“Development of an explicit rule of monetary policy for the economy of Ukraine”

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ARTICLE INFO	Serhiy Kozmenko and Taras Savchenko (2013). Development of an explicit rule of monetary policy for the economy of Ukraine. *Investment Management and Financial Innovations*, *10*(1)
RELEASED ON	Friday, 01 March 2013
JOURNAL	"Investment Management and Financial Innovations"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
0	0	0

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Development of an explicit rule of monetary policy for the economy of Ukraine

Abstract

The paper explains the expediency of developing an explicit rule of monetary policy for the economy of Ukraine. It studies the stages of its development, proving the expediency of formation of monetary rules for money aggregates, evaluates equilibrium values of the rule's parameters based on the use of the modified Hodrick-Prescott filter, and determines the possible parameters of the monetary rule and their estimated coefficients by developing multivariate regression models.

Keywords: monetary policy rule, central bank, monetary policy, the Hodrick-Prescott filter, inflation targeting.
JEL Classification: E50, E52, E58.

Introduction

The most well-known rule of the monetary policy is the Taylor rule. This rule was first formulated by the Stanford University Professor John Taylor in 1993 [22]. In his subsequent works John Taylor continued his research of methodological approaches regarding the development and implementation of the monetary rules [23]. In the second half of the 90s of the 20th century and the beginning of the 21st century other scientists also studied the ways of development and improvement of monetary rules [2, 15, 16]. The Taylor rule and its main modifications are presented in Table 1.

Within this paper the terms "monetary policy rule", "monetary rule", "policy rule" and "rule" will be used as synonyms.

Table 1. The Taylor rule and its main modifications

Conventional name of monetary rule	Analytical form of monetary policy rules	Peculiarities of development and use
Monetary rule developed by Taylor for the US economy [22]	$r = p + 0{,}5y + 0{,}5(p-2) + 2$, where r is the federal funds rate; p is the level of inflation (GDP deflator) for the previous four quarters; y is the percentage deviation of real GDP from the target level (GDP gap).	The first monetary rule for interest rate proposed by John Taylor in 1993.
Generalized rule developed by Taylor for different economies [23]	$r = \pi + gy + h(\pi - \pi^*) + r^f$, where r is a short-term interest rate; π is the retrospective level of inflation; y is the percentage deviation of real GDP (Y) from the trend; g, h, $r^f \pi^*$ are constants.	The form of monetary rule generalized by John Taylor.
Modification of Richard H. Clarida [3,4]	$r = \pi^* + gy_t + h(\pi_t - \pi^*) + r^f$, where r is a short-term interest rate; π^* is the long-term equilibrium level of inflation; y is the deviation of real GDP from the trend, r^f is the long-term equilibrium real interest rate; g, h are constants.	Monetary rule, which uses equilibrium inflation levels and a clear division of time horizons in the calculation of the rule's components.
Modification of Peters Amos [1]	$\mathrm{Log}(R_t / R) = \rho_y \log(y_t / y) + \rho_\pi \log(\pi_t / \pi) + \rho_\mu \log(\mu_t / \mu) + \rho_s \log(s_t / s) + \log(\nu_t)$, where R_t is a short-term interest rate; y_t is the GDP; π_t is the inflation; μ_t is the money supply growth; s_t is the real exchange rate.	Modified Taylor rule used in the structural dynamic model of small open economies of the developing countries, which tested the data of the South Africa, Mexico, Indonesia and Thailand.
Modification of Laurence Ball [2]	$wr + (1-w)e = ay + b(\pi + \gamma e_{-1})$, where e is a mean value of logarithms of the real exchange rate (higher values indicating appreciation); r is the average real interest rate; y is the logarithm of real GDP; π is the inflation; γ is the coefficient of influence of exchange rates on inflation; w, a, b – coefficients.	It proves the efficiency of the use of exchange rate in the Taylor rule. It is developed taking into account the specifics of developed countries with small open economies such as Canada, New Zealand and Sweden.
Modification of the National Bank of Canada [5]	$i_t = i_t^* + 3.0(\neq_t - \neq_t^*) + 0.5(y_t - y_t^*)$, where i_t is a short-term target interest rate; i_t^* is the equilibrium value of short-term interest rates; $\neq_t$ is the actual annual rate of core inflation; $\neq_t^*$ is the target annual rate of core inflation; y_t is the logarithm of real GDP; y_t^* is the logarithm of real potential GDP.	Monetary rule that was applied for the quarterly forecasting model of the National Bank of Canada.
Modification of the Central Bank of Hungary [7]	$R = \delta_1 \times R_{-1} + (1-\delta_1) \times (\overline{R} + \delta_2 \times (CPIVAI_{+4} - TARG) + \delta_3 \times \hat{Y} + \delta_4 \times \Delta S) + \varepsilon_R$, where R is a basic rate of the central bank; *TARG* is the target inflation indicators; $CPIVAL_{+4}$ are inflationary expectations; $\hat{Y}$ is GDP gap; ΔS are changes in the nominal exchange rate.	It is used by the Central Bank of Hungary in its monetary policy model.

Table 1(cont.). The Taylor rule and its main modifications

Conventional name of monetary rule	Analytical form of monetary policy rules	Peculiarities of development and use
Modification of the National Bank of Ukraine [12, pp. 55-93; 17]	$i_t^{tar} = \alpha_9 i_{t-1} + (1-\alpha_9)\left[r_t + E(\pi_t) + \beta_9(\pi_{t+4} - \pi_{t+4}^{t\,\arg}) + \gamma_9 y_t^{gap}\right] + \varepsilon_9$, where i_t^{tar} is the key interest rate; i_t is the short-term interest rate; r_t is the real interest rate; $\neq_t^*$ is the target annual rate of core inflation; $E(\pi_t)$ are inflationary expectations; π_{t+4} is the inflation forecast for four quarters; $\pi_{t+4}^{t\,\arg}$ is the target level of forecast inflation in four quarters; y_t^{gap} is the GDP gap.	It is used by the National Bank of Ukraine in its quarterly forecast model of the monetary policy transmission mechanism.

John Taylor defined [23] the monetary policy rule as a description (graphically formalized by a formula or numeric values) of a method for the use of monetary policy instruments, such as monetary base or federal funds rate, depending on the dynamics of economic parameters. In his other paper [24] he provides a similar definition of the monetary policy rule: a plan that determines, as clearly as possible, the conditions when a central bank should change its monetary policy instruments. He also clarifies that under this definition, the targeting of inflation or nominal GDP by a central bank is not considered a policy rule. These definitions explain the essence of explicit monetary rule used by the central bank.

In our opinion, there are two approaches to determine the parameters and estimation of monetary rules coefficients. The first approach involves the formation of a system of equations that describe the transmission mechanism of the monetary policy or the functioning of the economy as a whole. Monetary rule is used as an integral part of the model. Therefore, its coefficients and parameters will be formed in the process of development and implementation of the model in general. In this case, we can say that the monetary rule is used by the central bank implicitly (not explicitly) as one of the model's equations. Another way of the first approach realization is the use of the model to determine the coefficients of the monetary rule, which is used explicitly. That means the formation of a simple monetary rule directly used by the central bank to assess the expediency of changing the use of monetary policy instruments.

The second approach is based on developing a multivariate regression, which will connect the key parameter of the monetary policy (a basic rate or a monetary aggregate) with certain macroeconomic indicators (inflation, GDP gap, exchange rate, money turnover rate). In this case, the estimation of coefficients and parameters of the rule is based on the method of ordinary least squares [15]. This approach also requires the formation of an explicit monetary rule.

Table 1 presents monetary rules used both explicitly and implicitly. The latter are characterized by more complex forms and methods of calculation. Experts of the National Bank of Ukraine (NBU) have developed a quarterly forecasting model of the transmission mechanism of monetary policy in Ukraine [12, pp. 55-93, 17]. This model implicitly uses the monetary policy rule for the key interest rate.

The aim of this paper is to substantiate the expediency of developing an explicit monetary rule for the Ukrainian economy. We also examine the main stages of its development: (1) determination of the rule's basic form; (2) estimation of equilibrium values of the rule's parameters; and (3) determination of the parameters that should be included in the rule. The paper's material is presented in the context of the above mentioned objectives of the study.

1. Substantiation of expediency of developing an explicit monetary rule for Ukraine

John Taylor identifies five major problems to be solved in order to apply monetary policy rules in countries with emerging economies [24]: introduction of inflation targeting; the use of exchange rate values in the formation of the monetary rule, the choice of instruments for the monetary rule (interest rate or monetary aggregates); the level of the rule's formalization; taking into account the development of the long-term securities market. In our opinion, the first two issues define the methodology of the monetary rules' development, while the latter three are mostly related to methodological aspects of development of the monetary policy rules.

Therefore, the implementation of inflation targeting regime is a key prerequisite for the use of monetary rules. After the introduction of changes of July 9, 2010 to the Law of Ukraine "On the National Bank of Ukraine", the priority objective of the National Bank is to achieve and maintain price stability in the country. The introduction of these changes in the regulatory acts and the signing of the Memorandum with the IMF [26] demonstrated the strategic orientation of Ukraine to reform its monetary policy towards the implementation of inflation targeting regime. At this stage, the monetary system of Ukraine can be characterized as a "transitional one with a focus on price stability". That means a shift from exchange rate targeting to inflation targeting.

In our opinion, the introduction of any monetary policy regimes (with the exception of a strict exchange rate targeting) creates conditions for the

limited use of monetary rules if one of the monetary policy priorities is the achievement of price stability. The US experience is important in this regard. The purpose of the monetary policy of the Federal Reserve System is formulated quite broadly: the increase of production, maximum employment, stable prices, and the formation of moderate long-term interest rates. On the other hand, the most well-known monetary rule was developed by the American Professor John Taylor on the basis of a retrospective analysis of the U.S. macroeconomic data. Despite the fact that price stability is only one of the monetary policy goals in the United States, this country has extensive experience in the development and implementation of monetary rules. Thus, the development of an explicit monetary rule has a practical importance for Ukraine and is characterized by significant urgency level.

During the modeling of the monetary policy the National Bank of Ukraine for a long time has been implicitly using a modified Taylor rule (Table 1). However, we emphasize the need to develop a simplified explicit policy rule. The introduction of an explicit rule would make it possible to benefit from its direct use, not just using it as one of the forecasting models equations. The advantages of a partial transition from the purely discretionary monetary policy to a policy that uses explicit monetary rules have been studied in the following works [5; 22].

An attempt to introduce the explicit monetary rule for determining the discount rates was made by the National Bank of Ukraine in 2001: it approved a temporary provision "Definition of the interest rates on the National Bank of Ukraine operations" [19]. This provision was abrogated in August 2004 [20]. As shown in our paper [21, pp. 230-234], this monetary rule had a low efficiency and was seldom used by the National Bank of Ukraine.

2. Determination of the rule's basic form

After proving the expediency of the monetary rule we will proceed to its immediate formation. In our opinion, the choice of the monetary rule's basic form should be based on the relevant international experience. During the selection of the rule's basic form for the developing countries it is necessary to consider the recommendations given in the works of John Taylor [24]: substantiation for the choice of monetary rule instruments (interest rate or monetary aggregates); definition of an acceptable level of the rule's formalization; consideration of the development level of the long-term securities market. It should be noted that in selecting the monetary rule's basic form it is important to take into account some national peculiarities of the functioning of the money market, the financial system and the real economy.

The main problem in determining the rule's basic form is the choice of the key instrument of the monetary policy. The results of the study of the international experience lead to the conclusion regarding the prevalent use of monetary rules for determining the basic interest rates by central banks (Table 1). However, researchers note that under inefficient performance of the interest rate channel of transmission mechanism, a monetary rule can be developed to determine the equilibrium (optimal) monetary aggregates [2; 23; 24].

In their studies representatives of the National Bank of Ukraine [12; 13; 14] stress the lack of effectiveness of the interest rate channel of transmission mechanism in Ukraine. This inefficiency manifests itself in the lack of response (or reaction with considerable lags that makes impossible an effective application of interest rate policies) of rates of the wholesale and retail segments of the money market to the changes of basic rates by the National Bank of Ukraine. In particular, the analysis of functioning of the interest rate channel of transmission mechanism during the financial crisis demonstrates that the official rates of the National Bank of Ukraine (the discount rate and the average refinancing rate) do not have a significant influence on the interbank market rates. Researchers come to the conclusion about the gap in the interest rate channel of monetary policy transmission in Ukraine already during the first phase of the monetary impulse transmission. The impact of the discount rate growth on the increase of interest rates on loans and deposits with a lag exceeding 11 months has also been found. In our opinion, this lag eliminates even the weak influence of the basic rate on the dynamics of the money market retail rates. During a year (lag size) the dynamics of rates is influenced by a number of different factors (macroeconomic, political, social, bank internal, etc.). As a consequence, it is difficult to find a practical use for the impact of changes in the basic rate of the National Bank of Ukraine.

The results of the study of functioning of the interest rate channel in the pre-crisis period 2000-2007 are presented in the monograph of V. Stelmakh. In particular, this paper notes that the impact of the NBU discount rate as well as other interest rates on the rates of interbank credit market is statistically insignificant. Thus, the researchers come to the conclusion about the minimal impact of the National Bank of Ukraine on inflation through the instruments of interest rate policy.

At the current stage of development of the monetary policy in Ukraine it seems necessary to develop a monetary rule for money aggregates. It should be noted that paragraph 14 of the Memorandum of economic and financial policies signed by Ukraine and

the IMF [26] states that the use of interest rates will gradually become the main instrument of the monetary policy. Therefore, it is likely that in the medium term some prerequisites for the development of monetary policy rule for the basic interest rate will be formed.

We will study the preconditions for the development of the policy rule for Ukraine that will determine the equilibrium dynamics of money aggregates. First of all, we should note that paragraph 15 of the Memorandum [26] provides for monitoring of the IMF program implementation on the basis of target indicators of money aggregates set out in the annexes of this document. The main principles of the NBU monetary policy for 2010 state that the target objectives stipulated by the IMF program in relation to the monetary base and net international reserves, will be used as intermediate objectives of the monetary policy. According to these documents it was planned to establish a benchmark for the growth of the monetary base in Ukraine at the level of 9-14% in 2010. During 2002-2006 the Board of the National Bank of Ukraine in its Principles of the monetary policy defined the target objectives regarding the dynamics of the monetary base and money supply. In this way, the National Bank of Ukraine permanently uses the targeting of money aggregates as an intermediate objective for achieving the target indicators of inflation (strategic objective). The provisions of the key documents that define the target objectives of the NBU medium term monetary policy confirm the expediency of developing policy rules for money aggregates.

It is necessary to emphasize that the monetary rules for the money supply were developed earlier than the monetary rules for interest rates. The constant growth rate rule was formulated by M. Friedman in the 50s of the 20th century.

Milton Friedman substantiated the expediency of using monetary policy rules based on the arguments about the complexity of realization of discretionary monetary policy and taking into account the monetary history of the United States. In his opinion, the ineffectiveness of discretionary monetary policy is caused mainly by the presence of lags during its implementation. Milton Friedman conducted a study of the monetary history of the United States focusing on the relationship of changes in the money supply with the dynamics of prices and real GDP. Having concluded that the dynamics of the money supply has a significant impact on key macroeconomic indicators, he proposed to maintain a fixed nominal growth rate of money supply in the economy (according to the author, for the U.S. economy the money supply growth rate had to be 2 percent a year). The Friedman monetary rule is given as follows:

$$\Delta m = \pi + \Delta q - \Delta v, \quad (1)$$

where Δm is a growth rate of money supply; Δq is the growth rate of real GDP; Δv is the growth rate of money turnover; π is the growth rate of inflation levels.

In order to compare them, all indicators of equation (1) are given in growth rates. Milton Friedman believed that on the basis of equation (1) it is possible to determine the constant growth rate of money supply by using the following indicators: target growth rate of inflation, growth rate of potential (equilibrium) GDP, and selected trend of changes in money turnover. It should be emphasized that this rule is based on the equation of exchange proposed by Irving Fisher:

$$M \times V = P \times Y, \quad (2)$$

where, M is the money supply, V is the money turnover rate, P is the level of prices, Y is the real GDP.

Based on the comparative analysis of the Taylor and Friedman rules Edward Nelson made a conclusion about the similar views of these authors on the mechanism of the economy's functioning [15].

The following monetary policy rule, which is based on the use of monetary aggregates, was proposed in 1988 by Bennett McCallum [10, 11]. This rule is the result of dialectical development of Friedman's constant growth rate rule. The McCallum rule is given as follows:

$$\Delta m = \Delta x^* - \Delta v - \phi_{\Delta x}(\Delta x - \Delta x^*), \quad (3)$$

where Δm is the money supply growth rate; $\Delta x^* = \pi^* + \Delta q^*$ is the growth rate of equilibrium nominal GDP; Δv is the money turnover growth rate; Δx is the growth rate of nominal GDP; $\phi_{\Delta x}$ is constant.

By applying this rule Bennett McCallum proved that the efficiency of the monetary policy in the US could be much higher. This is especially true for the 30s and 70s of the 20th century, when the Federal Reserve System committed the biggest mistakes in monetary regulation.

Despite the fundamental character of the relationship between the money supply and price levels (equation (2) there are many factors that determine the strength, direction and form of this relationship. These factors include: the level of monetization, the rate of money turnover, the structure of channels for the issue of money supply, money demand, the share of cash in the money supply, etc. We will study the dynamics of some indicators that have an impact on the parameters of the relationship between money supply and price dynamics in Ukraine (Table 2).

Table 2. Key indicators that determine the nature of relationship between the dynamics of money supply and macroeconomic parameters in Ukraine

N	Indicators	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	Money aggregate M3, end of the period, mln. hryvnias	63896	95043	125801	194071	261063	396156	515727	487298	597872	685515
2	*M3 growth rate*	-	*1,49*	*1,32*	*1,54*	*1,35*	*1,52*	*1,30*	*0,94*	*1,23*	*1,15*
3	Money aggregate M3, average for the period, mln. hryvnias	54826	78917	113744	157616	218704	314474	451316	472678	537017	645322
4	Money turnover rate (11/3)	4,12	3,39	3,03	2,80	**2,49**	**2,29**	2,10	1,93	2,02	2,04
5	*Money turnover growth rate*	-	*0,82*	*0,90*	*0,92*	*0,89*	*0,92*	*0,92*	*0,92*	*1,04*	*1,01*
6	Money base, mln. hryvnias	30808	40089	53763	82760	97214	141901	186671	194965	225692	239885
7	*Money base growth rate*	-	*1,30*	*1,34*	*1,54*	*1,17*	*1,46*	*1,32*	*1,04*	*1,16*	*1,06*
8	Money multiplier (1/6)	2,07	2,37	2,34	2,34	**2,69**	2,79	2,76	2,50	2,65	2,86
9	Money aggregate M0, end of the period, mln. hryvnias	26434	33119	42345	60231	74984	111119	154759	157029	182990	192665
10	The share of cash in the money supply (9/1), %	41,4	34,8	33,7	31,0	28,7	28,0	30,0	32,2	30,6	28,1
11	Nominal GDP, mln. hryvnias	225810	267344	345113	441452	544153	720 731	948 056	913 345	1082569	1316600
12	Level of monetization (1/11), %	28,3	35,6	36,5	44,0	**48,0**	**55,0**	54,4	53,4	55,2	52,1
13	*Monetization growth rate*	-	*1,26*	*1,03*	*1,21*	*1,09*	*1,15*	*0,99*	*0,98*	*1,04*	*0,94*
14	GDP deflator, %	105,1	108,0	115,1	124,5	114,8	122,7	128,6	113,0	113,8	115,7
15	Real GDP, mln. hryvnias	214853	247541	299838	354580	474001	587393	737213	808270	951291	1137943
16	*Real GDP growth rate*	-	*1,10*	*1,12*	*1,03*	*1,07*	*1,08*	*1,02*	*0,85*	*1,04*	*1,05*
17	Consumer price index, %	99,4	108,2	112,3	110,3	111,6	116,6	122,3	112,3	109,1	104,6
18	Investment in fixed capital, mln. hryvnias	37178	51011	75714	93096	125254	188 486	233 081	151 777	171 092	-
19	*Investment growth rate, %*	-	*37,2*	*48,4*	*23,0*	*34,5*	***50,5***	*23,7*	*-34,9*	*12,7*	-
20	Official reserve assets, mln. US dollars	4469	6943	9714,78	19390,6	22358	32 479	31 543	26 505	34 576	31 795
21	*Official reserves growth rate*	-	*1,55*	*1,40*	*2,00*	*1,15*	*1,45*	*0,97*	*0,84*	*1,30*	*0,92*

According to the results presented in Table 2 and the analysis of the indicators' dynamics during 2002-2010, we have identified several important aspects that have a significant influence on the relationship between the money supply and price dynamics. Firstly, in 2006-2007 the values of monetization and money turnover rate approached their equilibrium levels (highlighted in bold in Table 2), leading to the gradual renewal of a close relationship between the money base growth and price dynamics in Ukraine. Secondly, we can make the conclusion about the similarity of official reserves dynamics, money supply and money base growth rates during the study period (Figure 1). Thus, interventions in the foreign exchange market of Ukraine were the main channel of money supply emission in the period of 2003-2010.

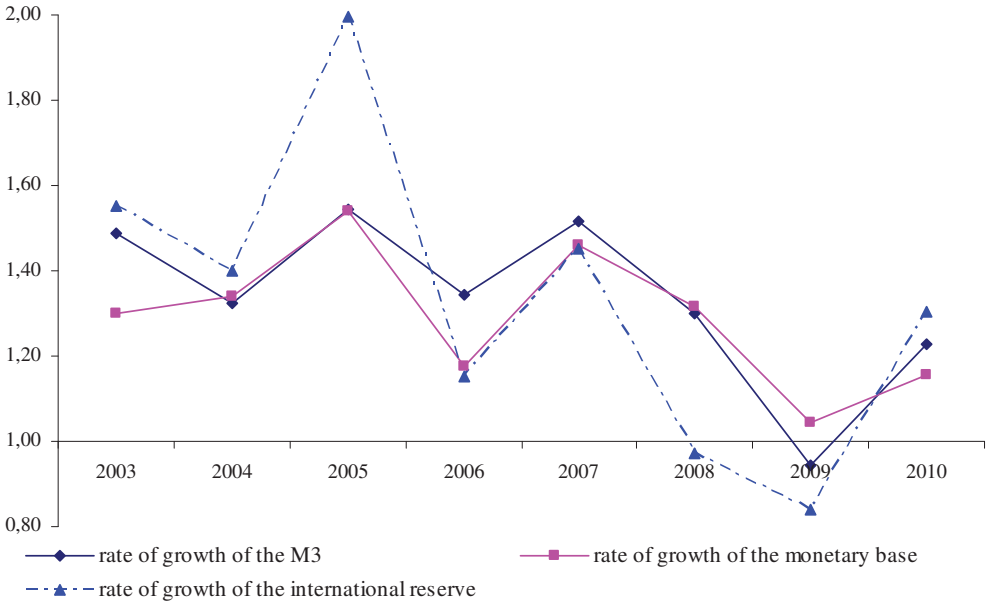

Fig. 1. Dynamics of official reserves of the National Bank of Ukraine and the money supply during the period of 2003-2010, decimal fraction

We should note that in comparison with the dynamics of the broad money supply the dynamics of the monetary base is close to the dynamics of official reserves. This fact confirms our conclusions, because in most periods the National Bank of Ukraine conducted the sterilization of excess money supply through interventions in the foreign exchange market. This structure of money issue had significant advantages during the actual exchange rate targeting and initial accumulation of official reserves. However, after the revision of the monetary policy priorities in 2010 in favor of maintaining price stability and practical restoration of pre-crisis levels of reserves, the National Bank of Ukraine should increase the diversification of money emission channels in order to bind its dynamics to domestic economic factors.

Thirdly, the analysis of indicators in Table 2 reveals a very complex type of connections between the dynamics of money supply and price dynamics. To a large extent this connection is determined by the efficiency of functioning of transmission mechanism individual channels in Ukraine.

3. Assessment of equilibrium values of indicators, which are included in the monetary rule

One of the most accurate and the most common methods for assessing the equilibrium values of macroeconomic indicators is Hodrick-Prescott filter. This filter is widely used by researchers to determine the equilibrium dynamics of indicators, which are included in the monetary rule [5; 16; 23].

A classical approach to Hodrick-Prescott filter has certain difficulties for practical calculations. If only input values of the time series are known, it would be difficult to find their components by conventional mathematical methods. Therefore, implementation of the classical approach of the filter's use involves the formation of additional optimization task to be solved in several stages. An example of the classical approach implementation with the use of Hodrick-Prescott Filter with additional restrictions and the use of VAR-models is presented in the work of specialists of the Department of Economic Analysis and Forecasting of the National Bank of Ukraine [18].

To solve these problems, different versions of the Hodrick-Prescott Filter were developed. To estimate equilibrium levels of the nominal and real GDP we apply the modified Hodrick-Prescott filter proposed by Hyeongwoo Kim [8]. This approach is also used by the World Bank [6, pp. 2-3]. In general, the modified model of the filter can be presented as follows:

$$y_T = (\lambda \times F + I_T) \times g_T, \quad (4)$$

where, y_T are the input (non-smooth) time series; g_T is the trend (non-smooth component) of time series; I_T is the identity matrix with $T \times T$ dimensions (square matrix); F is the special matrix of deviations of trend indicators.

It should be noted that matrix F (equation 5) is symmetrical and is determined on the basis of statistical selection. It has a standard form for any input time series.

$$F = \begin{bmatrix} 1 & -2 & 1 & 0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 0 \\ -2 & 5 & -4 & 1 & 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 \\ 1 & -4 & 6 & -4 & 1 & 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 \\ 0 & 1 & -4 & 6 & -4 & 1 & 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 & 1 & -4 & 6 & -4 & 1 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 & 1 & -4 & 6 & -4 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 & 1 & -4 & 5 \\ 0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 0 & 1 & -2 \end{bmatrix} \quad (5)$$

For each row and column of the matrix the components are positioned in such a way that their sum is equal to zero. It describes the condition of trend determination regarding the lack of deviation from the optimum value as well as the assumption that the long-term average of cyclical fluctuations is reduced to zero. Matrix components are selected as the most and the least optimal according to their absolute value. Diagonal values of the matrix correspond to the trend indicator in time t, with two adjacent components of the matrix of the same series − the coefficient of the trend performance in time t-1, and the next two adjacent components of the matrix − coefficient of the trend performance in t-2. On the basis of equation (4) trend and cyclical components are calculated by means of the following equations:

$$g_T = (\lambda \times F + I_T)^{-1} \times y_T,$$
$$c_T = y_T - g_T. \quad (6)$$

By using the Hodrick-Prescott filter we can qualitatively examine any incoming time series for the presence of cyclic components and trend (equilibrium) components. The results can be used in forecasting the turning points of economic cycles, in the correlation regression analysis of identified trends and in formation of economic and mathematical models, which are based on equilibrium macroeconomic indicators.

Taking into consideration the above-mentioned aspects, we will study the growth rates of real GDP in Ukraine in the period from the first quarter of 2001 till the first quarter of 2012. In our study we will use the statistical data from the official cite of the National Bank of Ukraine [25]. The results of the filter's use for the above-mentioned time series are shown in Figure 2.

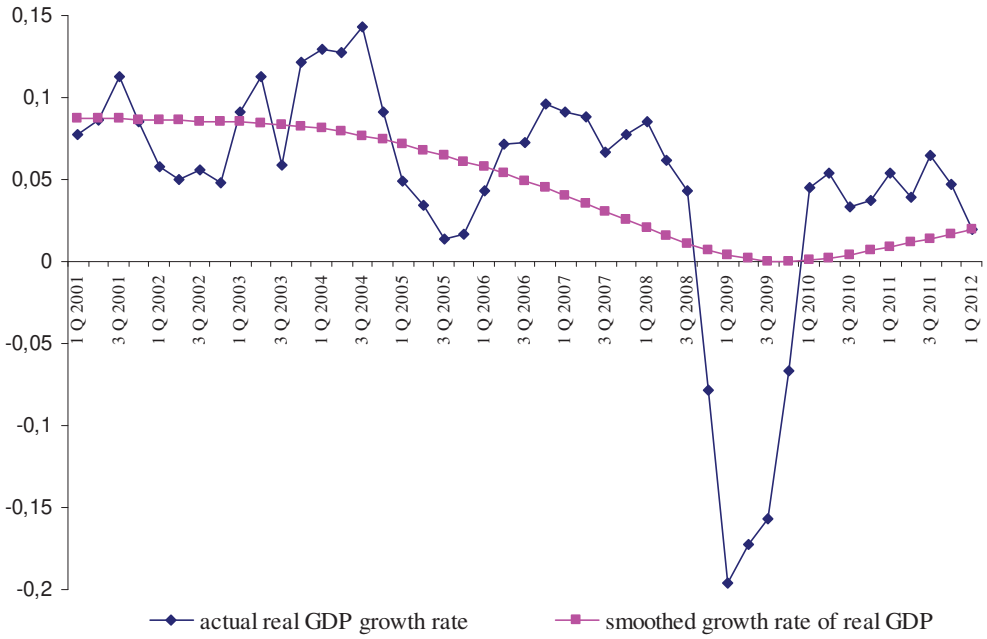

Fig. 2. Smooth (trend) component of the quarterly growth rate of real GDP in Ukraine for the period from January 1, 2010 to April 1, 2012, decimal fraction

It should be noted that in the context of formation of monetary rules we are primarily interested in the trend (equilibrium) component of macroeconomic indicators. According to the Bennett McCallum rule for money supply, one of the key parameters is the change of the equilibrium real and nominal GDP. Having obtained the equilibrium (smooth) time series of the real GDP (Figure 2), we can also predict changes of this indicator in the future on the basis of extrapolation of the smoothed series indicators. In addition, we can define the analytical function that describes this series with an acceptable level of accuracy and investigate it. The methods of use of equilibrium values for these macroeconomic indicators will be determined by the methodology for incorporating each indicator into the monetary rule.

4. Determination of parameters, which can be included in the monetary rule

We will study the equilibrium dynamics of money supply. Figure 3 shows the equilibrium growth of M3 for Ukraine's economy calculated on the basis of the Friedman monetary rule (equation (1)). Equilibrium dynamics of the money supply growth is calculated as the sum of GDP deflator (or Consumer price index) and real GDP. This figure gives the results of the indicator's calculation made in four different ways: based on the GDP deflator, based on the consumer price index (CPI), by using growth rates and by using growth rates logarithms. As a result, we have received four deviation indicators. Negative values of deviations indicate the excess of the actual dynamics of money supply (M3) over its equilibrium dynamics, whereas positive values indicate the opposite situation.

On the basis of the data analysis the following conclusions can be made. Firstly, the indicators calculated on the basis of GDP deflator are closer to the real dynamics of money supply compared to the indicators calculated by using the consumer price index. This conclusion is explained by the adequate methodology for the calculation of GDP deflator (a wide range of goods and services, the dynamics of which is taken into account in determining the GDP deflator) in the context of the Friedman monetary rule. Since the monetary rule includes GDP indicators, it is better to use the indicator of GDP deflator in retrospective construction of the money supply equilibrium dynamics.

Secondly, no significant differences were found in the calculations with the use of growth rates or natural logarithms of growth rates for the related indicators. As a result, we consider it necessary to use growth rates of the related indicators without taking their logarithms. This method of calculation is more conducive for adequate interpretation of the results' economic content.

Thirdly, the results confirm our hypothesis regarding the expediency of using the equations of money turnover and the Friedman monetary rule for determining the dynamics of the money supply, which will help achieve the money market and macroeconomic equilibrium. For example, significant deviations (more than ± 10%) of the actual dynamics of money supply were typical for the years 2005, 2007, 2009, 2010, which were characterized by significant imbalances of macroeconomic indicators. The smallest deviations were typical for the years 2003, 2004, 2006, 2008 and 2011.

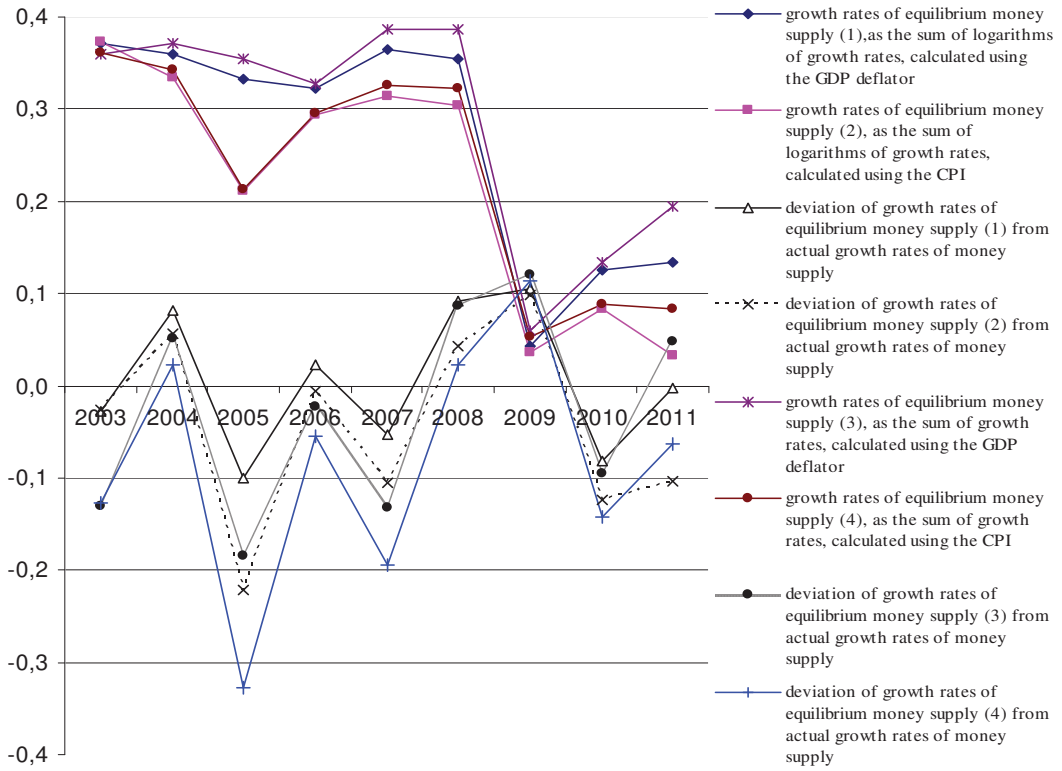

Fig. 3. Equilibrium annual dynamics of money supply in Ukraine and its deviation from the actual dynamics, decimal fraction

Analyzing the figures in Table 3 we can conclude that in periods of significant deviations of the money supply actual dynamics from this indicator's equilibrium dynamics, significant deviations from macroeconomic equilibrium were observed: inflation dynamics significantly exceeded the dynamics of economic growth. On the other hand, during the periods of insignificant deviations between the actual and equilibrium dynamics of the money supply (highlighted in bold in Table 3) the inflation was maintained within acceptable limits and was consistent with economic growth: the ratio of GDP growth and consumer prices was close to 1.

Table 3. The relationship of deviations of the equilibrium and actual money supply dynamics from macroeconomic indicators of Ukraine

Indicator	Years								
	2003	**2004**	2005	**2006**	2007	**2008**	2009	2010	**2011**
Real GDP growth rate, %	**110**	**112**	103	**107**	108	**102**	85	104	**105**
Consumer price index, %	**108**	**112**	110	**112**	117	**122**	112	109	**105**
The ratio of GDP growth rate to the rate of price increases	**1,02**	**1,00**	0,93	**0,96**	0,93	**0,83**	0,76	0,95	**1,00**
Average deviations of the equilibrium dynamics from the actual dynamics, %	**-7,81**	**5,32**	-20,81	**-1,50**	-12,14	**6,09**	10,92	-11,04	**-3,03**
Deviations of the equilibrium dynamics from the indicators defined by the basic principles of the monetary policy, %	11,5	1,6	5	3,3	3,2	1,1	-2	-	-

Table 3 also shows deviations of the equilibrium dynamics of M3 from its target dynamics defined by the basic principles of the monetary policy (in 2010 and 2011 target objectives for M3 were not set). These indicators were used by the National Bank of Ukraine as intermediate targets of the monetary policy. As we can see, the deviation of target indicators of the money supply dynamics from its equilibrium level is not significant. In addition, these deviations are much smaller than the deviations of equilibrium dynamics from the indicators' actual values, with only one exception in 2003.

The results of a comparative analysis of the equilibrium and target dynamics of M3 aggregate confirm the economic validity of our assessment of the money supply equilibrium dynamics. The only exception is the year 2008: the deviation of the money supply was observed at the intermediate level (6%), and the ratio of the GDP growth to the growth of consumer prices was significantly lower than 1. In our opinion, this situation is caused by the specific factors of the global and national financial crises that are not linked with inefficient management of the money supply by the National Bank of Ukraine.

We have established an algorithm for the construction of the money supply equilibrium dynamics and tested it on the basis of the annual data for the period of 2003-2011. The results confirm the thesis that focusing on the equilibrium dynamics of money supply will help in achieving macroeconomic equilibrium and in balancing the money market.

Further we will build a multiple regression to explain the dependence of the actual dynamics of money supply on factor characteristics, which are the components of the Bennett McCallum rule for money supply: money turnover rate, equilibrium real GDP, gap in nominal GDP, level of inflation.

In accordance with the McCallum rule (equation (3)) all indicators will be used as quarterly growth rates to the corresponding quarter of a previous year. Based on the calculations for the period from the fourth quarter of 2003 till the first quarter of 2012 (34 observations) we have built the following multivariate regression model:

$$\Delta m = 0{,}16 - 1{,}10\Delta v + 0{,}87(\Delta x - \Delta x^*) + \\ + 1{,}87\Delta q^* + 0{,}02\pi, \quad (7)$$

where Δm is the money supply growth (M3 aggregate); Δv is the money turnover growth; Δx is the growth of nominal GDP; Δx^* is the growth of equilibrium nominal GDP; Δq^* is the growth of equilibrium real GDP; π is the growth of inflation level (consumer price index).

In general, the regression dependence is significant (α = 0,05). All coefficients are also significant (excluding inflation π). A regression model with inflation lag in the first quarter improves regression statistics, but inflation coefficient remains insignificant. The use of other leads (inflation expectations) and lags (lag effects of inflation) at economically substantiated intervals does not improve the model.

In our opinion, insignificant influence of consumer price index on the dynamics of money supply can be explained by the fact that the analysis was conducted during the period of 2004-2011, when the main priority for the National Bank of Ukraine was to ensure the exchange rate stability while the main channel for increasing the money supply was currency interventions in the interbank market. Therefore, we will withdraw inflation from the regression model in order to improve its quality. For further research, which will not be conducted on the basis of retrospective data, the inclusion of consumer inflation in the monetary rule is recommended.

We have built the following regression model:

$$\Delta m = 0{,}16 - 1{,}10\Delta v + 0{,}87(\Delta x - \Delta x^*) + 1{,}87\Delta q^*, \quad (8)$$

where Δm is the money supply growth (M3 aggregate); Δv is the money turnover growth; Δx is the growth of nominal GDP; Δx^* is the growth of equilibrium nominal GDP; Δq is the growth of equilibrium real GDP.

Regression statistics for this model is shown in Table 4. Analyzing the data, we can conclude that the model is statistically significant (α = 0,05). All coefficients of the model are also significant. The analysis of the correlation matrix leads to the conclusion about the lack of *multicollinearity*. Based on the calculation of the Durbin-Watson criterion we have made the conclusion about the lack of autocorrelation of the regression model residuals. The average approximation error is 4.3%, while an acceptable error in economic research is up to 10%. Therefore, we can conclude that our multivariate model has a sufficient quality and can be used to analyze the relationship between its indicators as well as in forecasting.

In accordance with theoretical provisions, the growth of money turnover should result in the reduction of the money supply growth. Our regression model (equation (8) confirms the presence of a strong inverse relationship between these indicators.

The growth of real GDP has the most significant direct impact on the dynamics of money supply. A direct impact twice its size on the resultant indicator causes a gap in the GDP ($\Delta x - \Delta x^*$). It is used to determine the current levels of the GDP deviation from its equilibrium (smooth) trajectory. Theoretically, an inverse relation should exist between this indicator and the money supply.

Table 4. Static characteristics of multivariate regression equation

Indicators	Values of indicators
Regression statistic	
Multiple R	0,947560663
R-squared	0,897871211
Adjusted R-square	0,887658332
Standard error	0,055351462
Observations	34

Table 4 (cont.). Static characteristics of multivariate regression equation

Indicators	Values of indicators					
Analysis of variance						
	df	*SS*	*MS*	*F*	*F*-statistic	
Regression	3	0,808063173	0,269354391	87,91558349	5,84102E-15	
Residual	30	0,091913531	0,003063784			
Total	33	0,899976704				
Characteristics of indicators						
	Coefficients	Standard error	*t*-statistic	*P*-value	Lower 95%	Upper 95%
Y-intercept	0,161956023	0,014760621	10,97216892	5,05071E-12	0,1318108	0,1921012
Variable X 1	-1,100720162	0,142283919	-7,736082664	1,24649E-08	-1,3913026	-0,8101376
Variable X 2	0,871250518	0,091066531	9,567186878	1,26906E-10	0,6852678	1,0572332
Variable X 3	1,865530251	0,406867894	4,585100661	7,49785E-05	1,034595	2,6964653

Thus, the central bank should conduct anti-cyclical monetary policy, rapidly increasing the money supply during the periods of low growth or decline in GDP, while moderately increasing or reducing the money supply during the peaks of GDP growth, reflecting the economy's "overheating". In the monetary rule based on retrospective data there is a direct dependence between the GDP gap and the dynamics of money supply, which is explained by the lack of countercyclical monetary policy during the study period.

During the period of 2000-2005 pro-cyclical policy of the National Bank of Ukraine was justified. It helped balancing the money market parameters and ensuring high growth rates of the real GDP. However, for the period beginning in 2006 (stabilization of money turnover and acceptable levels of monetization) it would have been advisable to consider the possibility of introducing some elements of countercyclical monetary policy. The peculiarities of introduction of countercyclical monetary policy in Ukraine and some other CIS countries were analyzed in the previous paper of Serhiy Kozmenko and Taras Savchenko [9].

To improve the objectivity of research results we have analyzed multivariate regression dependencies with some modifications in comparison with the McCallum rule. In particular, we have examined the expediency of: (1) the use of equilibrium dynamics of the money supply; (2) the inclusion of exchange rate dynamics in the monetary rule; (3) the use of alternative inflation indicators (price index of industrial products, core inflation, inflation targets).

Modified multivariate regression dependences are summarized in Table 5. Calculations were carried out for the period from the 4th quarter of 2003 to the 1st quarter of 2012 (34 observations).

Table 5. Modified multivariate regression dependences of the money supply and the monetary rule parameters for Ukraine

$$\Delta m^* = 0{,}18 - 1{,}22\,v + 0{,}91(\Delta x - \Delta x^*) + 0{,}50\,\Delta q^* + 0{,}003\,\pi^*$$

Form of equation	R^2	Value and significance of *F*-criterion	Significance of coefficients
$\Delta m^* = 0{,}17 - 1{,}18\,v + 0{,}90\,(\Delta x - \Delta x^*) + 0{,}58\,\Delta q^* + 0{,}29\,\pi$ Δm^* is the equilibrium growth of money supply (M3 aggregate)	0,96	188; 2,80643E-20	All significant except π
$\Delta m^* = 0{,}18 - 1{,}22\,v + 0{,}91(\Delta x - \Delta x^*) + 0{,}49\,\Delta q^*$	0,96	247; 2,99807E-21	All significant
$\Delta m^* = 0{,}18 - 1{,}21\,v + 0{,}95\,(\Delta x - \Delta x^*) + 0{,}56\,\Delta q^* + 0{,}03\,\Delta e$ Δe is the quarterly growth of the exchange rate of Hryvnia to the US dollar	0,96	181; 4,6261E-20	All significant except Δe
$\Delta m^* = 0{,}19 - 1{,}24\,v + 0{,}93\,(\Delta x - \Delta x^*) + 0{,}45\,\Delta q^* - 0{,}11\,\Delta p$ Δp is the price index of industrial products	0,96	183; 4,049E-20	All significant except Δp
$\Delta m^* = 0{,}18 - 1{,}22\,v + 0{,}91(\Delta x - \Delta x^*) + 0{,}50\,\Delta q^* + 0{,}003\,\pi^*$ π^* is the inflation benchmark	0,96	180; 5,17E-20	All significant except Δq^* and π^*

The regression dependencies are characterized by relatively high general statistical significance. However, the coefficients of indicators that reflect the dynamics of inflation or the dynamics of the exchange rate are not significant. It is also interesting to note that there are insignificant fluctuations in the absolute value of the coefficients for most factor variables and constant values as well as the proximity of the coefficients' values to the corresponding figures of the basic models (equations (7) and (8)). Only the value of coefficient of the independent variable that reflects the dynamics of the equilibrium real GDP (Δq^*) significantly differs from the basic models.

Conclusions

We have substantiated the importance of developing the money supply explicit monetary rule for the economy of Ukraine. We have also analyzed the methodological approaches to its formation. In particular, the procedure for calculating the value of the equilibrium GDP, which is used in the formation of the policy rule, was determined. A multivariate regression model, which confirms the presence of a statistically significant relationship between the main parameters of the monetary rule, was developed.

In our opinion, the conception of "monetary rules" as any other economic conception that involves the use of certain stable relationships between macroeconomic parameters for solving the current economic problems, has several deficiencies. These deficiencies are caused by the unstable nature of socio-economic relations and the complexity of forecasting of the economic agents' behavior at macroeconomic level. Based on the general content of research publications Van Lear William identifies five major deficiencies in the development and implementation of monetary rules [27].

However, we believe that two key theses in support of monetary rules negate most of the deficiencies cited in the scientific literature. Firstly, all developers of monetary rules, including John Taylor, warn against their mechanical application and emphasize the importance of their use along with other decision making instruments (expert judgment, modeling, etc.) of the monetary authorities. Secondly, at the moment there is no theoretically substantiated and empirically confirmed alternative to monetary rules. This thesis is particularly important during the use of inflation targeting regime.

The findings of this study can be used by the National Bank of Ukraine to develop a monetary rule. It should be noted that an explicit monetary policy rule will have a limited sphere of application until the full implementation of inflation targeting regime in Ukraine. It should be used only as an additional instrument for analyzing the effectiveness of the monetary policy. However, after the transition to inflation targeting and the renewal of stable relationships between the money supply and price dynamics in the economy of Ukraine (which will cause the inclusion of inflation indicator in the monetary rule for money supply) this rule can become one of the main instruments in the development and implementation of the monetary policy.

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