VELOCITY OF MONEY:
DETERMINANTS IN UKRAINE

by

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Abstract

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This work studies the determinants of changes in the velocity of money in Ukraine in 2001:1 2011:4 period, in particular it considers such factors as variability of money growth, wealth and inflation. Four velocity measures corresponding to M0, M1, M3 and M4 money aggregates were considered. The data sample consists of quarterly observations of Ukrainian macroeconomic figures.

Two estimation procedures were performed: Granger causality tests and cointegration analysis. In the result, it was found that the drop in the velocity in the considered period was mostly explained by wealth effects while inflation and variability of money growth were found to be non significant in sense of explaining movements in velocity.

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Chapter 1

INTRODUCTION

The quantity theory of money states that money supply determines the price level, assuming velocity and real national income to be stable. This conclusion is immediately derived from the "income" (Friedman, 1970) version of equation of exchange PQ=MV. Here P is the price level, Q is the measure of real national income, M is the measure of money supply and V is the velocity of money or velocity of circulation, which equals to the average number of times the unit of money is spent. However, real life evidence suggests that we cannot expect velocity to stay stable neither in the short run, nor in the long run.

This brings up a question considering the factors that affect frequency of money circulation in the economy. Despite the fact that the concept of velocity was first introduced even before the twentieth century, still no generally accepted theory of velocity volatility is developed, thus there is a place to be occupied for empirical research that tests the dependence between velocity and other economic variables.

Such knowledge should be useful for governments, Central banks, other authorities and policymakers that shape monetary and fiscal policy of the country. Due to the inherent linkage between velocity and price level in the country authorities should account for velocity effects while considering their actions. For example if we assume that changes in money supply affect velocity we must account for both direct effect through the equation of exchange and indirect effect through the velocity on the price level.

The idea of this research is to study the determinants of velocity based on the Ukrainian data. As can be remarked from the data in the last decade we observed a significant drop in velocity, which fall from 8 at the beginning of the century down to 1 at end of the late 2000s (for M0 velocity). Finding the factors that can explain such behavior is the question of this paper.

The scope of variables that may affect velocity is huge, however, this paper focuses on just three of them: inflation, variability of money growth and wealth. Inclusion of all these variables is based on the intuitive idea that all three of them should have an impact on people's desire to spend money.

The hypothesis of causal relations between variability of money growth and velocity was first introduced by Friedman in 1970 and later attracted more attention in the 80th due to observed severe drop in velocity in US. Greater volatility of money growth implies greater uncertainty concerning the future real value of money and interest rates, thus we can expect it to have influence on inflation.

The inclusion of inflation variable is clear since the degree of the decrease in the money value should intuitively have an impact on desire to spend money rather than hold them. The impact of the inflation on the velocity in Ukraine was studied by Zholood (2001). He found the presence of nonlinear impact of inflation on the velocity, in particular his results state that only high levels of velocity above certain threshold had positive impact on the velocity.

As opposite to previously discussed variables that have expected signs of influence on the velocity the effect of wealth is theoretically ambiguous. The increase in the real wealth of the population, on the one hand, provides more possibilities for investing and spending activities, while on the other hand, pure money holdings can be viewed as more desirable especially taking into account Ukrainian circumstances as undeveloped financial markets and relatively stable inflationary environment.

In this work data I use the data to study sample period from 2001:1 to 2011:4. Such selection of the sample period is made because of the change in calculation methodologies of State Statistics Committee and Central bank and inability to get consistent dataset for longer period.

In this paper the real deposits of population were used as the proxy for wealth. Such proxy should be considered as more consistent in case of Ukraine comparing, for example, to stock and housing prices that were used by Dreger and Wolters (2009) as respective proxy for EU. Such conclusion was made taking into consideration the fact of the presence of bubbles on both housing and stock markets in the considered period.

The absence of ARCH effects in money aggregate growth regressions didn't allow to use methodology similar to the one in the Beg's(1997) paper, who managed to distinguish volatility on unanticipated and anticipated parts. Thus simple four-period (yearly frequency was chosen arbitrary, however, a small data sample does not really allow for longer) standard deviation of money growth was taken as the measure of money growth volatility.

The empirical part of the work begins with Granger causality tests between velocity and studied variables. This part is followed by cointegration analysis that studies a particular effect of variables that were found to make causality impact on the velocity.

In such a way this paper makes an aggregate study of the scope of theories considering the velocity in one joint analysis and finds out the factors that explained the velocity of circulation in Ukraine in 2000s.

The results obtained in the analysis are somewhat controversial to the results obtained previously by Hall and Noble (1987), Fisher and Serletis (1989), Beg (1997) concerning the impact of money growth variability, results by Zholood (2001) concerning the impact of inflation and Dreger and Wolters (2009) concerning the impact of wealth. In particular, inflation and money growth variability were found insignificant in explaining the behavior of velocity while wealth was found to have an opposite effect on velocity comparing to EU. However, accurate consideration of differences in using datasets shows that such results can be explained by number of economics factors that are discussed in details in conclusion chapter.

The paper is structured as follows. Literature related to the topic of research is discussed in Chapter 2. Chapters 3 and 4 will be dedicated to methodology and data description respectively. Obtained results are discussed in Chapter 5 and conclusions are presented in Chapter 6.

Chapter 2

LITERATURE REVIEW

In this literature review I start with the works that defined the concept of velocity and equation of exchange. Next, I proceed to the discussion of series of works related to so-called Friedman's hypothesis; these works focus on variability of money growth. After that I consider empirical and theoretical studies which focus on other determinants of velocity. Finally, I discuss only the Ukrainian literature related to the topic of velocity.

One of the earliest works, where the concept of velocity was discussed, was the work by Irving Fisher (1922) who introduced the equation of exchange. Fisher defines velocity of circulation as "the average number of times a year money is exchanged for goods" and defines the "transaction" version of exchange equation as

$$MV = \sum_{i=1}^{n} p_i q_i \,, \qquad (1)$$

where M is the amount of money, V is the velocity, p_i is the price of the good and q_i is the quantity of the good in particular transaction *i*. The simplified version proposed by Fisher is as follows:

$$MV = PT \,, \qquad (2)$$

where P= $\sum_{i=1}^{n} \frac{p_i}{n}$ and T= $\sum_{i=1}^{n} q_i$. However, neither original nor simplified equation turned out to be useful for empirical research purposes due to difficulties in measuring the right part of equation. Thus, for an empirical purpose right hand side of (1) is usually approximated by PQ, where P is the price index in the economy and Q is the measure of real national income. As a result, we get equation (3), which was called "the income form of equation" by M. Friedman (1970).

$$MV = PQ \quad (3)$$

Naturally equations (1) and (3) grant us with two different definitions of velocity:

$$V^T = \sum_{i=1}^{n} \frac{p_i q_i}{M} \quad \textbf{(4)}$$

$$V^I = \frac{PQ}{M}, \quad (5)$$

where V^T is transaction velocity and V^I is income velocity.

While we have no other choice despite using income velocity as the approximation of transaction velocity, it should be mentioned that such approximation remains questionable. For example, Jiang Tao (2002) claims that it is the income velocity that systematically understates transaction velocity and based on the obtained research results he concludes that we cannot substitute transaction velocity with income velocity.

There are different views considering the determinants of volatility in velocity, however, there is no generally accepted theory explaining the volatility in velocity. Rather the number of empirical studies that test different hypothesis forms the scope of current available knowledge of velocity variability. Different studies provide sometimes controversial answers to the same questions, which may be explained by the differences in the considered time periods and definitions of velocity.

J.M. Keynes(1936) states that velocity should not be assumed to stay constant. As of the main determinants of velocity Keynes picks out "the character of banking and industrial organization, social habits, the distribution of income between different classes and the effective cost of holding idle cash." According to Keynesian view the last part is the most important in determining velocity (and what is important, may be defined for empirical research). From described point of view it is expected that increase in interest rates or inflation will result in higher velocity due to lower willingness to hold money, while decrease in interest rates or inflation will contribute to decline in the velocity.

In his paper Friedman (1970) assumes the volatility of money growth to be the factor of the change in velocity. Fed's 1979-1982 monetary policy experiment, when Fed increased the emphasis on target monetary policy aggregates retained attention of economists to this hypothesis, due to a significant drop in velocity that was observed in 1982. In particular Friedman's (1984) paper where he restated the assumption of dependence between volatility of money growth and changes in velocity led to the number of works where this hypothesis was empirically tested.

Hall and Noble (1987) used 21 years of the US monthly data and 8-month volatility of M1 growth as a measure of volatility in money growth. They accepted Friedman's hypothesis by finding the Granger causality relation between standard deviation of money growth and velocity.

Fisher and Serletis (1989) have significantly extended the work by Hall and Noble. They used 15 years of the US monthly data and 9 different measures of money aggregate, which implies 9 different velocity definitions. In the result they conclude that both monetary growth and the variability of monetary growth cause velocity.

In her paper Beg (1997) improved the work by Fisher and Serletis. She did not only use the greater amount of data, but what is the most important is that she introduced new measures of volatility by using heteroskedastic models. Ceased from the assumption of a constant variance in money growth rate Beg managed to divide volatility of money growth into anticipated and non-anticipated part (in particular, conditional variance was used as anticipated and standardized residuals as unanticipated parts of money growth volatility) using GARCH models. She showed that only unanticipated volatility of money growth affected velocity of money, which was intuitively expected result since only unanticipated part of volatility should be considered as contributing to uncertainty. Beg also used TARCH and EGARCH models to account for asymmetrical effects but did not find any.

In 1998 Rodriguez developed a theoretical model in which changes in velocity are caused by endogenous changes in interest rates. The author used 1959 to 1996 time series to test the fit of his model on variables as output, money growth, inflation and nominal interest rates. This work is based on the Baumol-Tobin model that was originally presented in two papers (Baumol, 1952) (Tobin, 1956) and focuses on the trade-off between liquidity of holding money and the decline in the value of unspent money.

Another theoretical model is provided by Wang and Shi (2004). In their work authors developed the search model where factors that influence consumption velocity of money are buyers search for intensity and seller's inventory, while other factors have only indirect impact on velocity through these two. The authors calibrate their model on the US data and managed to explain more than 50% of the variability in the data.

Interesting results were obtained in the paper by Dreger and Wolters (2009) where the authors on the basis of EU data provided the evidence of negative long-run relation between velocity of money and wealth and positive long run relationship between velocity and inflation. The inflation adjusted stock and real estate prices were chosen as the proxies for wealth.

The only paper on the problem of velocity, which considers Ukrainian data in particular, is the paper by Zholood (2001) where he mostly focuses on the effect of inflation on the velocity. His results provide convincing evidence of significant nonlinear effect of inflation on the velocity.

Zholood in his paper states that dependence between inflation and velocity was non-linear and that velocity was positively influenced by inflation only after some threshold level, while low levels of inflation had negative effect on velocity. His results were pretty reasonable for those years – inflation levels that can be considered as high in western countries but could be considered rather as stability signs in Ukraine.

As the conclusion of this literature review I must state that there are several different directions for the research on the topic of velocity. However, my work focuses on three of them: Friedman's hypothesis, examination of the impact of inflation and testing whether wealth of the population affects velocity. Thus my work is naturally following works by Hall and Noble (1997) Fisher and Serletis (1989), Dreger and Wolters (2009) and Zholood (2001).

Chapter 3

METHODOLOGY

First I test whether it is possible to use heteroskedastic models to obtain different measures for anticipated and unanticipated volatilities of money growth. I use simple specification for money aggregate regressions:

$$m_t^l = a_0 + e_t \, , \qquad (6)$$

where m_t^l stands for money growth of respective money aggregate, *l=0…3*. The residuals of the regressions are tested for the presence of ARCH effects using Lagrange multiplier tests.

Since no presence of ARCH effects was found yearly (four-period) standard deviation of money growth is used as a volatility measure. The number of periods for the volatility measure is chosen arbitrary. Commonly some number of full year periods is chosen for such purposes, however, due to the small size of the sample it was chosen to take only four periods.

Variables that arrange the scope of interest are tested for the degree of integration, since the obtained results impact particular specifications of the models that are used later in the analysis.

I make use of the DF-GLS test proposed by Elliott, Rothenberg and Stock (1996), which is modified Dickey-Fuller test to obtain the integration properties of the data. The proponents of this test showed that this version of the test has greater power than the previous versions of ADF test. This test use GLS-detrended data with the same null hypothesis of unit root as the original Dickey-

Fuller test. The series of models include 1 to k lags of the first differenced variable, where k is determined by Schwert criteria. SBIC (Schwarz Bayesian Information Criteria) is used to determine the optimal model (in terms of lag structure).

Next, Granger causality tests could be done. All Granger causality tests should be performed for stationary variables. Consequently, differences are used for variables that were found to be I(1).

The Granger-causality tests are specified in such a way:

$$\Delta v_t^l = a_0 + \sum_{i=1}^{k} a_i^l \Delta v_{t-i}^l + \sum_{i=1}^{k} b_i^l g_{t-i} + \varepsilon_t , \qquad (7)$$

where v_t^l is respective velocity measure, l=0…3; g_{t-i} is variable tested for Granger causality relationship with velocity.

The number of lags k in respective VARs is determined by SBIC. Joint Granger causality tests (with inclusion all considered variables in one VAR model) are not performed since the number of lags suggested by SBIC in case of inclusion of all variables is too high and leads to omitting the variables in VAR model. However, the joint model is unlikely to produce any different results comparing to separated.

The presence of Granger causality is determined by F test for coefficients being jointly equal to zero.

$$b_1^j = b_2^j = \cdots = 0 \quad (8)$$

The rejection null hypothesis (8) implies the presence of causal relation between velocity and respective tested variables. However, Stata uses inverse Granger causality test with null hypothesis of no Granger causality, which determines the presence of relationship by exclusion of variables from VAR model.

The following step is the cointegration analysis. The variables, which were found to Granger cause velocity, are tested for cointegration by using Johansen trace statistics. Johansen trace test has null hypothesis of at most *r* cointegration relations between the set of variables. Trace statistics are calculated for all possible number of relations (from 0 to number of variables - 1). The null hypothesis is rejected when the trace statistic exceeds critical statistic.

Thus the rank of the VECM (vector error correcting model) is found by determining the lowest rank at which we cannot reject null hypothesis. The presence of cointegration relation between a pair of variables is just tested by applying the test to set of two variables.

The number of lags in VEC models is the same as for the respective VAR models and is determined by SBIC. However after running regressions the number of lags in the VEC models were increased in case of bad results of LM tests for autocorrelation in residuals. The number of lags were increased to the level where the autocorrelation in the residuals of the VEC model were ceased, however, no more than one additional lag was found to be necessary for such purpose.

The specification of the VEC models looks the following:

with

VEC model is calculated four times for each particular velocity measure. Thus based on the previous results of Granger causality tests Y_t is equal to vectors $(v0_t, ln(rdep))$, $(v2_t, ln(rdep))$, $(v3_t, ln(rdep))$ for M0, M2 and M3 velocities error correcting models respectively, and for the M1 velocity VECM Y_t is equal to the vector $(v1_t, ln(rdep), \sigma_{M1})$. Here $v0_t$, $v1_t$, $v2_t$ and $v3_t$ are velocities for respective money aggregates, $rdep$ is real deposits of population, σ_{M1} is volatility of M1 growth.

The way the VEC model is constructed implies that the matrix Π which represents long run relations between variables can be decomposed in the following way:

$$\Pi = \Gamma B^{`}, \qquad (10)$$

where Γ contains loading coefficients and $B^{`}$ contains linearly independent cointegration vectors.

After the appropriate VEC models are calculated the obtained cointegraiton vectors from $B^`$ allows us to determine the long run relationships between respective velocities and variables included in VEC models.

The standard approach is to impose normalization restriction to the variable that we are trying to explain. In particular the restriction that equalizes the coefficient before the velocity in every VEC to 1 is imposed. In this case the long run relationships will have the following form:

$$v_t^l = -\sum_{i=1}^{m} \alpha_i^l g_i^l - c^l \,, \qquad (11)$$

where *m* is the number of variables in particular VEC model, *l*=0…3, is the number of VEC models, v_t^l is respective velocity, g_i^l is variable *i* included in the model *l* and c^l is constant from cointegration vector in the model *l*.

The obtained long run relationships are exactly what was to be found.

C h a p t e r 4

DATA DESCRIPTION

The dataset is obtained from the State Statistics Service of Ukraine (ukrstat.gov.ua) and National Bank of Ukraine (bank.gov.ua). Unfortunately the amount of the available data is small, since the official quarterly data is unavailable for pre 2000 years while sets of unofficial estimates are inconsistent with the official data. Thus only 44 quarterly observations of GDP, CPI, population deposits, GDP deflator and money aggregates M0-M3 from 2001:1 up to 2011:4 are used.

The base year for CPI index and GDP deflator is 2007 (I did slight recalculations for GDP deflator since it is based on average prices for 2007, but not for the prices for a particular quarter). The definition of money aggregates given by the Ukrainian central bank is the following: M0 is the currency in circulation outside deposit-taking corporations, M1 equals to M0 plus transferable deposits in the national currency, M2 equals to M1 plus transferable deposits in the foreign currency and other deposits, while M3 equals to M2 plus securities other than shares.

Four measures of velocity corresponding to four available money aggregates are calculated according to the equation (5). The general price level P is measured by GDP deflator, while national income Q is measured by nominal GDP. As a result the numerator in velocity equation consists of real GDP while denominator equals to the respective money aggregate.

The chosen measure for wealth is the level of population deposits, consequently real wealth is measured by deposits divided by CPI index. The money growth volatility measure is calculated as four-period standard deviation of respective money aggregate growth.

Descriptive statistics of the data is available in Table 1. Comparing std. dev. to the mean values it can be seen that there is significant volatility in all four velocity measures, as well as in variables that are candidates for explaining such volatility in velocity.

Chapter 5

RESULTS

In this chapter I present the results of the empirical analysis. However not only final results of tests are presented, but also the discussion of number of preliminary tests, which determined latter specification of the used models is included.

First, the test for the presence of ARCH effects in the growth of money aggregates regressions is performed, which was important in sense of the choosing an appropriate model for testing Friedman's hypothesis. No evidence of heteroskedasticity in residuals was found for all four money aggregates therefore, standard deviation of money growth was chosen as a volatility measure. The results of the LM tests are available in table Table 2.

After that the list of variables for further analysis were defined and all of them were tested for the degree of integration. In particular, such variables were tested: velocities of respective money aggregates, standard deviation of growth for every money measure, log of deposits of population and inflation. For this purpose I use DF-GLS test. The results of the tests including optimal lag level determined using SBIC are presented in Table 3.

I have found that all variables except inflation are I(1) implying that they variables should be included in Granger causality tests in differences rather than in levels.

Next I proceeded to Granger causality test procedure. At first, the appropriate number of lags in the respective VARs was found relying on the SBIC. Next, the

Granger causality tests were performed between each considered variable and velocity separately. The results including lag order are presented in Table 4.

The results of the tests provide evidence of Granger causal relations between log of real savings and velocity, while inflation somewhat unexpectedly was found to have no causal impact on velocity. Only the volatility of M1 money growth was found to have causal impact on M1 velocity, while growth in other money aggregates was not found to cause changes in velocity in Granger sense.

Next, cointegration tests for variables, which were found to Granger cause velocity were performed. To find the cointegration relation between variables Johansen trace test were performed, the appropriate number of lags is again determined by SBIC. The results are presented in Table 5.

The results of the tests suggest that all velocities are cointegrated with log of real population deposits and that variability of M1 growth is not cointegrated with M1 velocity. Cointegration test for the set of M1 velocity, log of deposits and M1 growth variability suggests that respective VEC model should have rank 1.

Next, appropriate VECMs are estimated. The obtained cointegration vectors can be found in Table 6. The long-run relationships obtained from cointegration vectors have the following form:

$M0\ velocity = 23.241 - 1.863 \log(real\ deposits)$

$M1\ velocity = 11.459 - 0.915 log(real\ deposits) - 0.048 \sigma_{M1}$

$M2\ velocity = 25.319 - 2.032 \log(real\ deposits)$

$M3\ velocity = 7.659 - 0.62 \log(real\ deposits),$

where σ_{M1} is std. dev. of M1 growth

As can be seen from p-values all variables are statistically significant at 10% level and log of deposits highly statistically significant (p-values<0.01) for all obtained equations. However, the given only moderate level of significance for σ_{M1} and low level of economic significance of the coefficient we can state that M1 growth volatility has practically no impact on the velocity as well as volatilities of growth in other money measures.

The results of the LM residual tests for the VECMs can be found in Table 8. The tests suggest that for all models there is no evidence of autocorrelation in obtained residuals.

Chapter 6

CONCLUSION

In this work the effect of three factors such as inflation, volatility of money growth and real wealth on the velocity of circulation in Ukraine was studied for the 2001:1 – 2011:4 sample period.

For the case of inflation the results of empirical estimation at first glance were definitely unexpected. As can be seen from Table 4 Granger causality tests suggest that there should be no causal relation between inflation and velocity.

However, from some point of view the obtained results are rather consistent with intuition and previous results than contradicting. Results obtained in this paper can be viewed as intermediate between results what Zholood (2001) got (negative relation of inflation and velocity at low inflation levels) and what was expected to get for a developed country (positive relation between inflation and velocity at all levels). In particular, while according to Zholood in 90s the effect of increase in relatively low inflation levels on velocity was negative, inflation had no effect on velocity in 2000s.

Thus, it can be concluded that in the considered period inflation had no effect on velocity of money in terms of all four measures of velocity, and this result is probably explained by transitioning stage of development of the country when differences in low inflation levels has no effect on velocity.

Friedman's hypothesis of causal relation between volatility in money growth and velocity was not confirmed for all four velocity measures. This result suggests that Central Bank should have greater flexibility and predictability in its monetary policy, since changes in the supply of money will have no indirect effect on the components of equation of exchange through the velocity.

Finally, the results of cointegration analysis suggest that real wealth of population have significant negative effect on the velocity. The increase in wealth from low levels in late 90s to some moderate levels in 2000s resulted in declining all four velocity measures. Such result probably points to the lack of desirable and available investing and spending opportunities in the considered period combined with real wealth increase resulted in lower level of money circulation.

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Table 1. Descriptive statistics for sample period 2001:1 – 2011:4

	Variable	Mean	Median	Min	Max	Std. dev.
M0 velocity	v0	3.010	2.436	0.819	8.570	2.072
M1 velocity	v1	1.881	1.489	0.495	5.366	1.301
M2 velocity	v2	1.069	0.721	0.238	3.535	0.885
M3 velocity	v3	1.060	0.717	0.237	3.487	0.873
Std. dev. of M0 growth*	σ_{M0}	6.341	6.468	2.633	9.435	1.876
Std. dev. of M1 growth*	σ_{M1}	5.441	5.568	1.587	10.076	1.910
Std. dev. of M2 growth*	σ_{M2}	4.185	3.804	1.243	8.893	2.230
Std. dev. of M3 growth*	σ_{M3}	4.181	3.933	1.105	8.804	2.220
inflation	inf	0.025	0.025	-0.016	0.097	0.025
Real GDP	rgdp	155219	154745	96169	208851	28057
M0	m0	87072	66455	12736	192665	61180
M1	m1	138145	108849	21159	311047	95733
M2	m2	285518	223282	32531	681801	210986
M3	m3	287202	224453	33188	685515	212000
Population deposits	dep	121908	90094	7436	310390	100105

* calculated as 4 period standard deviation of money growth. 44 observations included.

Table 2. Results of heteroskedasticity tests for money aggregates

Lags	M0 growth	M1 growth	M2 growth	M3 growth
1	0.376	0.633	0.913	0.924
2	0.618	0.610	0.955	0.959
3	0.799	0.558	0.810	0.806
4	0.871	0.289	0.885	0.893

Results are presented as p-values obtained from LM tests. High p-values indicate absence of ARCH effects in residuals.

Table 3. Results of DF-GLS unit root tests

Variable	Lags	DF-GLS t statistic
M0 velocity	4	-0.967
Δ M0 velocity	5	-3.753**
M1 velocity	4	-0.623
Δ M1 velocity	1	-17.601**
M2 velocity	5	-1.900
Δ M2 velocity	4	-3.715**
M3 velocity	5	-1.828
Δ M3 velocity	4	-3.694*
σ_{M0} (std. dev. of M0 growth)	1	-2.317
Δ σ_{M0}	3	-3.844**
σ_{M1} (std.dev. of M1 growth)	1	-2.250
Δ σ_{M1}	3	-4.456**
σ_{M2} (std.dev. of M1 growth)	1	-2.881
Δ σ_{M2}	3	-4.768*
σ_{M3} (std.dev. of M1 growth)	1	-2.831
Δ σ_{M3}	1	-4.535*
log real deposits	1	-0.250
Δ log real deposits	1	-3.888**
inflation	1	-3.928**

*, ** denotes significance at 0.05 and 0.01 level. Number of lags according to SBIC.

Table 4. Results of Granger causality tests

Variable	M0 velocity	M1 velocity	M2 velocity	M3 velocity
σ_{M0} (std. dev. of M0 growth)	0.949 (4)	-	-	-
σ_{M1} (std.dev. of M1 growth)	-	0.01 (5)	-	-
σ_{M2} (std.dev. of M2 growth)	-	-	0.279 (4)	-
σ_{M3} (std.dev. of M3 growth)	-	-	-	0.248 (4)
inflation	0.271 (4)	0.176 (4)	0.681 (4)	0.698 (4)
log real deposits	0.05 (4)	0.026 (4)	0.09 (4)	0.08 (4)

Results are presented as p-values. Low p-values indicate presence of Granger causality between variable and velocity measure specified in second column. Number of lags determined by SBIC is presented in parentheses. All tests performed between stationary variables.

Table 5. Results of Johansen cointegration tests

Variables	Rank null hypothesis	Johansen trace statistics
(M0 velocity, log real deposits)	0	31.840
	1	4.060*
(M1 velocity, log real deposits)	0	43.636
	1	5.187*
(M1 velocity, std. dev. of M1 growth)	0	16.680*
	1	4.382
(M1 velocity, log real deposits, std. dev. of M1 growth)	0	52.070
	1	18.637*
	2	4.676
(M2 velocity, log real deposits)	0	81.025
	1	4.560*
(M3 velocity, log real deposits)	0	76.951
	1	4.615*

Lag-order in underlying VAR models obtained with SBIC. * denotes absence of significance at 0.01 level.

Table 6. Cointegration vectors obtained from VEC models

Cointegration vector	Velocity	log real deposits	Std. dev. of M1 growth	const
(M0 velocity, log real deposits)	1	1.863 (0.000)	-	-23.241
(M1 velocity, log real deposits, std. dev. of M1 growth)	1	0.915 (0.000)	0.480 (0.052)	-11.459
(M2 velocity, log real deposits)	1	2.032 (0.000)	-	-25.319
(M3 velocity, log real deposits)	1	0.620 (0.000)	-	-7.659

p-values presented in parentheses.

Table 7. Results of LM tests for autocorrelation in VECM residuals

Model	Lag	p-value
M0 velocity	1	0.833
	2	0.606
M1 velocity	1	0.631
	2	0.170
M2 velocity	1	0.239
	2	0.294
M3 velocity	1	0.247
	2	0.280

High p-values indicate absence of autocorrelation