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INFLUENCE OF SELECTED FACTORS ON THE DEMAND FOR MONEY 1994–2000

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The views and opinions expressed in this study are those of the authors and are not necessarily those of the Czech National Bank.

Contents

Introduction

The demand for money represents one of the most important components of the transmission mechanism existing among monetary and real processes of a market economy. Developments in the demand for money, together with their influencing factors are closely tied to overall economic development. The analysis of the demand for money plays an important role in the decision-making process of central banks dealing with monetary policies, including the European Central Bank which has been working on a demand-for-money analysis intensively. Due to the rather irregular status of economic theory in its explanation of the demand for money and relevant influencing factors, a number of feasible approaches exist that may be exploited within an analysis. Additionally, the situation is complicated by the development of new financial products, changes in payment contacts, the growing influence of non-banking financial institutions, recurrent global or local monetary crises, as well as other factors.

The analysis in this study does not attempt to find a comprehensive answer to issues related to the development of the demand for money. In addition, it does not focus on the expansion of theoretical discussions devoted to the role of money, nor does it try to evaluate the quality of particular theories. Nevertheless, it does attempts to show the developments in the demand for money in the Czech Republic between

1994 and 2000[1] and to show the effects of some factors influencing its development. This analysis shares a common base with and draws on earlier studies: The Demand for Money in the Czech Economy (Hanousek, Tuma, 1995), The Demand-for-Money Function: the Case of the Czech Economy (Klacek, Šmídková, 1995) and others. The period of publication of the studies above – making it possible to implement longer time series – has created room for applying a new theoretical and econometric approach. It has also brought new information and confirmed the significance of traditionally analysed variables for the long-run development of the demand for money in the Czech economy.

This analysis comprises three parts. In the first part, some theoretical approaches to the examination of the demand for money are outlined. The second part includes data, a methodological determination of the analysis, and an econometric analysis of the problem. The examination is based on the methodology of multi-equation and single-equation models. From the viewpoint of economic theory, the fundaments are provided by the adjusted Arestis model (Arestis, 1988), based on traditional Keynesian growth factors. The Arestis model is mainly preferred because, apart from not being too complicated, it also makes it possible to consider the additional effects of external relationships. Due to the rather short range of the available time series, models with a limited number of variables may only be used. Consequently, the results obtained on the basis of simpler models are of an indicative character only, owing to the specifics of the transformation process and the relatively varying economic environment of the Czech Republic, which has not yet been through a closed economic cycle. The third part of the work includes an economic evaluation of the previously mentioned econometric analysis, together with a brief summary of the overall results.

[1] The study does not include an analysis of 1993 due to the irregular monetary and economic development associated with the split of the former Czechoslovakia during this year. From the viewpoint of statistics, including 1993 in the analysis would also be inappropriate, because no year-quarter data concerning GDP development are available for this particular year that are methodically comparable with 1994–2000 .

1 The role of the demand for money in the transmission mechanism of monetary policy and theoretical approaches to its analysis

1.1 The role of the demand for money in the transmission mechanism of monetary policy

The demand for money reflects the degree of desirability to possess money for companies, households, individuals and other economic entities. In its nominal representation, it indicates the attractiveness of a certain amount of money; in real representation, however, it shows how attractive it is to possess money corresponding to the number of units of assets and services that may be acquired for the money. The role of the demand for money has become the subject of nearly all discussions concerning the monetary transmission mechanism with fundamental significance usually attached[2] to demand-for-money issues (including theories

[2] Of the wide range of monetary transmission mechanism patterns presented, G. J. Bondt's transmission pattern has been generally recognised and accepted: Credit and asymmetric effects of monetary policy in six EU countries: an overview, De Nederlandsche Bank NV, 1998. G. J. Bondt distinguishes between 5 primary channels of monetary transmission: direct monetary transmission, the interest channel, the assets price channel, the credit channel, and the expectancy and uncertainty channel. Demand-for-money issues are already included in the first monetary transmission channel. A previous study at the CNB, Arlt, Guba, Matalík, Stiller, Syrovátka: Definition and primary relation analysis of the monetary transmission

preferring the importance of monetary supply influence over the demand influence on the economy).

Even in the absence of fundamental doubts at the general level pertaining to the necessity of dealing with the demand for money, opinions concerning its specific impact on the economy differ depending on the theoretical bases taken into account by particular scholars. In the relatively heterogeneous spectrum of opinions prevailing within this particular field, long-term recognition has been granted to a few basic approaches: the Keynesian approach, emphasising the importance of the demand for money in the economy and motives for possessing real money balances, and the monetarist approach, stressing the effects of the exchange area on demand for money developments as represented by developments in nominal GDP. Concurrently, the monetarists maintain that developments in money supply take precedence in economic development. A significant degree of interplay between the two approaches has led to their mutual interaction and development. At present, however, they represent alternative theoretical concepts based on different methodological viewpoints.

1.2 Primary theoretical approaches to examination of the demand for money

1.2.1 Keynesian interpretation of the demand for money

The most important relationship found in a Keynesian economy is the relationship between economic growth (GDP development) and investments (as the most volatile component of aggregate demand). Development of the relationship is reflected in the demand for money and in the monetary field, where the demand for money induces the money supply. In the long run, both supply and the demand for money are balanced[3]. In comparison with the monetary approach, a lower degree of

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mechanism in the Czech Republic (1998), provides a detailed discussion of monetary transmission issues.

[3] An explanation of the general principles of Keynesian, neo-Keynesian, and post-Keynesian theory exceeds the scope of this study. A detail discussion of the principles is provided e.g. in the book *John Maynard Keynes and contemporary economics* (Sojka, 1999).

efficiency in the effects on economic development is attributed to the monetary area in the Keynesian theory.

The Keynesian theoretical analysis of the development of the demand for money is based on the preference liquidity theory of J. M. Keynes. This theory provides an answer to why economic entities (companies, households) demand and hold money that does not yield any interest, instead of securities or similar assets. An answer to the question is closely related to the scope of transactions that the money is to service, as well as to the degree of uncertainty associated with the future results of economic activities of companies and households, and the needs of economic entities stemming from uncertainty, such as maintaining a liquid position, avoiding insolvency, or bankruptcy, as the case may be. The demand for money, i.e. the demand for liquidity, ensues from not being able to predict future events with sufficient accuracy under market economy conditions.

In relation to Keynes' *General theory of employment, interest, and money*, the Keynesian theory of the economy distinguishes between three motives of liquidity preference, i.e. the transactional, precautionary and speculative motive[4].

Keynes adopted the transactional motive from the monetarist approach of the Cambridge school (A. Marshall, A. Pigou, et al) and correspondingly considered the fact that a part of the demand for money is associated with transactions related to income developments (nominal gross domestic product). In addition, the precautionary motive is mentioned in studies ascribed to the Cambridge school. The speculative motive of money possession, however, is Keynes' own invention. Schematically, Keynes' approach can be expressed as follows

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[4] "The three divisions of liquidity-preference which we have distinguished above may be defined as depending on

(i) the transactions-motive, i.e. the need of cash for the current transaction of personal and business exchanges;
(ii) the precautionary-motive, i.e. the desire for security as to the future cash equivalent of a certain proportion of total resources; and
(iii) the speculative-motive, i.e. the object of securing profit from knowing better than the market what the future will bring forth." (Keynes, 1953, page 170.)

"In normal circumstances the amount of money required to satisfy the transactions-motive and the precautionary-motive is mainly a resultant of the general activity of the economic system and of the level of money-income. ... For the demand for money to satisfy the former motives is generally irresponsive to any influence except the actual occurrence of a change in the general economic activity and the level of incomes; whereas experience indicates that

$$M = L_1(Y) + L_2(i), \quad (1)$$

where L_1 is a function of liquidity expressing the transactional and precautionary motive, L_2 is a function of liquidity expressing the speculative motive of liquidity preference, Y is nominal gross domestic product (nominal GDP) and i is the interest rate (Keynes, 1953). In reality, however, there is unified demand for money, because these motives exert influence simultaneously and are mutually independent. In this study, the motives are only discussed separately for explanation and analysis purposes. While Keynes only considers nominal quantities in his demand-for-money theory, notions of his followers emphasise the issue of the demand for real money balances, because individuals and institutions mainly possess money due to its potential of being exchanged for assets and services, or according to Dornbusch, Fisher (1994), "people possess money because of its purchasing power, i.e. the quantity of goods and services that they can purchase with money".

1.2.2 Neo-Keynesian interpretation of the demand for money

The neo-Keynesian interpretation of the demand for money is based on Keynesian principles. The transactional motive and precautionary motive are expressed as directly proportional to GDP and synoptically are described as "demand for active balances". The speculative motive causes dependence between the demand for money and interest rates. Formally, such dependence can be expressed using the following formulae

$$M_{da} = kY \quad \text{and} \quad M_{ds} = \alpha - \beta i, \quad (2)$$

where M_{da} is demand for active balances, k is the share of active balances in GDP, Y is nominal GDP, M_{ds} is speculative demand for money, α and β are parameters and i is the interest rate.

This interpretation is simplified, because the direct proportionality may be undoubtedly linked to the effects of the transactional motive of liquidity preference, however, it is rather problematic with the precautionary motive. In the case of the

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the aggregate demand for money to satisfy the speculative-motive usually shows a continuous curve relating changes in the rate of interest. ..." (Keynes, 1953 , page 196-7.)

precautionary motive, it is a response to uncertainty related to future developments and the tendency of protection against the possible negative consequences of future income developments. Therefore, the relationship between GDP and precautionary demand for money should be formulated as anti-cyclical instead of pro-cyclical, similar to the transactional motive. This pattern seems to be indicated by developments in savings in the Czech Republic during the 1998 recession. For econometric modelling, additionally, a serious problem is presented by the probable non-linearity of the precautionary demand for money. Such complications lead to a situation, where practical attempts of modelling developments in the demand for money disregard the precautionary motive.

The speculative motive of liquidity preference is related to the question of what rate of uncertainty and yield in savings accumulation are the economic entities willing to bear. The previous is associated with the choice between money and various types of long-term deposits, obligations and other types of interest-bearing securities.

The demand for money can be expressed as follows:

$$M_d = L(Y,i), \qquad (3)$$

where M_d is demand for money, L is the "liquidity preference function", Y is nominal GDP, and i is an interest rate.

This approach was developed by Baumol (1952) and Tobin (1956) to an approach based on the possession of money as inventory, where the transactional motive of liquidity preference is particularly emphasised. Results of such considerations lead to the well-known formula:

$$M_d / P = \sqrt{cY_r / 2i}\ , \qquad (4)$$

where M_d is demand for real balances, c is transactional costs, Y_r is real GDP and i is the interest rate. To its disadvantage, the Baumol-Tobin model rather narrowly focuses on the demand and an assumption of cost stability in a transaction (c-parameter), which does not seem realistic in the long run.

In this concept, "optimum" demand for real money balances is directly proportional to transactional costs and real income, and indirectly proportional to interest rates.

Another interpretation used stems from an approach based on the precautionary demand for money (Whalen, 1966). In the context of this approach, individuals carefully consider the possible interest yield from money "invested" in comparison with the advantage of avoiding "payment insolvency". A weakness of this approach, however, lies in its emphasis on the knowledge of the income and expenditure probability distribution.

Yet another interpretation is based on the concept of money as an asset and is related to the portfolio composition theory formulated in the neo-Keynesian interpretation by James Tobin (1958). This concept focuses on an intrinsic money interest rate (usually considered to be equal to zero (Laidler, 1993), or may be negative in the case of a high inflation rate), and the yield rate related to alternative assets.

1.2.3 Post-Keynesian interpretation of the demand for money

Post-Keynesian economics accentuates the role of uncertainty associated with the historical developments of the economy and puts the demand-for-money concept into a broader context typical for its emphasis on the role of money as a "value custodian" and the endogenous nature of the money supply ensuing from the credit money-creation by commercial banks in response to demand for loans. The money supply is affected by the relevant policy of the central bank. Even though this policy is not capable of directly determining the money supply, it is able to affect the development of interest rates, influencing demand for loans from economic entities. The volume of money in the economy, then, is the result of a demand vs. supply process interaction. Through its instruments, the central bank is able to influence the conditions for issuing loans due to the impact of such instruments on interest rate developments. Additionally, the behaviour of the banking sector towards economic entities applying for loans is significantly influenced by institutional characteristics of the banking sector. In this context, an important role is maintained by banking regulation and banking supervision functions (see Dow, Rodríguez-Fuentes in Arestis, Sawyer, 1998).

In the formulation of the demand for money itself, post-Keynesian economics differs from neo-Keynesian, especially in the inclusion of the financial motive (Keynes, 1937) in the demand for money. The financial motive reflects the fact that entrepreneurs must maintain certain money balances in the course of time, so that they are able to meet their liabilities when entering future contracts associated with the purchase of inputs necessary for the production of capital assets. If the planned investments do not change, the money balances will remain permanent; if they increase, additional financial demand for money is created. Inclusion of the financial motive and consideration of governmental demand for money lead to a situation in which the demand for active balances assumes the following form

$$M_{df} = \gamma C + \delta I + \omega G \quad (5)$$

If we express $C = A + cY$ (where C is consumption, A is a constant expressing autonomous consumption and c is the marginal propensity to consume), $I = a - bi$, G is governmental expenditures, γ, δ and ω are constants, the value of which primarily depends on payment frequency and the overlay of payments within the economy.

Substitution of C, I and G in the original equation provides the following relation

$$M_{df} = \gamma(A + cY) + \delta(a - bi) + \omega G\ . \quad (6)$$

Having supplemented the speculative demand for money to the previous relation, the total demand for money should be the following

$$M_d = M_{df} + (\alpha - \beta i)\ . \quad (7)$$

In the next step, the speculative demand can be expanded into a portfolio analysis form, where investments in various kinds of assets and associated interest rates are comprised.

In this approach, the demand for money is usually expressed nominally. For transformation to the real demand for money form, it is necessary to consider, subsequently, inflation development.

Most economists, however, ignore the fourth motive.

Philip Arestis is one of several important post-Keynesian scholars working on the demand for money theory. In his article (Arestis, 1988), in contrast to e.g. Keynes and other scholars, he discusses the demand for money in a small, open economy. His approach to the demand for money can be expressed using the following equation

$$M_d /P = K(Y_r)^a (P^e)^{-b} (CR)^{-c}(ER^e)^{-d} u, \quad (8)$$

where M_d /P are real money balances, K is the Cambridge coefficient, which is a function of GDP growth, prices and the volume of money in circulation and is expressed by a reversed value of money velocity (velocity of a money unit is understood as a function of income, prices, and money stock growth), Y_r is real GDP, P^e is the expected rate of inflation, CR is an estimated variable for credit limitations, ER^e is the expected appreciation or depreciation rate of the currency, u is a non-systematic component and $a, b, c,$ and d are elasticity values.

Arestis' model in the previous expression, however, is not ideally suited for conditions prevailing in the Czech Republic. At present, quantifiable[5] credit limitations do not exist in the Czech economy, and the long-term analysis of the demand for money on an exchange rate basis is challenged by a long-term applied fixed rate regime.[6] The relationship to abroad may be expressed better in the long run by an interest rate differential, while an expected differential can be substituted for the existing one, and expected inflation may be substituted for current inflation. Consequently, the modified formula reads as follows

$$M_d /P = K(Y_r)^a (P^e)^{-b}(IRD)^{-c} u, \qquad (9)$$

where M_d /P are real money balances, K is the Cambridge coefficient, Y_r is real GDP, P^e is the expected rate of inflation, IRD is the interest rate differential, u is a non-systematic component, and a, b, c are elasticity values.

1.2.4 Monetarist approach to the demand for money

The monetarist approach to the economic problems analysis is based on the assumed existence of a close dependency between the volume of money in the economy and nominal income, usually expressed by nominal GDP. In monetary considerations of the economy, money plays a primary role with the money supply being a decisive factor. It is the money supply, according to monetarists, that fundamentally influences the developments of particular economic variables reflected

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[5] The most common quantifiable limitations of credit issues primarily include ceilings on credit volumes granted by commercial banks, as well as administrative limitations on interest rates associated with loans granted, and others. In his original model version, Arestis considers the discount interest rate as a regulation factor for credits granted, which, in countries where this particular interest rate directly relates to credit processes, may really represent a significant regulation factor. In the Czech banking system, however, the discount interest rate plays a different role (it is used for the interest calculation on commercial bank overnight deposits with the Czech National Bank).

in the demand for money. The demand for money, on both the short- and medium-run horizon, may differ from the money supply. However, an equilibrium is assumed for both variables in the long run. Heyne (1991) comments accurately on monetarist principles: "Briefly, the monetarists' thesis maintains that if there are problems, an error is not to be found with those who demand money, but with those who offer money" (see Sojka, 1996).

The traditional monetarist approach to the demand for money emphasised, in particular, the role of money as a means of exchange. The demand for money was, in the conception of I. Fisher and other supporters of the quantity theory of money, a function of the nominal income that should correspond in its volume to the volume of money necessary to satisfy transactional needs.

Modern monetarists withdrew from the notion of an exclusive tie between the demand for money nominal income. They acknowledge, however, the influence of both interest rates and yields of other tangible and financial assets (obligations, shares, goods). The position of modern monetarists to issues of the demand for money is clearly presented in the approach of Milton Friedman. Friedman refreshed the traditional quantitative money theory in the Cambridge version, however, simultaneously respected the Keynes' theory of liquidity preference. According to Friedman, development of the demand for money depends on the overall wealth of society in various forms (money, obligations, shares, material and human resources) as well as on the taste and preferences of holders of the wealth. Stability of demand-for-money development is an important assumption on which Friedman and other monetarists base their expansions of the theory.

Formally, the demand for money in Friedman's concept may be expressed as follows:

$$\frac{M_d}{P} = f\left(y, w; r_m, r_e - r_m, r_b - r_m, \frac{1}{P}\frac{dP}{dt}; e\right), \qquad (10)$$

where M_d/P is demand for real money balances, y is the overall wealth, w is a share of accumulated human resources in the overall wealth, r_m is the expected money yield, r_b is the expected yield of obligations, r_e is the expected yield of securities (shares),

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[6] After partially freeing up the CZK exchange rate and widening of the fluctuation band from $\pm 0.75\%$ to $\pm 7.5\%$ as of 29th February 1996, the fixed exchange rate of the CZK was abolished on 27 May 1997.

$\frac{1}{P}\frac{dP}{dt}$ is the expected change in commodity prices and e is the influence of other factors.

The equation clearly indicates the wide range of Friedman's view of demand-for-money issues. However for practical analyses, such an approach is really only manageable with difficulties in both transitive and non-transitive economies. This similarly applies to the utilisation of other theoretical approaches. Experience with their application within analytical activities has gradually led to the conclusion that clear, theoretical concepts do not interpret the development of the demand for money sufficiently due to their tendency to ensue from rather simplified model interpretations, which as a basis for a sufficiently realistic analysis of the demand for money, provide a rather coarse instrument. Such a conclusion is well supported by the fact that analyses of the demand for money performed abroad gradually withdraw from the more traditional theoretical approach based on either the Keynesian or monetarist positions. Theoreticians repeatedly prefer a combination of these theoretical approaches, a task of which is to determine the long-term balance and short-term dynamics stemming from an analysis of statistical data. This approach is represented by the error correction model (see Sriram, 1999). In this approach, the statistical data analysis is "framed" in a primary theoretical framework, which is not considered to be a satisfactory explanation of demand-for-money behaviour.

2 Influence of selected factors on the demand for money, 1994–2000

2.1 Econometric models

For the sake of econometric analysis simplification, seasonally adjusted time series are applied in the demand-for-money model. The time series are usually non-stationary and mostly I(1) type. It is therefore meaningful to accept this fact during the construction of econometric models of the demand for money. A cointegration analysis of time series leads to the construction of error correction models that enable the characterisation of short-term relationships separately, i.e. relationships among stationarised time series, long-term relationships, i.e. relationships among non-stationarised time series.

In this part of the document, let us describe some basic aspects of the cointegration analysis in multi-equation and single-equation models. For the sake of simplification, we will only focus on special types of models, (VAR(2), ADL(1,1;1)), however, conclusions derived from such models apply generally for VAR and ADL models of any order.

2.1.1 Cointegration in multi-equation and single-equation models

VAR models

Let us assume the l-dimensional VAR(2) model

$$\boldsymbol{X}_t = \boldsymbol{c} + \boldsymbol{\phi}_1\boldsymbol{X}_{t-1} + \boldsymbol{\phi}_2\boldsymbol{X}_{t-2} + \boldsymbol{a}_t, \tag{11}$$

where $\boldsymbol{X}t$ is the l-dimensional vector of time series, c is the l-dimensional vector of constants, $\boldsymbol{\phi}_1$ and $\boldsymbol{\phi}_2$ are l x l-dimensional parameter matrices, $\{\boldsymbol{a}_t\}$ is the l-dimensional white noise process with normal random variables, and $\boldsymbol{\Sigma}_a$ is a covariance matrix. The VAR model may be expressed as follows:

$$\Delta\boldsymbol{X}_t = \boldsymbol{c} + \boldsymbol{\Gamma}_1\Delta\boldsymbol{X}_{t-1} + \boldsymbol{\Pi}\boldsymbol{X}_{t-2} + \boldsymbol{a}_t, \tag{12}$$

where

$$\boldsymbol{\Gamma}_i = -(\boldsymbol{I}_l - \boldsymbol{\phi}_1),\ \boldsymbol{\Pi} = -(\boldsymbol{I}_l - \boldsymbol{\phi}_1 - \boldsymbol{\phi}_2). \tag{13}$$

This model is called the vector error correction model (VEC). The model includes short-run relationships among processes, i.e. relationships among differenced (stationarised) processes. In addition, it includes long-run relationships, i.e. relationships among non-differenced processes. Information concerning the long-run relationships is contained in the $\boldsymbol{\Pi}$ parametric matrix. The VEC model allows these relationships to be examined separately. The following three situations may occur in the VEC model:

1. $h(\boldsymbol{\Pi}) = l$, i.e. the $\boldsymbol{\Pi}$ matrix has full rank, which means that the l-dimensional time series is generated by a stationary vector process $\{\boldsymbol{X}_t\}$. If a multi-dimensional time series is stationary, the particular time series are also stationary and their stationarisation is not needed; if it is done regardless, the non-differenced part remains in the model developed from the VAR model, i.e. $\boldsymbol{X}_{t-2}$ in the model (12).
2. $h(\boldsymbol{\Pi}) = 0$, i.e. the $\boldsymbol{\Pi}$ matrix is zero and the (12) model does not include any non-differenced member, the l-dimensional time series is generated by a non-stationary vector process $\{\boldsymbol{X}_t\}$ (it is assumed that the particular processes are I(1) type) and their stationarisation can be performed by differencing the particular time series. The differencing does not lead to a loss of information concerning the long-term relationship among the time series, because it does not exist.

3. $0 < h(\boldsymbol{\Pi}) = r < l$. In this case, the non-differenced member of the (12) model does not disappear and concurrently, the $\{\boldsymbol{X}_t\}$ process is not stationary (the particular processes are I(1) type). Due to the fact that $\boldsymbol{\Pi}$ is a non-zero matrix, the long-run relationships exist among the time series and stationarisation through the individual differencing of particular time series leads to the loss of information.

The first two situations are obvious, and their explanation is quite logical. The third situation is difficult to explain by intuitive reasoning alone. It is dealt with by Granger's theorem [Engle, Granger (1987), Johansen (1991), Banerjee at al. (1993), Arlt (1995), (1999)].

ADL type single-equation models

Let us now assume a single-equation model in the following form:

$$Y_t = c + \alpha_1 Y_{t-1} + \beta_0 Z_t + \beta_1 Z_{t-1} + a_t, \tag{14}$$

where $\{a_t\}$ is a white noise process with normal random variables, variance σ_a^2, and the $\{Z_t\}$ process is weakly exogenous for the β_0, α_1 and β_1 parameters of interest. This model is called ADL(1,1;1) ("Autoregressive Distributed Lag"). Similarly as in the case of the VAR model, it may also be expressed in EC ("Error Correction") form

$$\Delta Y_t = c + \beta_0 \Delta Z_t + (\alpha_1 - 1)[Y_{t-1} - \frac{\beta_0 + \beta_1}{1 - \alpha_1} Z_{t-1}] + a_t. \tag{15}$$

Where the $\alpha^* = (\alpha_1 - 1)$ parameter, representing the influencing force of a long-term relationship of processes considered, is called "loading" and the $\beta^* = (\beta_0 + \beta_1)/(1 - \alpha_1)$ parameter characterising the long-run relationship itself is called a long-run multiplicator.

Let us assume that the $\{Y_t\}$ and $\{Z_t\}$ processes are I(1) type, and that the three situations are in static regression:

$$Y_t = c + \beta_0 Z_t + u_t: \tag{16}$$

a) $\{u_t\}$ is a white noise process, i.e. it is an I(0) type.

b) The $\{u_t\}$ process is stationary and autocorrelated, and also an I(0) type.

c) The $\{u_t\}$ process is an I(1) type.

In the first case of the (15) model, $u_t = a_t$, $\alpha_1 = 0$ and $\beta_1 = 0$. The (14) and (15) models are transformed to a static regression form and $\beta^* = \beta_0$, so that β_0 becomes a long-run multiplicator. The long-run relationship between the $\{Y_t\}$ and $\{Z_t\}$ processes is therefore characterised by the (16) regression.

Let us now consider the situations ad b) and ad c), i.e. $u_t = \rho u_{t-1} + a_t$, where $\{a_t\}$ is a white noise process with normal variables. In such a situation, the (16) model can be expressed in the following form:

$$Y_t = c + \rho Y_{t-1} + \beta_0 Z_t - \rho\beta_0 Z_{t-1} + a_t, \tag{17}$$

i.e. as ADL(1,1;1). In respect to the (14) model, $\alpha_1 = \rho$ and $\beta_1 = -\rho\beta_0$.

Let us now consider the ad c) situation. If the $\{u_t\}$ process from the (16) model is an I(1) type, then $\rho = 1$. In such a case, inclusion of the explanatory I(1) type process in the model does not decrease the integration order of the process being explained. It further applies that $\alpha^* = (\alpha_1 - 1) = 0$ and the EC (15) model has the following form:

$$\Delta Y_t = c + \beta_0 \Delta Z_t + a_t. \tag{18}$$

The time series are not cointegrated and therefore no equilibrium state exists; subsequently, the model does not contain any long-run multiplicator – i.e. the model looses its EC status. It becomes obvious that a two-dimensional process, when particular processes are not cointegrated, can be stationarised by the differencing of each process separately. It is worthwhile to remember that if a static regression, i.e. the (16) model, is applied to an analysis of such generated time series, the regression becomes spurious.

In the case of ad b), the processes included in the model are cointegrated. Because $|\rho| < 1$, then the $-2 < \alpha^* < 0$ relationship applies, and the (15) model includes an EC part. This case can be explained intuitively: inclusion of an I(1) type process cointegrated with the process being explained into the model decreases the integration order of the process being explained and $\alpha^* \neq 0$. The long-run multiplicator in this case has the following form:

$$\beta^* = \beta_0 \frac{\rho + 1}{1 - \rho} \ . \tag{19}$$

Its value therefore depends on the β_0 parameter value and the auto-correlation strength, i.e. on the ρ parameter value. It additionally becomes obvious that a two-dimensional process including the cointegrated processes cannot be stationarised by their particular differencing alone.

If the ADL model includes k explaining processes, the maximum of $r = k$ basic cointegration relationships may exist; apart from these, however, other cointegration relationships exist that are created by their linear combination.

2.1.2 Tests of cointegration in multi-equation and single-equation models

VAR models

Testing cointegration means testing the rank of the $\boldsymbol{\Pi}$ matrix from the (12) model. Testing of the cointegration rank means determination of the number of cointegration vectors, i.e. the number of cointegration relationships. The hypothesis H_1 means that the rank of $\boldsymbol{\Pi}$ is full, i.e. $r = l$. In such a case, all time series of the system are I(0) type. The hypothesis $\mathrm{H}_2(r)$ means that the rank of $\boldsymbol{\Pi}$ is $r < l$, so the l-dimensional time series is a non-stationary, I(1) type and cannot be stationarised by the differencing of particular time series, because some of their linear combinations are stationary already. For determining the number of cointegration vectors using the likelihood ratio tests, the $\mathrm{H}_2(r)$ hypothesis is tested inside the H_1 hypothesis. The testing criterion is the ratio of likelihood functions

$$\mathrm{Q}(\mathrm{H}_2(r)|\mathrm{H}_1) = \frac{L_{\max}^{-2/T}(\mathrm{H}_2(r))}{L_{\max}^{-2/T}(\mathrm{H}_1)} = \frac{|\boldsymbol{S}_{00}|\prod_{i=1}^{r}(1-\hat{\lambda}_i)}{|\boldsymbol{S}_{00}|\prod_{i=1}^{l}(1-\hat{\lambda}_i)} = \frac{1}{\prod_{i=r+1}^{l}(1-\hat{\lambda}_i)}, \tag{20}$$

After logarithmic transformation, it has the form:

$$\eta_r = -2\ln\left[\mathrm{Q}(\mathrm{H}_2(r)|\mathrm{H}_1\right] = -T\sum_{i=r+1}^{l}\ln(1-\hat{\lambda}_i). \tag{21}$$

The testing criterion for testing the $\mathrm{H}_2(r)$ hypothesis inside the $\mathrm{H}_2(r+1)$ hypothesis has the form:

$$\xi_r = -2\ln\left[\mathrm{Q}(\mathrm{H}_2(r)|\mathrm{H}_2(r+1))\right] = -T\ln(1-\hat{\lambda}_{r+1}). \tag{22}$$

The above-described tests are called, according to the author, Johansen's cointegration tests. Its detail explanation is provided in the following studies: Johansen (1991), (1995), Johansen, Juselius (1990), Hansen, Juselius (1995), Arlt (1999). Additionally, these works include an explanation of other tests concerning $\boldsymbol{\delta}$ (cointegration parameters) and γ(loading).

ADL type single-equation models

The cointegration testing in single-equation models is based on the evaluation of whether a non-systematic component of the static model, in the form

$$\boldsymbol{\beta}'\boldsymbol{X}_t = u_t, \qquad (23)$$

where $\boldsymbol{\beta}$ is a l-dimensional parameter vector and $\boldsymbol{X}_t$ is a l-dimensional vector of time series, is an I(1) or I(0) type. In the first case, the series are not cointegrated; in the second one, the series are cointegrated.

In order to acquire $\hat{u}_t$ residuals that could be used in the testing, it is necessary to estimate the cointegration vector. It is assumed that all the time series of the $\boldsymbol{X}_t$ vector are I(1) type and only one cointegration relationship exists, i.e. one cointegration vector $\boldsymbol{\beta}$. This may be estimated by the least squares method. It is based on relation (23) where a particular time series is considered to be explained and the other is considered to be explanatory. Such a regression is called a cointegration regression. The estimator of the cointegration vector is a good approximation of the cointegration vector, because Stock (1987) proved that it is consistent and that it converges to the cointegration vector very quickly.

The testing is based on cointegration regression residuals, and the testing hypothesis is that the series are not cointegrated, i.e. the non-systematic component is an I(1) type. The following tests can be applied: the Durbin-Watson test, the Dickey-Fuller test, the Dickey-Fuller augmented test, and the Phillips-Perron test [see the detailed description in Arlt (1999)].

The cointegration in the single-equation model can be tested also on the basis of the EC model (15). It is tested whether loading $\alpha^* = (\alpha_1 - 1)$ equals zero or is something different than zero. If this parameter equals zero, the processes are not cointegrated. This test is rather problematic, because the distribution of its testing criterion has not been developed yet. Nevertheless, the estimation of parameter α^* can be derived approximately from the estimation of parameter α_1. If this estimate is close to one, it may be assumed that there is no cointegration relationship among the analysed processes.

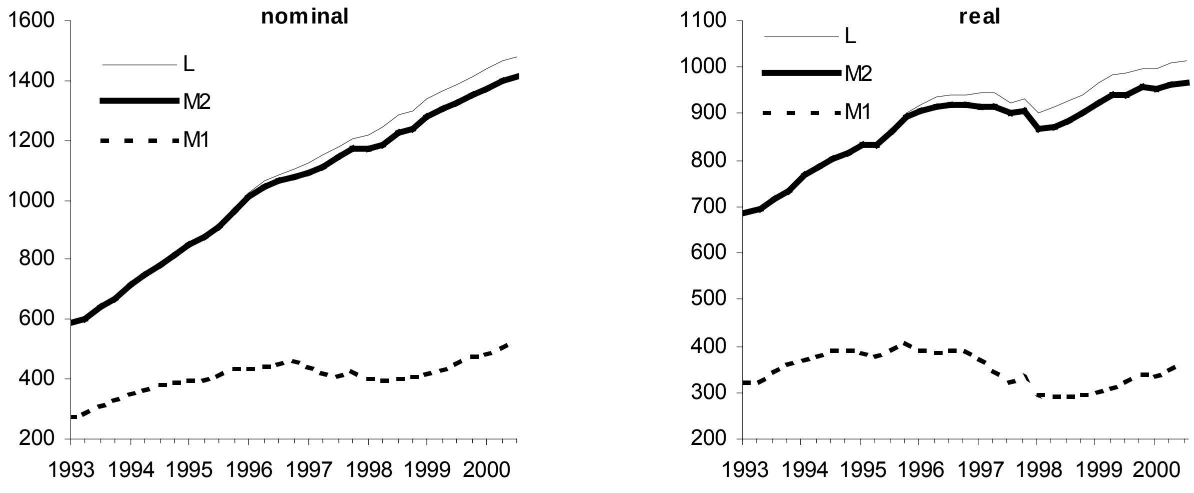
2.2 Data and their basic characteristics

The model creation process ensued from an in-house study: "Influence of selected factors on demand-for-money developments in the period 1993–1996" (1997). The models were expanded, reviewed and recalculated on the basis of extended time series (GDP corrections included), from the first quarter of 1994 to the second quarter of 2000.

Within the analysis, the demand for money is represented by three monetary aggregates: M1, M2, and L, which in fact is the M2 monetary aggregate plus short-term securities possessed by domestic non-banking subjects. The development of the aggregates is indicated in Figure 1. Due to the small difference in the development of the L, M2 aggregates, respectively, only the M2 aggregate is considered in the following.

Figure 1

Nominal and real money aggregates



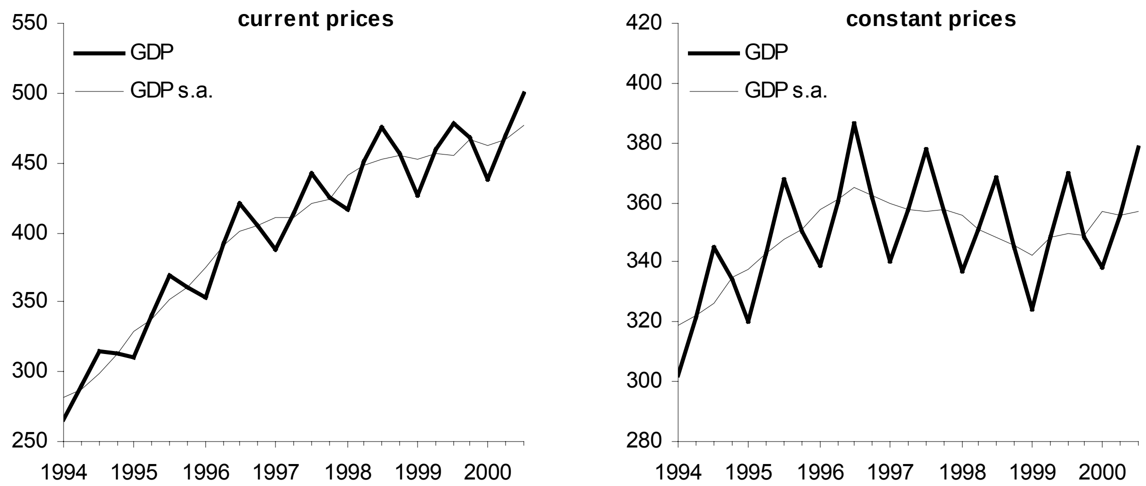
Source: CNB.

The analysis is based on quarterly data. The monetary aggregates (M1, M2, and L) were transformed to quarterly time series using a chronological average from end-of-month data. The real values of the monetary aggregates were calculated using the consumer price index.

One of the primary factors influencing the demand for money is a scaling variable, represented by GDP[7]. The development of nominal and real GDP from 1994 to 2000 Q3 is shown in the following chart in a seasonally adjusted and non-adjusted form.

Figure 2

GDP in current and constant prices



Source: CSO.

Other factors determining the demand for money may include the 1Y PRIBOR[8] and the non-term deposit interest rate (the theoretically recommended obligation

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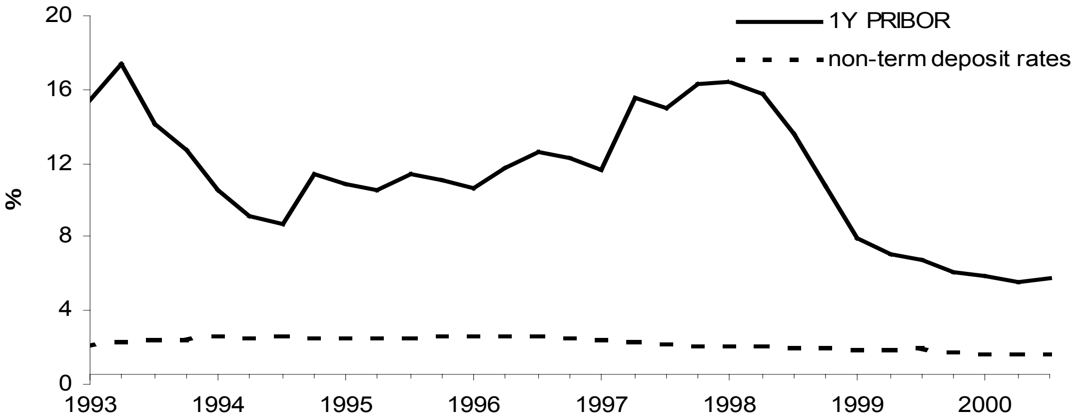
[7] As an alternative to GDP, domestic demand, e.g. may be used for the scaling variable. Due to similar long-term development for both time series, GDP was used in compliance with the original Arestis concept.

[8] The application of average interest rates to term deposits would be better suited to the analysis concept. Available monthly average data for deposit interest rates are not immediately reflected, however, in the current statistical concept, the interbank market and client deposit developments, because they include deposits from 1-week to 10-years and longer notice terms and various interest rates. Therefore, a statistically problem-free 1Y PRIBOR interest rate was applied, which is close to the newly announced client interest rates for new deposits and newly granted loans.

yield[9] still could not be used due to the lack of necessary data). The quarterly data for the 1Y PRIBOR rate were acquired as the average of daily data; for non-term deposit rates, end-of-quarter data were applied. Interest rate developments are provided in Figure 3. Due to the fact that "it is not suitable to combine short-term interest rates in conjunction with the wider definition of money" (Hanousek, Tůma, 1995) and that the non-term deposit interest rate is low and has almost constant development in comparison to the 1Y PRIBOR, it shall not be considered in the calculations.

Figure 3

1Y PRIBOR interest rate and non-term deposit rates



Source: CNB.

For calculation of the interest rate differential, the 1Y LIBOR (USD) interest rate is frequently applied.

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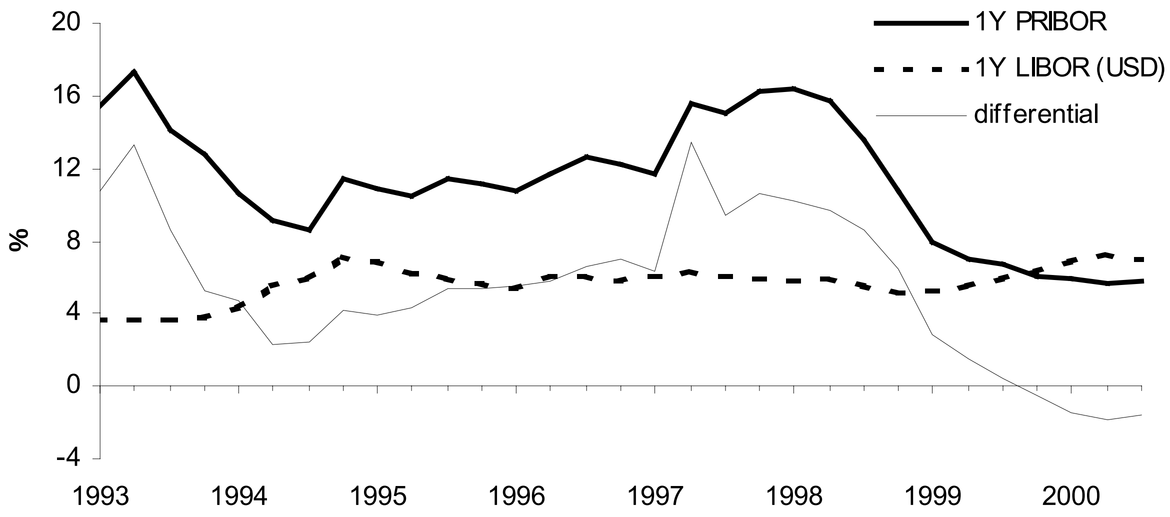
[9] The volume of government bonds and treasury bills as alternative assets to the possession of money in non-banking hands is not yet widespread in the Czech Republic. As of 31 December 2000, the ratio of government bonds held by non-banking clients to the volume of money included in the M2 monetary aggregate was 2.4%, and the ratio to the volume of treasury bills was 3.5%. For the volume of government bonds, not only interest rates played a significant role (as considered by Keynes), but other factors were important as well, e.g. restructuring of investment fund portfolios created before the funds had to open, etc.

Figure 4

Interest rates and differential

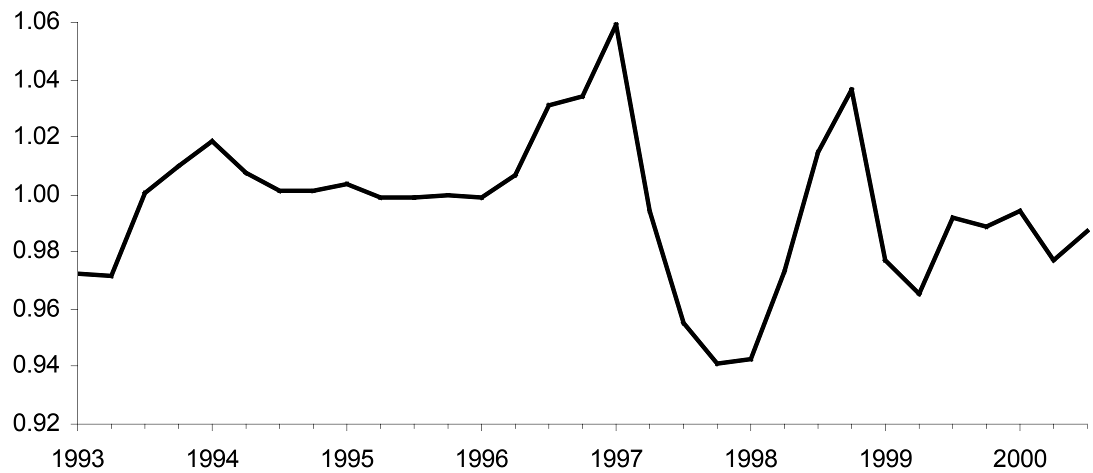


Source: CNB.

The exchange rate was another factor to be considered. For its analysis, an index of the CZK nominal effective exchange rate (without Russia) was applied. Its development is shown in Figure 5.

Figure 5

Nominal effective exchange rate



Source: CNB.

Apart from GDP and the interest rate influence, the inflation effects were also analysed (see more in Section 2.3).

2.3 Model construction and hypothesis testing

This part of the analysis does not focus on the acquisition of coefficients and elasticity values applicable for the prediction of future developments. Its objective is verification of factors and the direction of their influence on demand. In the analysis of particular equations, it is therefore necessary to consider the signs of parameter estimates rather than their level.

The econometric modelling of the demand for money is based on the post-Keynesian interpretation and Arestis' model (9) in particular, where some adjustments were implemented, due mostly to the character of the time series available. The seasonally adjusted time series are employed. The model includes real M1 and M2, real GDP and the 1Y PRIBOR interest rate. Inclusion of the growth rate of the consumer price index (may be interpreted as the rate of inflation) is being considered. Because of the exponential form of model (9), all time series included in the model are in a logarithmic transformation (described using lower-case letters: *hdpr* – logarithm of real GDP; *m1r*, *m2r* – logarithms of real M1, M2; *s1rp* – logarithm of 1R PRIBOR rate; *mi* – logarithm of the inflation rate). In such a designed model, the constant is understood as a logarithm of the Cambridge coefficient.

Figure 6

***mi, s1rp* time series**

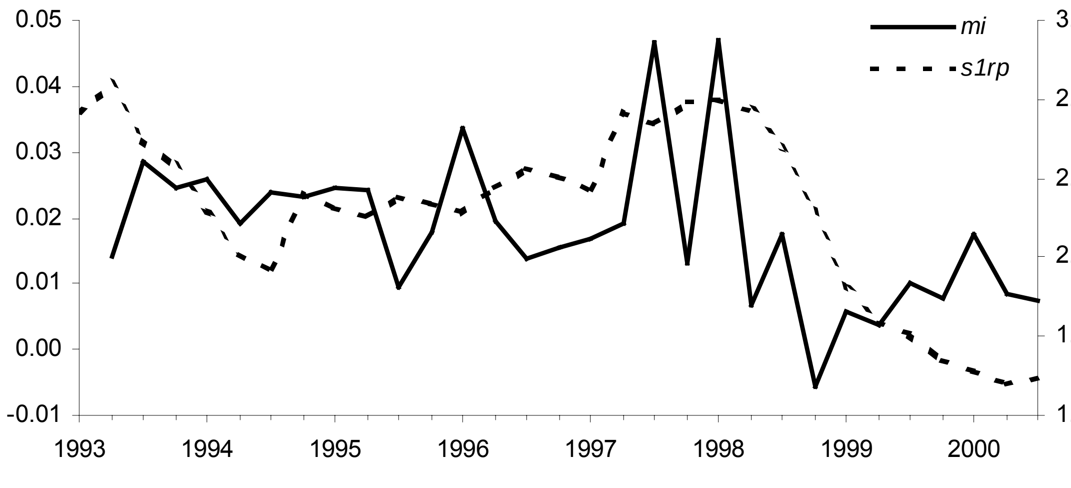


Figure 6 illustrates the curve of the *mi* and *s1rp* time series. It is obvious that the level behaviour of both time series is similar (the correlation coefficient is 0.75).

Consequently, only one of them could have been applied in the model. Both econometric and economic explanations exist for the *s1rp* choice. In empirical calculations, the rate of inflation is reflected in the dynamics of real M1, M2, and real GDP, which must modify the primary characteristics of the designed model. It is probable that with the inclusion of the inflation rate in the model, the real GDP series would have a spuriously endogenous character. The nominal interest rate is defined as a sum of the real interest rate and expected inflation. If inflation expectations are rather adaptive and the real interest rate is approximately constant, the nominal interest rates behave similar to current inflation.

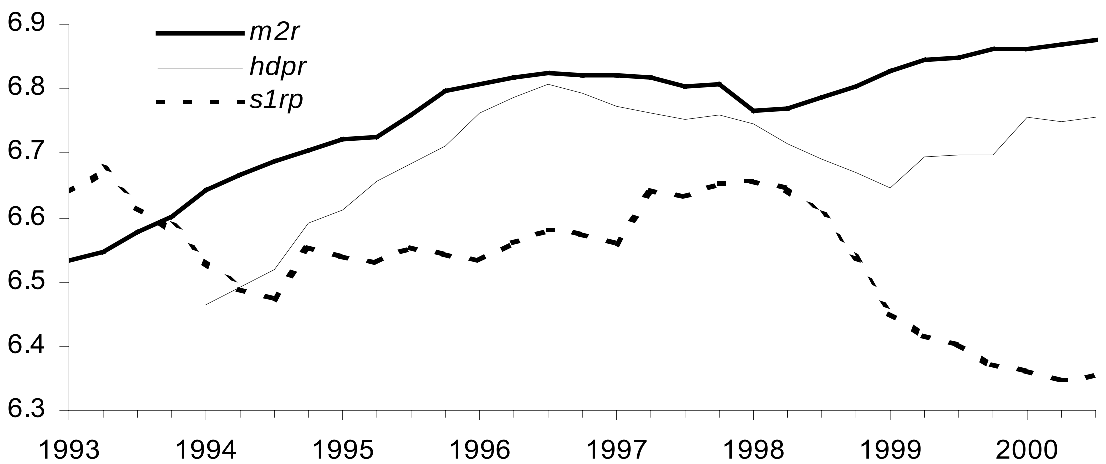
2.3.1 Relationship of the *m2r, hdpr* and *s1rp* time series

VAR model

The econometric analysis is based on multi-equation models, and the results obtained from them shall be compared with the results from the single-equation models. Let us begin with an analysis of the *m2r*, *hdpr* and *s1rp* time series. These time series are illustrated in Figure 7.

Figure 7

***m2r, hdpr, s1rp* time series**



Tests of unit roots (the Dickey-Fuller test and the Phillips-Perron test) and other identification indicate that they are I(1) type time series. The standard diagnostic tests included in PcFiml show that their relationship may be captured by the VAR(1) model (see Appendix for detail results). As the time series being analysed are relatively short, it is logical to apply a lag of order 1. Higher order lags do not significantly improve the model. On the contrary, risks of loss of information increase.

Using Johansen's cointegration tests (21) and (22), the rank of matrix $\hat{\boldsymbol{\Pi}} = \hat{\boldsymbol{\gamma}}\hat{\boldsymbol{\delta}}'$ is tested. Thus, it is examined whether the time series being analysed are cointegrated. Test results are provided in Table 1.

Table 1

Johansen cointegration relationship

Ho: rank = r	η_r	95% quantile	ξ_r	95% quantile
$r = 0$	23.74**	17.9	29.89**	24.3
$r <= 1$	4.882	11.4	6.155	12.5
$r <= 2$	1.272	3.8	1.272	3.8

Since, with both criteria, the first value is higher than the critical value, and the second and the third values are lower, it was proved that the system contains one cointegration vector and two common trends (see Arlt, 1999).

After standardisation, an estimate of cointegration vector $\hat{\boldsymbol{\delta}}$ and a corresponding estimate of loading vector $\hat{\boldsymbol{\gamma}}$ include the following (order of time series within the model: *m2r, hdpr* and *s1rp*)

$$\hat{\boldsymbol{\delta}}' = [1.000 \;\; \text{-}1.214 \;\; 0.128], \; \hat{\boldsymbol{\gamma}}' = [\text{-}0.347 \;\; \text{-}0.208 \;\; \text{-}0.487]. \qquad (24)$$

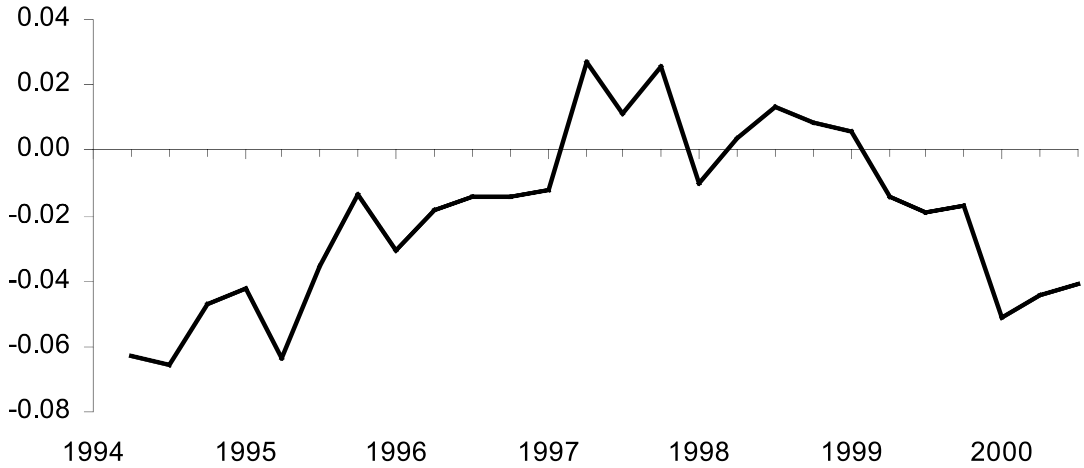
The cointegration vector indicates that *m2r* develops in the long run in direct proportion to *hdpr*, and in indirect proportion (reciprocally) to *s1rp*. Figure 8 illustrates the cointegration relationship:

$$C_t = m2r_t - 1.214hdpr_t + 0.128s1rp_t. \qquad (25)$$

Figure 8 shows the short length of the time series analysed as the fundamental problem of the cointegration analysis. The series C (25) characterising the cointegration relationship should be stationary, however, Figure 8 indicates nonstationarity. Yet, this view may be misleading. Figure 8 only characterises a certain episodic time interval. Development of the time series, however, can imply also long-term stationarity. Nevertheless, the test results in such a situation should be interpreted rather carefully.

Figure 8

Cointegration relationship



In addition, the weak exogenous character of the time series for parameters of the conditioned model may be tested within the system. A time series is weakly exogenous if a corresponding parameter of the loading vector γ equals zero (see Arlt, 1999). The likelihood ratio test only indicates weak exogeneity for *s1rp*. The other series may not be considered as weakly exogenous. A reduced model should be subject to the result of the double-equation form. Under the assumption of the weak exogeneity of *s1rp*, the estimate of the cointegration vector and the corresponding estimate of the loading vector include, after standardisation, the following (order of time series within the model: *m2r*, *hdpr* and *s1rp*):

$$\hat{\boldsymbol{\delta}}' = \left[1.000 \;\; \text{-}1.216 \;\; 0.130\right],\ \hat{\boldsymbol{\gamma}}' = \left[\text{-}0.356 \;\; \text{-}0.194 \;\; 0.000\right]. \qquad (26)$$

The above stated indicates that the results of weak exogeneity tests may not plausibly reflect the real situation. Detailed results of the cointegration analysis based on the VAR(1) model are provided in the Appendix.

ADL model

Let us now construct a single-equation model of M2 demand and compare the results acquired with the above stated results based on the VAR model.

The PcGive diagnostic tools indicate as a suitable single-equation model of M2 demand the ADL(1,0;2) model in the following form:

$$m2r_t = \alpha_1 m2r_{t-1} + \beta_{01} hdpr_t + \beta_{02} s1rp_t + a_t. \quad (27)$$

On a basis of this model, an error correction model may be derived in the following form:

$$\Delta m2r_t = \beta_{01}\Delta hdpr_t + \beta_{02}\Delta s1rp_t + (\alpha_1 - 1)[m2r_{t-1} - \frac{\beta_{01}}{1-\alpha_1} hdpr_{t-1} - \frac{\beta_{02}}{1-\alpha_1} s1rp_{t-1}] + a_t. \quad (28)$$

Estimates of model (27) parameters were acquired using the least square method as follows: $\hat{\alpha}_1 = 0.680, \hat{\beta}_{01} = 0.387, \hat{\beta}_{02} = \text{-}0.037$ (detail results are provided in the Appendix). The estimates indicate the loading estimate of model (28) as $(\hat{\alpha}_1 - 1) = 0.32$, which is a relatively large number, from which it can be derived that the loading differs from zero and that the time series are cointegrated. This conclusion corresponds with the conclusion of the multi-equation analysis based on the VAR(1) model. Estimates of long-run multiplicators are the following values: $\hat{\beta}_1^* = 1.209$ and $\hat{\beta}_2^* = \text{-}0.114$. These values correspond with the values of cointegration vector (24) and (26). The differences are small and may be attributed partially to the estimation method and partially to the disparity of assumptions concerning the exogenous character of *hdpr*. Nevertheless, even the single-equation analysis indicates that *m2r* develops in the long run in direct proportion to *hdpr*, and in indirect proportion (reciprocally) to *s1rp*. Due to a missing constant member in the model, the Cambridge coefficient equals one.

2.3.2 Relationship of *m1r*, *hdpr* and *s1rp* time series

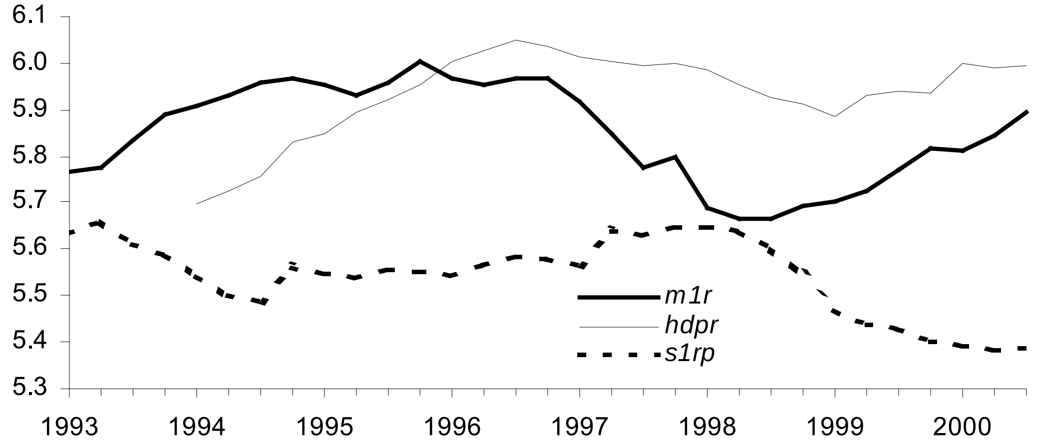
VAR model

Time series *m1r*, *hdpr,* and *s1rp* are illustrated in Figure 9.

Tests of unit roots (the Dickey-Fuller test and the Phillips-Perron test) and other means of identification indicate that the *m1r* is an I(1) type. Standard diagnostic tests included in PcFiml show that the relationship of these time series may be expressed by the VAR(1) model, as well (see Appendix for detailed results).

Figure 9

***m1r, hdpr, s1rp* time series**



Using Johansen's test, the rank of matrix $\hat{\boldsymbol{\Pi}} = \hat{\gamma}\hat{\delta}'$ is tested, and whether or not the time series being analysed are cointegrated is examined. The test results are provided in Table 2.

Table 2

Johansen cointegration test

Ho: rank = r	η_r	95% quantile	ξ_r	95% quantile
$r = 0$	22.36*	17.9	36.37**	24.3
$r <= 1$	9.137	11.4	14.02*	12.5
$r <= 2$	4.879*	3.8	4.879*	3.8

Table 2 provides information according to which the system should include three cointegration vectors and no common trend. This result, however, is highly improbable, because if the time series are type I(1), then they must include one common trend, at least, if they are cointegrated. If they are not cointegrated, they must include three common trends. The situation in which they do not include any common trend would mean that the time series are I(0) type, which is highly improbable. A view of loading matrix $\hat{\gamma}$ shows that their values are rather small (in comparison with matrix $\hat{\gamma}$ of the previous model for M2 – see Appendix). It may be derived from the fact that there is no cointegration relationship among the time series, because the system being constructed does not include any long-run relationships, or the long-run relationships assert extremely weakly.

$$\hat{\gamma} = \begin{bmatrix} 0.05731 & 0.11102 & -0.00010 \\ 0.05073 & -0.00555 & -0.00005 \\ 0.18880 & -0.10491 & 0.00339 \end{bmatrix} \quad (29)$$

ADL model

The PcGive diagnostic tools show as a suitable single-equation model of M1 demand the ADL(1,0;1) model in the following form:

$$m1r_t = \alpha_1 m1r_{t-1} + \beta_{02} s1rp_t + a_t. \quad (30)$$

It is obvious during the model construction process that the *hdpr* parameter equals zero. On the basis of this model, an error correction model may be designed:

$$\Delta m1r_t = \beta_{02}\Delta s1rp_t + (\alpha_1 - 1)[m1r_{t-1} - \frac{\beta_{02}}{1-\alpha_1} s1rp_{t-1}] + a_t. \quad (31)$$

Estimates of the parameters of model (30) were acquired using the least square method $\hat{\alpha}_1 = 1.029, \hat{\beta}_{02} = \text{-}0.074$ (detailed results are provided in the Appendix). The estimates indicate that the estimate of model (31) loading $(\hat{\alpha}_1 - 1)$ is a number approaching zero, which means that the loading equals zero with high probability and consequently, the time series are not cointegrated. Therefore, there is no long-run relationship among the time series, and a short-term relationship only exists between $m1r$ and $s1rp$. This conclusion corresponds with the fact that, in a multi-equation error correction model, the estimate of loading matrix $\hat{\gamma}$ includes values close to zero.

2.3.3 Relationship of other factors to the demand for money

In the analysis that follows, an attempt is made to include the effect of other economic variables on the demand for money in the Czech Republic. First, an interest rate differential was used instead of the 1Y PRIBOR interest rate. Due to the lower volatility of foreign interest rates in the past, development of the interest rate differential was identical to that of the PRIBOR rate. At present, due to the levelling of interest rates, the previous is not true anymore. However, the results still do not differ from the models applying the 1Y PRIBOR rate.

As the next step, the influence of the nominal effective rate was evaluated. Inclusion of another variable in the previous VAR models is rather unsuitable in respect to their quality (the series are too short). Therefore, only the ADL single-equation model was examined. As a start, all variables with single lags were included in the model. The gradual elimination of variables with statistically insignificant parameters led to the following ADL model:

$$m2r_t = \alpha_1 m2r_{t-1} + \beta_{01} hdpr_t + \beta_{02} s1rp_t + \beta_{13}\, ek_{t-1} + a_t. \qquad (32)$$

Estimates of model (32) parameters were acquired using the least square method: $\hat{\alpha}_1 = 0.70$, $\hat{\beta}_{01} = 0.36$, $\hat{\beta}_{02} = -0.035$, $\hat{\beta}_{13} = 0.103$, and the *t*-test indicates the statistical insignificance of parameter β_{13} (see Appendix). It is not, therefore, a surprise when other estimates of the model parameters do not practically differ from estimates of model (27) parameters. Thus, elimination of the effective rate leads back to the originally tested relations among money stock, product, and rate. A similar result is available for monetary aggregate M1. In this case, too, the statistically insignificant effective rate may be eliminated from the equation:

$$m1r_t = \alpha_1 m1r_{t-1} + \beta_{01} s1rp_t + \beta_{12}\, ek_{t-1} + a_t. \qquad (33)$$

Estimates of model (33) parameters ($\hat{\alpha}_1 = 1.03$, $\hat{\beta}_{01} = -0.075$, $\hat{\beta}_{12} = -0.14$, see Appendix) were acquired using the least square method.

Within the process of modelling, an alternative with all the variables in a nominal expression was implemented, as considered by, e.g. J. M. Keynes and other scholars. After elimination of statistically insignificant variables, the following model came into existence, differing from models (27) and (30) only in the statistically significant parameter of the constant.

Firstly, the analysis was supplemented by nominal demand for M2. The ADL(1,0;2) single-equation model acquires the following form:

$$m2_t = c + \alpha_1 m2_{t-1} + \beta_{01} hdp_t + \beta_{02} s1rp_t + a_t, \qquad (34)$$

where $m2$ is a logarithm of nominal M2, and hdp is a logarithm of the nominal seasonally adjusted GDP. Estimates of model parameters were acquired using the least square method, as follows: $\hat{c}$ = 0.35, $\hat{\alpha}_1$ = 0.75, $\hat{\beta}_{01}$ = 0.25, $\hat{\beta}_{02}$ = -0.024 (see Appendix).

In the case of nominal demand for M1, the model assumes ADL(1,0;1) form:

$$m1_t = c + \alpha_1 m1_{t-1} + \beta_{01} s1rp_t + a_t \, , \tag{35}$$

where $m1$ is a logarithm of nominal M1. Estimates of model (33) parameters were acquired using the least square method, as follows: $\hat{c}$ = 1.01, $\hat{\alpha}_1$ = 0.86, $\hat{\beta}_{01}$ = -0.071 (see Appendix for the results).

3 Assessment of econometric analysis results and development of money velocity

3.1 Assessment of econometric analysis results

3.1.1 Demand for money in a wide context

The results of econometric analysis in the field of the demand for money in a wider context (using monetary aggregate M2) support the theoretically and practically accepted neo-Keynesian opinion that the demand for real money balances is directly proportional to real income and indirectly (reciprocally) proportional to the interest rate, and therefore is related to the transactional and speculative motive. Whilst the relationship between the demand for money and the transactional money expressed by GDP is logical, assessments of the relationship between the demand for money and the development of interest rates must take into consideration that a substantial part of products, interest rates associated with the 1Y PRIBOR rate, is included in the analysed wider concept of the demand for money and therefore is of an "endogenous character" in relation to the model. In this case, the speculative motive is reflected in the demand for money, through the interest rate at two levels:

- As a structural change in the demand for money (with relative stability and generally small allocation significance of interest rates to non-term deposits) when interest rate changes are accompanied by structural changes in the wider monetary aggregate and additionally, income money velocity changes and therefore the demand for money decreases or increases.

- As an effect on the transfer of money assets to alternative forms of assets, both financial and non-financial.

A significant factor reflecting the relationship of the demand for money and interest rates also seems likely to be the anti-cyclical character of the precautionary motive, which between 1998 and 1999 led to a relatively high rate of savings, despite the relatively fast decrease in interest rates.

Within the analysis based on Arestis' model, either by utilising the nominal effective rate or in an adjusted form using the interest rate differential, foreign (external) influence was not proved. Under conditions of a relatively long-lasting period of the fixed CZK exchange rate, only slowly relaxing in 1996, the negative result in the case of utilisation of the nominal effective rate is not surprising, as well as in the case of the interest rate differential, development of which is, due to the long-term relative stability of interest rates abroad, essentially identical to PRIBOR developments. Under these circumstances, the speculative motive related to foreign effects is already included in PRIBOR developments, and the transactional motive is included in GDP development, which also reflects the influence of foreign effects.

The analysis was performed on the basis of multi-equation and single-equation models yielding similar results. In the case of single-equation models, an analysis of transactional and speculative motive effects on the development of nominal money balances was performed – apart from an analysis of real money balances, proving again the influence of both of these factors.

The results of the analyses performed, however, are rather conditional in nature, mostly because of the short time series and, perhaps, also a possible review of the GDP development time series in 2001.

3.1.2 Demand for money in a narrow context

In contrast to the analysis of the demand for money in a wide context, no long-run relationship was identified within the demand analysis in a narrow context (using the M1 monetary aggregate). This result is logical, considering the higher degree of

M1 variability, into which various non-economic effects are quite often randomly reflected (banking sector restructuring, etc.). The ADL model implementation, however, proved a short-run relationship (indirectly proportional) between real money balances in the narrow concept and the development of interest rates. The impact of real GDP on the development of the demand for money in the narrow concept was not proved in the analysis. An assessment of the results of the demand for money analysis in the narrow concept from the viewpoint of the liquidity preference theory shows rather that the speculative motive is important for the demand for money. A spurious paradox of the non-importance of GDP development, to which the movement of transactional money is often attributed, is caused by the narrow concept of M1. A part of transactional money servicing GDP (both CZK and forex deposits with a very short term of notice, non-termed deposits in foreign exchange), a volume of which was substantial in some periods, is included into quasi-money, that belongs to the wide concept of the demand for money[10]. On the contrary, a rather narrow concept of M1, including highly liquid money (currency and practically non-interest bearing, non-term deposits), supports the effects of the speculative motive. An econometric analysis of the demand for money in the narrow concept, in the nominal expression of variables being analysed, i.e. in the concept close to J. M. Keynes, provided similar results.

3.2 Relationship of the demand for money and money velocity

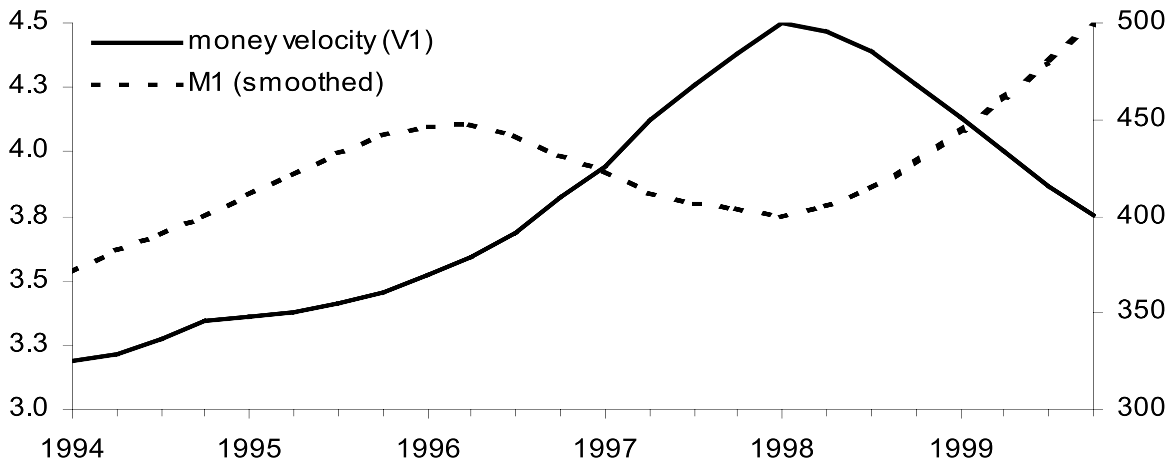
R. Dornbusch and S. Fischer recommend the development of money velocity as “a very appropriate tool in the demand for money analysis”. Both scholars derive

[10] In this context, a change in the definition of money in western European countries must be noted. Together with the establishment of the EU (under the influence of the European Central Bank) the definition of money assumed a narrower sense, mostly from the viewpoint of the shortening of terms of notice applicable to non-banking client deposits and a maturity reduction for securities issued by non-banking entities included in the widest monetary aggregate of the European Central Bank (M3) to 2 years. The narrower meaning emphasised its transactional character in the new money definition, while some liabilities of the banking sector (e.g. deposits of non-banking clients with banks, with a period of notice exceeding 2 years), where the speculative motive prevailed and which used to be included in the wider concept of money, remain outside the category of money according to the new definition.

an indirect proportional relationship between the two variables (Dornbusch, Fischer 1994). Under the conditions prevailing in the Czech Republic, the relationship is particularly evident in the case of the narrow concept of money velocity (V1), Figure 10.

Figure 10

Money velocity and M1 development



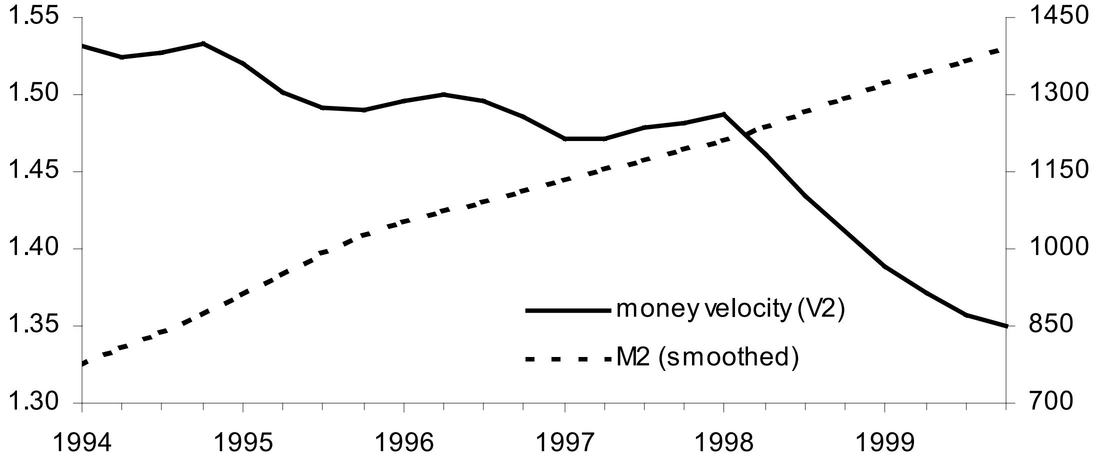
Source: CNB.

The figure, including the smoothed data, indicates an increasing V1 velocity by the end of 1998 with a considerably sharp extreme towards the end of 1998 and a following drop. This development reflects both the rise and decline of interested rates applicable to term deposits from 1998 to 2000 and corresponds with the econometric analysis results. The V1 development therefore complies with the thesis of an indirect proportional relationship between the demand for money and the development of the money velocity, but it does not fulfil the notion of traditional monetarists pertaining to its stable development.

The situation appears rather different in the case of the wide concept of money velocity (V2), Figure 11.

Figure 11

Money velocity and M2 development



Source: CNB.

In contrast to V1 development, V2 development does not have such a close indirect relationship to the demand for money, even if, in the long run, the indirect relationship here is also obvious. A monotonous trend is discernible in V2 development in comparison with V1. As factors disturbing the relationship between the development of money velocity and the demand for money, monetary transactions associated with activities unrelated to GDP development are most often considered, i.e. introduction of new financial instruments, fluctuations in inflation expectations with consequences for interest rate development, introduction of new forms of the payment contact, inter-company indebtedness, circulation of money related to property transfers, as well as e.g. development of both a grey and black economy, etc. Under the conditions of the Czech Republic economy, transactions not related directly to GDP development were mostly reflected in the fluctuations in the relationship of V2 and the demand for money by 1998, such as the introduction of new products, new forms of the payment contact, and the development of inter-company indebtedness, etc. It must be emphasised, however, that these factors were reflected in fluctuations in the indirect relationship between V2 development and the demand for money with an overall decreasing tendency mostly caused by standard factors determining the development of the demand for money. A temporary interruption in the declining tendency occurred only in 1998 under the influence of institutional factors, and the V2 decrease has been accelerated since 1999 with smaller fluctuations, because the effects of certain factors causing these fluctuations decreased. Not even V2 development entirely corresponds to the traditional monetarist notions, characteristic for its idea of stability concerning the developments of money velocity, i.e. stability of the demand for money. However, it complies relatively with the long-run development in EMU countries[11], where the trend towards a decrease in money velocity has persisted with fluctuations for two decades. Opinions concerning its grounds and survival in the future are not unambiguous. The opinion of growing demands for real GDP towards the volume of money and the growing importance of new financial products (not immediately tied to GDP development) in money flows seems to be probable.

[11] The comparison, however, is only of an orientation character, due to methodology differences existing in a calculation of money velocity between the Czech Republic and EMU countries. On the other side, however, a relatively long-term trend similarity in the developments of money velocity in the Czech Republic and EMU countries shows that, although some calculation methodology differences exist, a long-run trend in the development of money velocity in the Czech Republic is not, in spite of the transformation of economy, entirely atypical.

Conclusion

It is clear from the results of the analysis that, in its wide concept, the real demand for money in the Czech Republic from 1994 to 2000 had developed mostly under the influence of traditional factors, i.e. under the influence of real GDP and nominal interest rate development. Whilst the influence of real GDP is only important for the demand for money in its wide concept, the speculative motive asserts itself in both the wide and narrow concept of the demand for money, though only in the short-run for the latter case. The influence of an external economic environment in the development of the demand for money has not yet been econometrically proved. Additionally, the analysis indicates that the conclusions derived for real money balances apply to nominal money balances as well. It must be noted, however, that the results of the analysis are only informative in nature. They are conditioned by the short time interval, to which the analysis applies.

Additional improvements in the data basis for research in the field of the demand for money will be provided by the gradual approximation of the definition of money used at the CNB to the definition applied at the ECB, which will eliminate from the concept of money some items that are of a rather capital character associated with the influence of the speculative motive, and which will also enable better comparison of the results of CNB monetary analyses with the corresponding analyses abroad.

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Appendices

Relationship of *m2r, hdpr* a *s1rp*

VAR model

Cointegration analysis 1994 (2) to 2000 (3)

eigenvalue	loglik for	rank
	279.502	0
0.598666	291.371	1
0.171203	293.812	2
0.0477586	294.448	3

Ho:rank=p	-Tlog(1-\mu)	95%	-T\Sum log(.)	95%
p == 0	23.74**	17.9	29.89**	24.3
p <= 1	4.882	11.4	6.155	12.5
p <= 2	1.272	3.8	1.272	3.8

standardised \delta' eigenvectors

m2r	*hdpr*	*s1rp*
1.0000	-1.2143	0.12789
-0.85152	1.0000	-0.038779
0.076439	-0.45711	1.0000

standardised \gamma coefficients

m2r	-0.34744	-0.038646	0.0054063
hdpr	-0.20832	-0.047036	-0.0039917
s1rp	-0.48700	1.4650	-0.045244

long-run matrix Po=\gamma*\delta', rank 3

	m2r	*hdpr*	*s1rp*
m2r	-0.31411	0.38079	-0.037530
hdpr	-0.16858	0.20776	-0.028811
s1rp	-1.7379	2.0771	-0.16434

Number of lags used in the analysis: 1

Restricted Cointegration analysis 1994 (2) to 2000 (3) (weak exogeneity tests)

***m2r*:** standardised \delta' eigenvectors

m2r	*hdpr*	*s1rp*
1.0000	-1.2131	0.12869

LR-test, rank=1: Chi^2(1) = 13.914 [0.0002] **

***s1rp*:** standardised \delta' eigenvectors

m2r	*hdpr*	*s1rp*
1.0000	-1.2155	0.13001

LR-test, rank=1: Chi^2(1) = 0.39383 [0.5303]

hdpr: standardised \delta' eigenvectors

m2r	*hdpr*	*s1rp*
1.0000	-1.2046	0.10550

LR-test, rank=1: Chi^2(1) = 10.844 [0.0010] **

Model ADL

Modelling *m2r* by OLS

The present sample is: 1994 (2) to 2000 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
m2r_1	0.68002	0.087773	7.747	0.0000	0.7230
hdpr	0.38677	0.10431	3.708	0.0012	0.3741
s1rp	-0.036551	0.0099118	-3.688	0.0012	0.3716

R^2 = 0.999997 \sigma = 0.0126733 DW = 1.91

* R^2 does NOT allow for the mean *

RSS = 0.003694068022 for 3 variables and 26 observations

Solved Static Long Run equation

m2r = 1.209 *hdpr* -0.1142 *s1rp*

(SE) (0.011) (0.02598)

Relationship of *m1r, hdpr* a *s1rp*

Model VAR

Cointegration analysis 1994 (2) to 2000 (3)

eigenvalue	loglik for	rank
	255.091	0
0.576779	266.269	1
0.296317	270.837	2
0.171083	273.277	3

Ho:rank=p	-Tlog(1-\mu)	95%	-T\Sum log(.)	95%
p == 0	22.36*	17.9	36.37**	24.3
p <= 1	9.137	11.4	14.02*	12.5
p <= 2	4.879*	3.8	4.879*	3.8

standardised \delta' eigenvectors

m1r	*hdpr*	*s1rp*
1.0000	-0.86428	-0.30902
-0.80946	1.0000	-0.49703
56.307	-58.801	1.0000

standardised \gamma coefficients

m1r	0.057306	0.11102	-0.00010311
hdpr	0.050726	-0.0055527	-0.00004906
s1rp	0.18880	-0.10491	0.0033897

long-run matrix Po=\gamma*\delta', rank 3

	m1	*hdpr*	*s1rp*
m1r	-0.038364	0.067552	-0.072991
hdpr	0.052458	-0.046509	-0.012965
s1rp	0.46458	-0.46740	-0.0028114

Number of lags used in the analysis: 1

Restricted Cointegration analysis 1994 (2) to 2000 (3) (weak exogeneity tests)

s1rp: standardised \delta' eigenvectors

m1r	*hdpr*	*s1rp*
1.0000	-0.83400	-0.37574

LR-test, rank=1: Chi^2(1) = 1.435 [0.2310]

m1r: standardised \delta' eigenvectors

m1r	*hdpr*	*s1rp*
1.0000	-0.90214	-0.21538

LR-test, rank=1: Chi^2(1) = 1.1196 [0.2900]

hdpr: standardised \delta' eigenvectors

m1r	*hdpr*	*s1rp*
1.0000	-1.7760	1.9763

LR-test, rank=1: Chi^2(1) = 12.736 [0.0004] **

hdpr, s1rp: standardised \delta' eigenvectors

m1r	*hdpr*	*s1rp*
1.0000	-0.89353	-0.22520

LR-test, rank=1: Chi^2(2) = 3.5813 [0.1669]

ADL model

Modelling *m1r* by OLS

The present sample is: 1994 (2) to 2000 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
m1r_1	1.0292	0.007938	129.654	0.0000	0.9986
s1rp	-0.07385	0.019771	-3.735	0.0010	0.3676

R^2 = 0.999971 \sigma = 0.0330549 DW = 2.28

* R^2 does NOT allow for the mean *

RSS = 0.02622303332 for 2 variables and 26 observations

Relationship of other factors to the demand for money

Modelling *m2r* by OLS

The present sample is: 1994 (2) to 2000 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
m2r_1	0.69976	0.089045	7.858	0.0000	0.7373
s1rp	-0.034742	0.0099880	-3.478	0.0021	0.3548
hdpr	0.36324	0.10583	3.432	0.0024	0.3487
ek_1	0.10311	0.091961	1.121	0.2743	0.0541

R^2 = 0.999997 \sigma = 0.012603 DW = 1.93

* R^2 does NOT allow for the mean *

RSS = 0.003494390075 for 4 variables and 26 observations

Solved Static Long Run equation

m2r = -0.1157 *s1rp* +1.21 *hdpr* +0.3434 *ek*

(SE) (0.0278) (0.012) (0.3414)

Modelling *m1r* by OLS

The present sample is: 1994 (2) to 2000 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
m1r_1	1.0296	0.0080848	127.355	0.0000	0.9986
s1rp	-0.075091	0.020174	-3.722	0.0011	0.3759
ek_1	-0.13693	0.24074	-0.569	0.5750	0.0139

R^2 = 0.999971 \sigma = 0.0335308 DW = 2.30

* R^2 does NOT allow for the mean *

RSS = 0.02585926926 for 3 variables and 26 observations

Modelling *m2* by OLS

The present sample is: 1994 (2) to 2000 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Constant	0.35490	0.089402	3.970	0.0006	0.4174
m2_1	0.74559	0.11486	6.491	0.0000	0.6570
hdp	0.25040	0.14492	1.728	0.0980	0.1195
s1rp	-0.024149	0.010270	-2.351	0.0281	0.2009

R^2 = 0.997951 F(3,22) = 3572.5 [0.0000] \sigma = 0.00901399
DW = 1.68 RSS = 0.0017875 for 4 variables and 26 observations

Solved Static Long Run equation

m2 = 1.395 +0.9843 *hdp* -0.09492 *s1rp*
(SE) (0.861) (0.1323) (0.02306)

Modelling *m1* by OLS

The present sample is: 1994 (2) to 2000 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Constant	1.0148	0.37901	2.678	0.0134	0.2376
m1_1	0.86206	0.060512	14.246	0.0000	0.8982
s1rp	-0.071012	0.015488	-4.585	0.0001	0.4775

R^2 = 0.929095 F(2,23) = 150.69 [0.0000] \sigma = 0.02477
DW = 2.08 RSS = 0.0141118 for 3 variables and 26 observations

Solved Static Long Run equation

m1 = 7.357 -0.5148 *s1rp*
(SE) (0.5503) (0.216)