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THE ESTIMATION OF MONEYDEMAND ELASTICITY: CASE OF CROATIA

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ABSTRACT

The estimation of money demand function provides important insight for theory and policy making. The stable demand for money in the long run is very important for the implementation of monetary policy. The income and interest rate elasticity of money demand in Croatia is estimated in this paper using Johansen co integration method. In line with previous research, the quarterly data on money demand, interest rate and gross domestic product in Croatia are used in the co integration analysis. The trace test and maximum eigen value test both show the existence of one co integrating relation and the long run money demand function is estimated. In the long run both output and interest rate are significant in explaining money demand. The impact of domestic income on money demand is positive, while interest rate impact is negative, what is in line with relevant empirical research and economic theory. The error correction term shows that variables return into equilibrium for approximately13 quarters. The conducted analysis offers the coefficients of interest elasticity and income elasticity of money demand which can serve in future research for calibration of dynamic stohastic general equilibrium models of Croatian economy.

KEYWORDS: Co integration, Elasticity, Error Correction Term, Money Demand, Vector Error Correction Model

INTRODUCTION

The stability of money demand is widely researched in macroeconomic theoretical and empirical literature. The elasticity of money demand with respect to income/interest rates refers to the change in money demand caused by a change in income/interest rates. One of the centerpieces of macroeconomic models has been the demand for money and the stability of this relationship.

Moreover, the elasticity of money demand is one of the parameters which are essential in calibration of dynamic stohastic general equilibrium models. Dynamic stochastic general equilibrium models lead to the integration of macroeconomics and microeconomics by providing microeconomic foundations macroeconomic analysis. Such an approach provides a general framework for analyzing economic policy and its implications, which is used in recent economic research.

The money demand has been widely researched topic in macroeconomic analysis for decades. The work of [14] developed the liquidity preference theory which explicitly highlights the transaction, precautionary and speculative motives

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for holding money. The result of the Keynesian speculative theory is that there is a negative relationship between money demand and the rate of interest [19]. The paper of [17] opposed the Keynesian view that money does not matter and presented the quantity theory as a theory of money demand. He modeled money as abstract purchasing power (meaning that people hold it with the intention of using it for upcoming purchases of goods and services) integrated in an asset and transactions theory of money demand set within the context of neoclassical consumer and producer behavior microeconomic theory.

In his paper [17] argued that the velocity of money is highly predictable and that the demand for money function is highly stable and insensitive to interest rates. This implies that the quantity of money demanded can be predicted accurately by the money demand function [19]. There has been huge amount of research on the estimation of a stable money demand function with respect to various economies, different monetary aggregates, as well as varying methodological approaches [13]. A simple money demand function implies that demand for money depends on variable that reflects the level of transactions in the economy such as income or wealth, and another variable that reflects the opportunity cost of holding money such as interest rate.

According to economic theory, income is expected to positively affect money demand, while interest rate is expected to have negative effect. These relationships are important due to their relevance for macroeconomic analysis, especially in selecting appropriate monetary policy actions, where the stability of money demand function is considered important prerequisite for effective money targeting [19]. The level and stability of the demand for money has received huge academic attention because an understanding of its causes and consequences can usefully inform the setting of monetary policy. It is necessary to investigate and test the stability of money demand since its instability is a major determinant of liquidity preference [21]. Therefore, the understanding of the demand for money is therefore an extremely important issue of macroeconomic policy. According to [6], the existence of stable demand for money in the long run is very important in the implementation of monetary policy even in the era of inflation targeting. Many economists agree that the fundamental monetary policy task is providing adequate amount of money to achieve price stability. Inflation is, as stated in [17], monetary phenomenon, and price stability must be achieved via monetary policy. Monetary authorities should supply “just the right” quantity of money demanded by businesses and individuals in the economy. In order to do so, they need to know how the money demanded in an economy is determined.

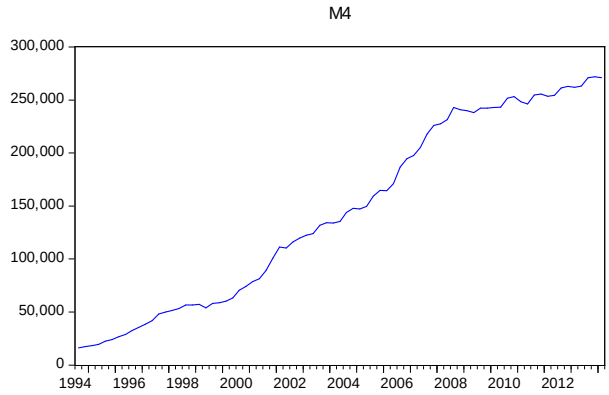
Therefore, various money demand functions are estimated for use in economic policymaking. A desirable feature of money demand function is stability [1]. Recently, the elasticity of demand for money in Croatia has not been empirically researched. According to [18], the analysis of money demand in Croatia is important since it is a small country which is dependent on European monetary union. Regarding the research of money demand function in Croatia, [24] estimated univariate partial adjustment model (PAM), using least squares method and monthly data from January 1991 to November 1993. This research points to inflation, real economic activity and lagged real money as the main determinants of the money demand during the hyperinflation period. The paper of [1] also investigated the money demand determinants in Croatia and found out that inflation is not significant in explaining money demand in Croatia. The research of [18] analyzed the function of money demand in Croatia by using vector error correction model, while indicating that the estimated long run interest elasticity of demand for money (which is approximated by monetary aggregates M1 and M1) equals zero. Furthermore, [2] approximated the demand for money by the monetary aggregate M1, and identified long run demand for money in Croatia on the basis of short run model of partial adjustment of the demand for money, with the

estimated partial elasticity of demand for money to change in short-term interest rate equal to 0.314.

The purpose of this paper is to quantify the impact of income and interest rate on money demand function in Croatia. In addition to the importance of the estimation of money demand function and assessment of the stability of money demand, this research might serve as the basis for calibrating money demand elasticity in Croatia, what is important for development of new Keynesian dynamic stohastic general equilibrium (DSGE) models. Central banks around the world are increasingly interested in the use of DSGE models in the analysis of monetary policy. The assumptions of real business cycle DSGE models are perfect competition, fully flexible prices, and monetary policy has no effect on real variables in the economy. It is necessary to include nominal rigidities in the model so that monetary policy can have an effect on real variables. With inflexible prices, companies can gradually adjust rates over time, which creates real implications for monetary policy [11]. Since the monetary policy has real effects in new Keynesian DSGE models, the question is how monetary authorities should establish and implement monetary policy in order to achieve their objectives such as price stability and full employment [4]. In new Keynesian DSGE models one of the crucial equations for model simulation is money demand function. In order to calibrate new Keynesian DSGE model, it is necessary to take into account the elasticity of money demand.

DATA AND MODEL

The quarterly data on money demand, interest rate and gross domestic product in Croatia are used in the cointegration analysis. Since data on monetary aggregate M2 are not available in Croatia, monetary aggregate M4 is used to approximate the demand for money. Broadest money (M4) comprises money (M1), savings and time deposits, foreign currency deposits as well as bonds and money market instruments and money market funds' shares [7].



Source: Croatian National Bank

Figure 1: Monetary Aggregate M4 in Croatia from 1994, Q3 to 2014, Q1, in Millions of Croatian Kuna

The monetary aggregate M4 shows an increasing trend since 1994. Therefore it is interesting to analyze the impact of interest rate and GDP on money demand in Croatia. Furthermore, the average nominal interest rate of the money market is used. Variable interest rate is represented by money market interest rate. In Croatia, 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 [16]. For the purpose of the analysis, the nominal values of M4 are deflated by consumer price indices available at [7]. The gross domestic product refers to the real value of gross domestic product. The nominal value of the quarterly gross domestic product available at [9] is deflated by consumer price indices available at [7].

Quarterly seasonally adjusted logarithmic data on these variables for the period from the first quarter of 1997 to the first quarter of 2014 were used in co integration analysis. Seasonal adjustment is conducted using X-13 ARIMA SEATS adjustment method.

Prior to conducting co integration analysis, the stationarity of logarithmic values of selected variables is tested using Augmented Dickey-Fuller (ADF) unit root test. ADF test t-statistics as well as p-values are presented in Table 1. All selected variables are stationary in first differences, i.e. variables are shown to be integrated of order one, *I(1)* at 1% significance.

If a linear combination of non-stationary variables is stationary, the variables are co integrated [23]. The analysis of money demand function in Croatia is conducted using Johansen co integration approach. Co integration approach is widely used for money demand analysis. In Croatia, it is used in research of [2], [13] and [18]. For example, the co integration approach is used in [18] to estimate money demand in Fiji Islands. The co integration approach is also used in [21] to assess the stability of money demand in Nigeria. The research of [5] uses co integration approach to estimate long run and short run money demand in New Zealand.

Table 1: ADF Unit Root Test T-Test Statistics and Corresponding P-Values for M4, Interest Rate and Income

Variable	Constant	Constant and Trend	No Deterministic Components
M4	-1.989 (0.2908)	-0.8267 (0.9572)	2.0274 (0.9892)
i	-2,029 (0.2742)	-2.364 (0.3948)	-1.852 (0.0614)
Y	-2.0351 (0.2715)	0.1021 (0.9967)	1.0426 (0.9205)
ΔM4	-3.7940* (0.0048)	-4.2330* (0.0071)	-1.7769 (0.0713)
Δi	-7.806* (0.0000)	-7.751* (0.0000)	-7.826* (0.0000)
ΔY	-3.9011* (0.0035)	-7.2860* (0.0000)	-3,7424* (0.0003)

Source: Authors' calculation
***denotes the stationarity of time series at 1% significance**

After the explanation the data used in the analysis, the Johansen co integration approach will be described in brief. Observe the set of economic variables that are in the long-run equilibrium [11]:

$$\beta_1 x_{1t} + \beta_2 x_{2t} + ... + \beta_n x_{nt} = 0 \quad \textbf{(1)}$$

The system is in long run equilibrium if $\beta x_t = 0$. The deviation from the long-term equilibrium is given by:

$$e_t = \beta x_t \quad \textbf{(2)}$$

If there is equilibrium, the deviation e_t is a stationary process. Co integrated variables are related in a long run, i.e. long run equilibrium exists. It should be noted that the term "equilibrium" is used differently in econometric terms in relation to how that term is used by economic theorists. Economic theorists use this term 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. Co integration does not require the long run equilibrium to be the result of a market mechanism or behavior of individuals [15]. The components of vector x_t are co-integrated of order *d, b* if all components are integrated, and there is vector β such that the linear combination:

$$\beta x_t = \beta_1 x_{1t} + \beta_2 x_{2t} + ... + \beta_n x_{nt} \quad \textbf{(3)}$$

Is integrated of order (*d-b*), where *b*> 0. The vector is called the co integrating vector.

Vector error correction (VEC) model is given by equation (4) according to [10]:

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + ... + \Gamma_{p-1} \Delta y_{t-p+1} + u_t \quad \textbf{(4)}$$

Where $\Pi = -(c - A_1 - \cdots - A_p)$ and $\Gamma_i = -(A_{i+1} + \cdots + A_p)$ for *i=1, p-1*. Parameters Γ_j for *j=1, p-1* are short run parameters and Πy_{t-1} is the long run part of the model. Vector error correction model is explained in detailed in [10].

Based on the analysis of integration and co integration of variables, the appropriate VAR or VECM model can be defined. To determine the number of co integration relations Johansen procedure is used, according to which it is necessary to determine the rank of the matrix Π of the equation (4). If the rank of matrix Π is equal to the number of variables in the model, the process is stationary. If the rank of matrix Π is less than the number of variables in the model, a matrix can be decomposed as:

$$\Pi = \alpha\beta' \quad \textbf{(5)}$$

Where α and are matrices of order *k x r*. In this case, the y_t is non-stationary vector and there are *r* co integrating relations between the variables of the model. So, if the matrix Π is zero matrixes or a regular matrix whose rank is equal to the number of variables, then there is no co integration among the variables. In the case where the matrix Π is singular matrix whose rank *r* is less than the number of variables, there are *r* co integration relation between variables. The matrix β is called the co integration matrix whose columns contain the parameters of long run equations. The matrix α is a matrix of error correction speed, whose elements are interpreted as the speed of the return of variables to equilibrium. Number of co integration relations is determined by the Johansen procedure, which is based on determining the rank of a matrix Π using the estimated eigenvalues of the matrix. Matrix rank is equal to the number of eigenvalues of the matrix different from zero. Therefore, the VEC model is estimated and the eigenvalues of matrix are calculated [11].

COINTEGRATION ANALYSIS OF MONEY DEMAND IN CROATIA

In order to assess the existence of co integration among money demand, gross domestic product and interest rate, Johansen co integration test is conducted using EViews8 software. Firstly, it is required to select the proper model regarding the existence of deterministic components (trend and constant). The lowest values of Schwarz and Akaike criteria are found for model in which constant and trend are present neither in vector error correction model nor in co integrating equation. The lowest value of Schwarz Criteria (SC) of -4.449 is found for model in which constant and trend

do not exist neither in vector ECM nor in co integrating equation, and for model in which constant is present only in cointegrating equation. Akaike Information Criteria is lowest for model in which constant and quadratic trend are present both in VECM and in co integrating equation. However, calculated average values of first differences of time series in ECM are close to zero, what implies that trend is not present in observed data [12]. Model in which constant exists neither in long run model (co integrating equation), nor in the short run model, is selected for the analysis.

After choosing the most appropriate model, it is necessary to determine the number of co integrating relations. Two tests are defined to determine the number of co integration vectors: trace test and maximum eigenvalue test. Tests are carried out until the first time the null hypothesis cannot be rejected. For detailed explanation of trace test and maximum eigenvalue test see, for example, [23]. When null hypothesis is rejected for the first time; the conclusion about the number of co integration vectors can be drawn. The decision on the outcome of the tests is made by comparing the test statistics with the critical values of the trace test the maximum eigenvalue test. Both tests indicate that the number of cointegration relations is equal to one. The results of the both tests are presented in Table 1 showing that the cointegration among selected variables exists at 5% significance. After the determination of number of co integrating relations, the long run equation of money demand is estimated.

Table 2: The Results of the Trace Test and the Maximum Eigen value Test

Hypothesized Number of Co integrating Equations	Eigen value	Trace Statistic	0.05 Critical Value (Trace Statistic)	Max Eigen value Statistic	0.05 Critical Value (Max Eigen value Statistic)
0	0.3290	36.1231	24.2760*	24.7377	17.7973*
1	0.1553	11.3854	12.3210	10.4636	11.2248
2	0.0148	0.9217	4.1299	0.9217	4.1299

Source: Authors' calculation

*** denotes rejection of the hypothesis at the 0.05 level**

The co integrating relation, i.e. the long run equation, with corresponding *t*-values in brackets is given by equation (6):

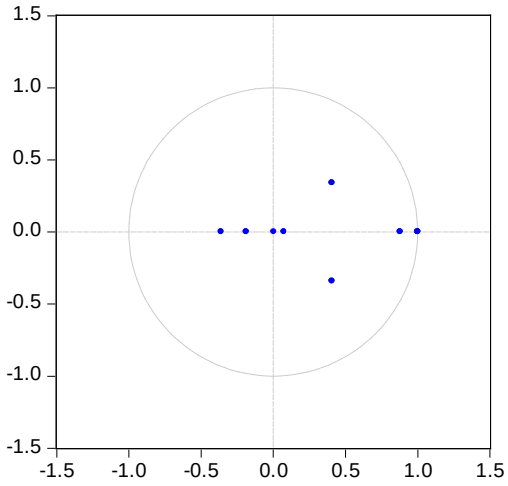
$$M4 = 1{,}354Y - 0{,}045i \quad \textbf{(6)}$$
$$(350.696)\ \ (-9.368)$$

Therefore, in the long run both output and interest rate are significant in explaining money demand. Moreover, the impact of domestic income on money demand is positive, while interest rate impact is slightly negative. However, it should be noted that the interest elasticity of money demand is close to zero, what is in line with previous estimates by [18] for Croatia.

Regarding the elasticities of income and interest rate in empirical literature, the estimated income elasticities vary between 0.18 [3] and 2.66 [20] but are usually slightly above than one. According to [21] many developing countries have underdeveloped, undiversified financial markets that lack financial sector instruments and payment technologies such that most transactions involve the use of narrow money. Therefore it is expected that the income elasticity of money demand should be around or slightly above unity. The estimated interest rate elasticities are in the range of -0.71 [8] and 0.008 [22], where the latter value should be treated as an exception with a sign contrary to theory. Therefore, the estimated income and interest elasticities of money demand are in line with economic theory and previous empirical research.

Concerning the correction of disequilibrium, the error correction term (ECT) obtained on the basis of the equation equals -0.0754, whereat corresponding *t-statistics* equals -3.135 and points to the significance of error correction term. The negative sign of calculated ECT indicates that variables return to equilibrium, while its value provides information about the adjustment speed; what refers to the fact that 7.54% of disequilibrium is corrected in each quarter and money demand returns to the equilibrium level for approximately 13 quarters.

Regarding the diagnostics of the model residuals, White heteroskedasticity test is conducted. The White test chi-square test statistic equals 252.696, with corresponding *p-value* of 0.0234, what indicates that the null hypothesis of homoscedasticity cannot be rejected at 1% significance level. Regarding the residual autocorrelation test, the LM test is conducted. The null hypothesis of no autocorrelation of residuals cannot be rejected up to lag length k=12 at 5% significance level, since all corresponding empirical significance levels are higher than 0.05.



Source: Authors' calculation

Figure 2: Inverse Roots of AR Characteristic Polynomial of Estimated VEC Model

Regarding the stability of VEC model, the estimated VEC with *r* co integrating relations is stable if *k-r* roots are equal to unity and the remaining roots have modulus less than one and lie inside the unit circle, where k is the number of endogenous variables and r is the number of co integrating relations.

The stability of model is checked by calculating the inverse roots of characteristic AR polynomial using EViews8. The graphical representation of inverse roots is shown in Figure 2. The analysis has shown that VEC specification imposes 2 unit roots and the remaining roots have modulus less than one. Since there are three variables in the model and one co integrating relation, the existence of two unit roots shows that the system is stable. Therefore, the ECM diagnostic tests show that the estimated model is appropriate. For detailed explanation of problems of heteroskedasticity, autocorrelation as well as AR roots calculation, see [23].

CONCLUSIONS

The estimation of money demand function has important implications for monetary policy creators and macroeconomic modelling. The money demand has been widely investigated topic in macroeconomic analysis for decades due to the fact that stable money demand is important for monetary policy effectiveness. The estimation of elasticity of money demand is insufficiently explored in Croatian literature. Therefore, the income and interest rate elasticity of money

demand in Croatia is analyzed in this paper. In order to analyze long run impact of income and interest rate, Johansen co integration approach is used. After determining the existence of one co integrating relation, the long run co integrating equation is estimated. In the long run both output and interest rate are significant in explaining money demand. Moreover, the impact of domestic income on money demand is positive, while interest rate impact is slightly negative. The estimated income and interest elasticities of money demand are in line with economic theory and previous empirical research. The estimated elasticities offer the basis for future research of money demand. Furthermore, since elasticity of money demand is very important for the calibration of new Keynesian dynamic stohastic general equilibrium models, the estimated results provide the important basis for macroeconometric modelling in Croatia. The perspective for future research refers to includingmore countries into estimation of money demand and using panel cointegration estimation techniques to analyze money demand elasticities on the level of European Union.

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