, Maddala, Lahiri, 2009). Since observed time series data show presence of seasonal component, seasonal adjustment is conducted for all variables. Tramo/Seats method in Demetra 2.1., which is often used by Eurostat and Central Bureau of Statistics, Republic of Croatia, is used for seasonal adjustment of original data series.

Hence, variables included in cointegration analysis are:

[1] Eurostat announces real production indices for euro area 16.

- domestic income y_d, represented by domestic seasonally adjusted logarithmic real industrial production indices, 2001=100
- domestic money supply m, represented by domestic seasonally adjusted logarithmic real values of monetary aggregate M1
- domestic interest rate r, approximated by domestic seasonally adjusted logarithmic real money market interest rate
- exchange rate e, represented by domestic seasonally adjusted logarithmic real effective exchange rate indices, 2001=100
- euro area income y_f, approximated by seasonally adjusted logarithmic real industrial production index in the euro area 16, for total industry (excluding construction), 2001=100

2.2. Long run equation

ADF unit root tests have shown that all variables are stationary in first differences at 5% significance[2]. To define model, it is necessary to determine lag length. Values of Akaike information criteria (AIC), Schwartz-Bayes information criteria (SBC) and Hannan-Quinn information criteria (HQ) are calculated[3]. AIC indicates the highest lag length. Lag length which minimizes AIC for variables in levels equals k=12. This is chosen as the optimal lag length due to the fact that it is justified to expect that changes in domestic money supply, exchange rate, domestic interest rate and euro area income will affect domestic income with 12 months delay. Studies have showed that monetary policy affects the economy with large time lag. Therefore, it is generally accepted that monetary policy should not react to momentary, but the expected effects and it is important to take into account time delay of monetary measures (HUB analyses, 2009).

Information criteria is also used for choosing appropriate model regarding the deterministic components in the multivariate system show that. The lowest value of SBC and AIC is found for Model 4[4] in which intercept exists in both vector error correction model and in cointegrating equation, and linear trend exists only in cointegrating equation. Model is appropriate for analysis of trend stationary time series. For detailed explanation of models see, for example, Asteriou (2006).

Number of cointegrating relations is tested using trace test and maximum eigenvalue test. Both tests indicate four cointegrating relations at 5% significance. Variables are shown to be cointegrated, i.e. there is a long-

[2] ADF test Eviews 6 output is available on request.
[3] Calculated values are available on request.
[4] Calculated values are available on request.

run relationship between them. First cointegrating vector is mostly correlated to the stationary part of the model (Čibarić, 2010, Wongbangpo, Sharma, 2002). Hence, error correction model is defined.[5] Model diagnostics tests are conducted. LM test of autocorrelation shows that null hypothesis of no autocorrelation of residuals can not be rejected up to lag length k=13 at 1% significance. White heteroskedasticity test has shown that null hypothesis of homoskedasticity can not be rejected at 1% significance. Test statistic of White test is chi-square, χ^2 = 1834.147 with corresponding p-value=0.4683.

Since variables are shown to be cointegrated, long run equilibrium between domestic income, money supply, exchange rate, domestic interest rate, and euro area income exists. It is important to note that term "equilibrium" is used differently in econometric terms in relation to how that term is used by economic theorists. Economic theorists use term equilibrium in the sense of equality between actual and desired state of economic variables. In econometric sense, the term refers to the long run relationship between non-stationary variables. Cointegration does not require the long run equilibrium to be the result of a market mechanism or behavior of individuals (Čibarić, 2010).

Cointegrating equation is given in (1). Coefficients $\lambda_1,\ldots,\lambda_4$ show long run effects of domestic money supply, exchange rate, domestic interest rate, euro area income on domestic income, respectively. Coefficient λ_0 shows that variables are cointegrating around constant, while coefficient λ_5 shows the existence of trend component in cointegrating relation, what is characteristic for this model (Model 4 mentioned above).

$$y_d = \lambda_c + \lambda_1 m + \lambda_2 e + \lambda_3 r + \lambda_4 y_f + \lambda_5 t \tag{1}$$

Table 1: Long-run equation parameters with t-statistics and standard errors

Variable	m	e	r	y_f
Parameter value	0.279135	-0.278071	-0.006560	1.093852
Standard error	0.02471	0.08646	0.00146	0.13338
t-statistics	-11.2963	3.21633	4.49863	-8.20093

Source: Authors' calculations

Table 1 shows values of parameters $\lambda_1,\ldots,\lambda_4$ with corresponding standard errors and t-statistics. All included variables are significant in explaining real income in Croatia in long run. In other words, direct channel, exchange rate channel and interest rate channel are significant in long run, as well as the impact of euro area income. Increase in monetary aggregate M1, holding all other variables constant, has a positive impact on income in Croatia. Exchange rate increase, ceteris paribus, has negative impact on the income, as well as the interest rate. Impact of euro area income, holding all other variables constant, is positive.

[5] Due to large number of parameters and k=12 lags Eviews output is available on request.

Table 2 : The expected effects of increase in money supply, interest rate, exchange rate and EU income on domestic income regarding economic theory and relevant empirical research

Variable	Economic theory	Empirical research
Money supply	+	+
Interest rate	-	+ or -
Exchange rate	+	-
EU income	+	+

Source: Benazić (2008), Čenić (2004), Lang and Krznar (2004), Vizek (2006).

Table 2 shows impacts of analyzed variables regarding economic theory and empirical research. An increase in real money supply increases real income in Croatia, what is in line with both economic theory and empirical research. Real interest rate effect in long run in this paper is shown to be negative, what is in line with economic theory, although Vizek (2006) obtained different empirical result for Croatia. Coefficient of real interest rate is relatively small, as in other empirical research of interest rate channel in Croatia (Benazić, 2008, Vizek, 2006). This shows that interest rat echannel is relatively weak in Croatia. The Croatian National Bank does not lead interest rate based monetary policy, and using policy or market interest rates as indicators of monetary policy is unreliable since they suffer from structural breaks due to problems in the banking sector (Lang and Krznar, 2004). Real exchange rate increase, i.e. real depreciation theoretically leads to increase in income through increase in net exports. However, this research, as well as other empirical research in Croatia, has shown that real exchange rate depreciation negatively affects real income. This result explains that the relationship between exchange rate and industrial production is not in accordance with basic economic principles (kuna depreciation will not have the expected expansionary effect on the industrial production). Such behavior of industrial activity is characteristic of economic systems such as Croatia, in which monetary policy is based on nominal exchange rate anchor (Vizek, 2006). Real euro zone income increase leads to increase in Croatian income in long run. Therefore, long run equation is in line with relevant empirical research and partly in line with economic theory.

2.3. Innovation analysis

Innovation analysis shows impulse response function (IRF) and variance decomposition. Impulse response function shows the effects of increase of one standard deviation in mentioned variables on domestic income. Response of domestic income to one standard deviation shock in money supply is positive (except after three and six months) up to 4 years (48 months) after the shock. Shock in interest rate, as well as shock in exchange rate and euro zone income is positive after one month and then alters from positive to negative and

vice versa, thus it is hard to claim that the effects of the shock is either positive or negative[6]. In transition countries it is often hard to predict how economic variables affect one another. According to Tica (2007), various econometric tests on Croatian economic variables have shown that economic theory is often not confirmed in empirical analyses. Variance decomposition is shown in Figure 1.Variance decomposition shows which percentage of variance of the forecasting error in domestic income is explained by each variable in the system. Domestic income explains 100% of the variation of its forecasting error in the next period. After 2 years variable itself explains 59,70% variation in forecasting errors. After 4 years this percentage falls to 55.95%. Share of money supply in explaining variations in domestic income equals 16.37% after 4 years, followed by euro area income which explains 13.46% of the variation after 4 years. Furthermore, after 4 years exchange rate explains 7.38% of variation and interest rate explains 6.84% of the variation in forecasting errors.

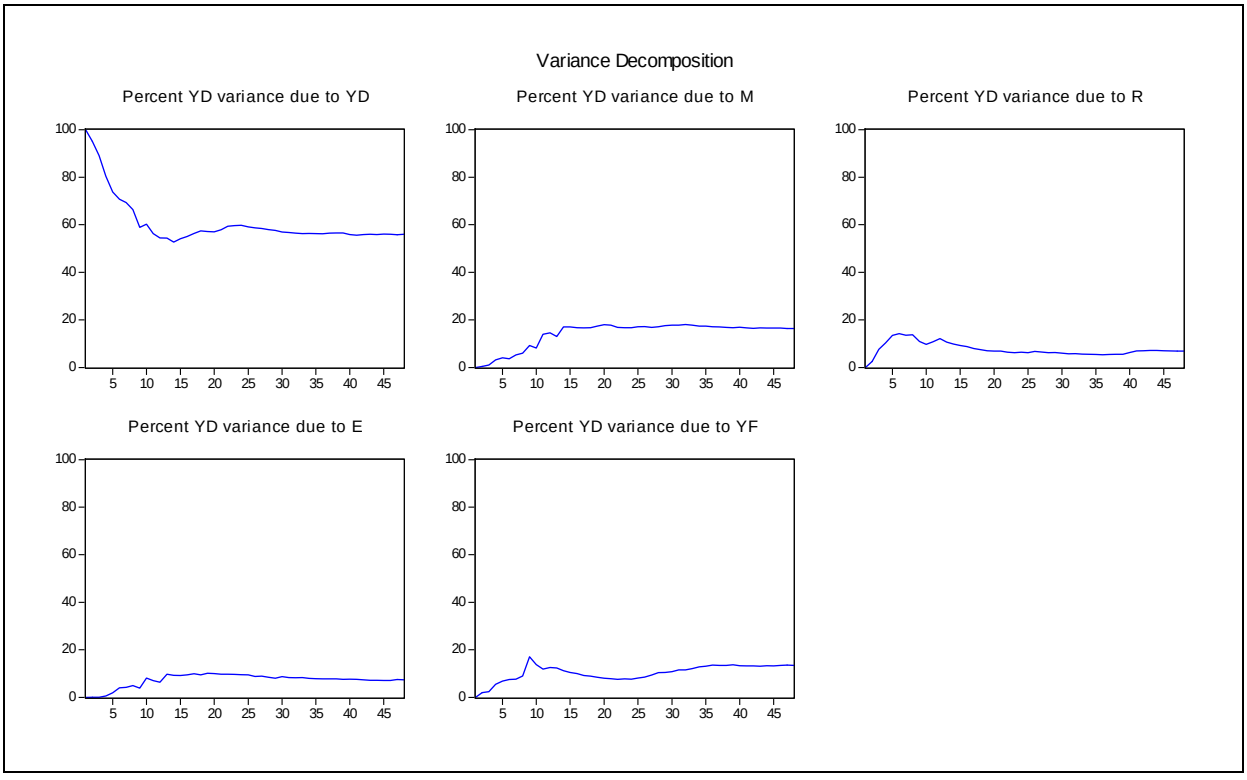

Figure 1: Forecast error variance decomposition of y_d

Source: Authors' calculations

3. CONCLUSION

Monetary transmission mechanism in Croatia is analyzed using cointegration approach. Interest rate channel, exchange rate channel and direct channel, as well as the impact of euro area income on Croatian income are

[6] Calculations are available on request.

discussed. Cointegration test of variables which are integrated of order one has shown the existence of long run equilibrium between real values of money supply, interest rate, exchange rate, euro area income and Croatian income. All the variables are adjusted for inflation, given in logarithmic values and seasonally adjusted. All mentioned variables are significant in explaining domestic income in long run. The sign of money supply and euro zone income is positive, what is in line with economic theory and previous empirical research. Sign of exchange rate is negative, what is also shown in other empirical studies of monetary transmission in Croatia. Although economic theory claims that real depreciation causes income growth, in Croatia this can not be confirmed. CNB has to maintain the stability of exchange rate in order to achieve price stability since Croatian economy is highly euroised. Although it does not determine upper and lower limit exchange rate movements, it should be noted exchange rate against the German mark and the euro fluctuated in the period since the ranging from plus/minus 6% around the average exchange rate during this period (Croatian National Bank). In this sense, although exchange rate channel is shown to be strong, its impact on income is limited. Negative sign of interest rate is also in line with theoretical background and empirical research. Since in European Union interest rate channel is the most important monetary policy channel, in context of integration into EMU, attention should be devoted to interest rate channel in Croatia.

Impulse response functions show that effects of shocks in selected variables on domestic income are twofold. Positive and negative effects of shock switch from month to month. Variance decomposition shows that domestic income explains largest part of its forecast error variation, followed by money supply, euro area income, exchange rate and interest rate.

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