

SELECTED FACTORS INFLUENCING THE MONEY DEMAND DEVELOPMENT IN THE CZECH REPUBLIC IN 1994 – 2000

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Abstract:

The demand for money represents one of the most important components of the transmission mechanism. Its analysis plays an important role in the decision-making process of central banks dealing with monetary policies. This paper follows a post-Keynesian approach to the analysis of the demand for money. The econometric analysis is based on the Arestis's model, adjusted for the conditions of the Czech Republic. The cointegration analysis on the basis of both the VAR and ADL models is applied. The premise is confirmed that the demand for money in the Czech Republic from 1994 – 2000 had developed in the long-run mostly under the influence of GDP and interest rate development. This conclusion is valid for balances in both real and nominal money.

Keywords: money demand, time series, econometric model, cointegration analysis

JEL Classification: E410, C220, C320, C510, C520

1. 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

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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 attempts to show the developments in the demand for money in the Czech Republic between 1994 and 2000¹⁾ and the effects of some factors influencing its development. This analysis shares a common base with it and draws on earlier studies, Hanousek, Tůma (1995), Kláček, 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 fundamentals are provided by the adjusted Arestis model (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.

2. The Role of the Demand for Money in the Transmission Mechanism of Monetary Policy and Theoretical Approaches to Its Analysis

2.1 *The Role of the Demand for Money in the Transmission Mechanism of Monetary Policy*

The demand for money reflects the degree of desirability to hold 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 hold 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 usu-

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.

ally attached²⁾ to demand-for-money issues (including theories 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, emphasizing 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. In this paper we follow the Keynesian approach to the analysis of the demand for money.

2. 2 *Primary Keynesian Theoretical Approaches to Examination of the Demand for Money*

2. 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 demand for money are balanced.³⁾ In comparison with the monetary approach, a lower degree of 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's *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

2) Of the wide range of monetary transmission mechanism patterns presented, G. J. Bondt's transmission pattern has been generally recognised and accepted (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, Ařt, Guba, Matalík, Stiller, Syrovátka (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 Sojka (1999).

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

– the transactions-motive, i.e. the need of cash for the current transaction of personal and business exchanges;

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's own invention. Schematically, Keynes's approach can be expressed as follows

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

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 (see Keynes, 1953). In reality, however, there is unified demand for money, because these motives exert influence simultaneously and are mutually interdependent. While Keynes only considers nominal quantities in his demand-for-money theory, notions of his followers emphasize 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.

2. 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

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

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 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

– the precautionary-motive, i.e. the desire for security as to the future cash equivalent of a certain proportion of total resources;

– the speculative-motive, i.e. the object of securing profit from knowing better than the market what the future will bring forth" (Keynes, 1953, p. 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 the aggregate demand for money to satisfy the speculative-motive usually shows a continuous curve relating changes in the rate of interest ..." (ibidem, pp. 196-197).

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:

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

where M_d is demand for money and L is the "liquidity preference function."

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 emphasized. Results of such considerations lead to the well-known formula:

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

where M_d/P is demand for real balances, c is transactional costs and Y_r is real GDP. 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. 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 Tobin (1958). This concept focuses on an intrinsic money interest rate (usually considered to be equal to zero (see Laidler, 1993), or may be negative in the case of a high inflation rate), and the yield rate related to alternative assets.

2. 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 (see 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), $I = a - b\dot{i}$, 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

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

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

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

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 (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 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), 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, quantifiable⁵⁾ credit limitations

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).

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

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

where *IRD* is the interest rate differential.

3. Influence of Selected Factors on the Demand for Money, 1994–2000

3.1 *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 to separate short-term relationships, i.e. relationships among stationarised time series and long-term relationships, i.e. relationships among non-stationarised time series. Cointegration analysis on the base of both VAR and ADL models is applied (see Engle, Granger, 1987; Johansen, 1991; Banerjee et al., 1993; Arlt, 1995, 1999).

3.2 *Data and their Basic Characteristics*

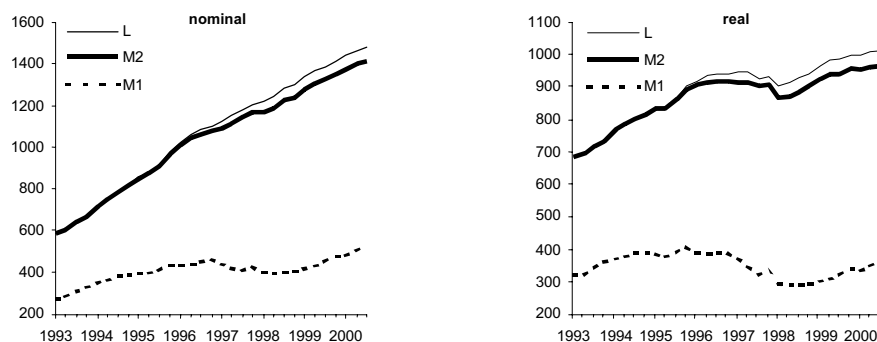
The model creation process ensued from an in-house study of CNB (1997). The models were expanded, reviewed and recalculated on the basis of extended time series (GDP corrections included), from the 1994:I to the 2000:III. Within the analysis, the demand for money is represented by three monetary aggregates: 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.

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:I to 2000:III is shown in Figure 2 in a seasonally adjusted and non-adjusted form.

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 February 29, 1996, the fixed exchange rate of the CZK was abolished on May 27, 1997.

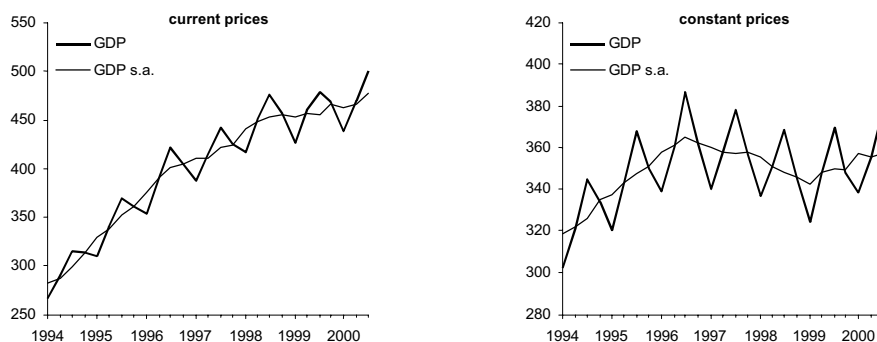
7) As an alternative to GDP, domestic demand, e.g. may be used for the scaling variable. Due to similar long-term development for both time series, GDP was used in compliance with the original Arestis's concept.

Figure 1
Nominal and Real Money Aggregates (CZK billion)



Source: CNB.

Figure 2
GDP in Current and Constant Prices (CZK billion)



Source: CSO.

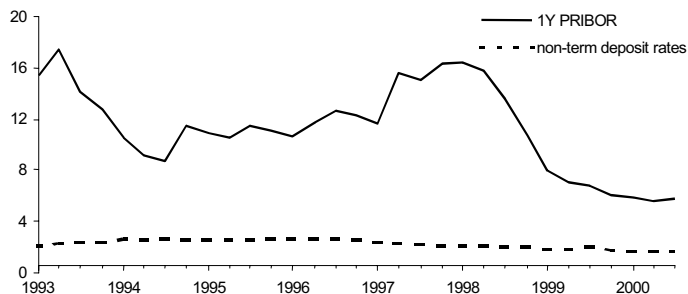
Other factors determining the demand for money may include the 1Y PRIBOR⁸⁾ and the non-term deposit interest rate (the theoretically recommended obligation yield⁹⁾ still could not be used due to the lack of necessary data). The quarterly data

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 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.

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 funds portfolios created before the funds had to open, etc.

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 p. 261) 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.

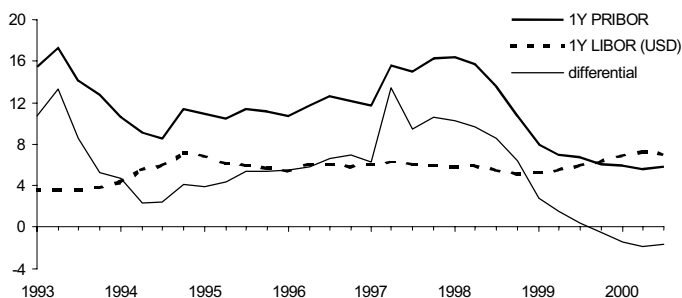
Figure 3
1Y PRIBOR Interest Rate and Non-term Deposit Rates (in %)



Source: CNB.

For calculation of the interest rate differential, the 1Y LIBOR (USD) interest rate is frequently applied (see Figure 4).

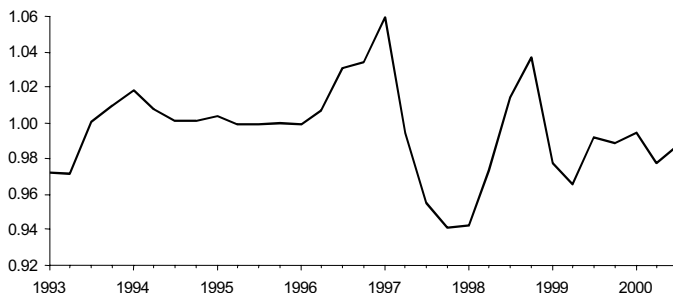
Figure 4
Interest Rates and Differential (in %)



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.

3.3 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's 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

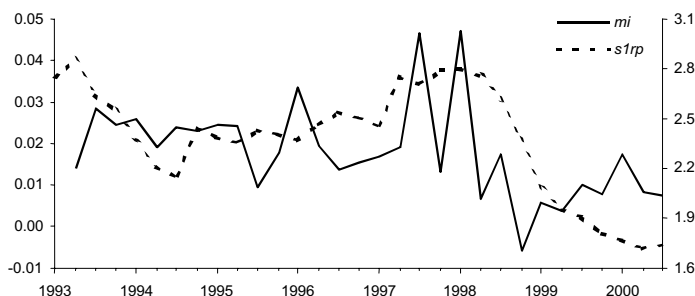


Figure 6 illustrates the curve of the *mi* and *s1rp* time series. It is obvious that the level behaviour of both time series is similar (the correlation coefficient is 0.75). Consequently, only one of them could have been applied in the model. Both econo-

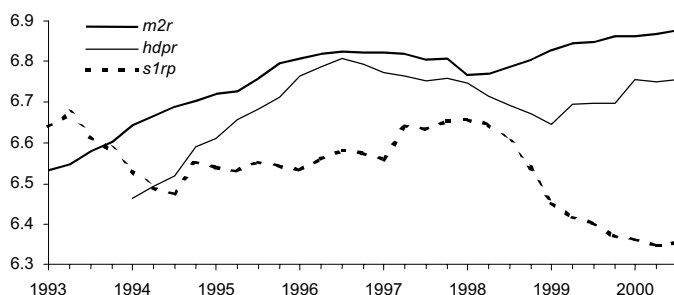
metric and economic explanations exist for the *s1rp* choice. In empirical calculations, the rate of inflation is reflected in the dynamics of real M1, M2, and real GDP, which must modify the primary characteristics of the designed model. It is probable that with the inclusion of the inflation rate in 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.

3. 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. 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. 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.

Figure 7
m2r, hdpr, s1rp Time Series



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

Table 1
Johansen's Cointegration Test

Ho: rank = r	η_r	95% quantile	ξ_r	95% quantile
$r = 0$	23.74**	17.9	29.89**	24.3
$r \leq 1$	4.882	11.4	6.155	12.5
$r \leq 2$	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 standardization, an estimate of cointegration vector $\hat{\delta}$ and a corresponding estimate of loading vector $\hat{\gamma}$ include the following (order of time series within the model: $m2r$, $hdpr$ and $s1rp$)

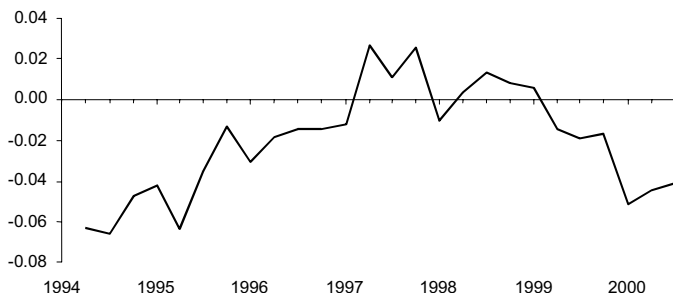
$$\hat{\delta}' = [1.000 \ -1.214 \ 0.128], \hat{\gamma}' = [-0.347 \ -0.208 \ -0.487] \quad (10)$$

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:

$$C_t = m2r_t - 1.214hdpr_t + 0.128s1rp_t \quad (11)$$

Figure 8 shows the short length of the time series analysed as the fundamental problem of the cointegration analysis. The series C_t (11) 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 standardization, the following (order of time series within the model: $m2r$, $hdpr$ and $s1rp$):

$$\hat{\delta}' = [1.000 \ -1.216 \ 0.130], \hat{\gamma}' = [-0.356 \ -0.194 \ 0.000] \quad (12)$$

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:

$$m2r_t = \alpha_1 m2r_{t-1} + \beta_{01} hdpr_t + \beta_{02} s1rp_t + a_t \quad (13)$$

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

$$\Delta m2r_t = \beta_{01} \Delta hdp_r_t + \beta_{02} \Delta s1rp_t + (\alpha_1 - 1) \left[m2r_{t-1} - \frac{\beta_{01}}{1 - \alpha_1} hdp_r_{t-1} - \frac{\beta_{02}}{1 - \alpha_1} s1rp_{t-1} \right] + a_t \quad (14)$$

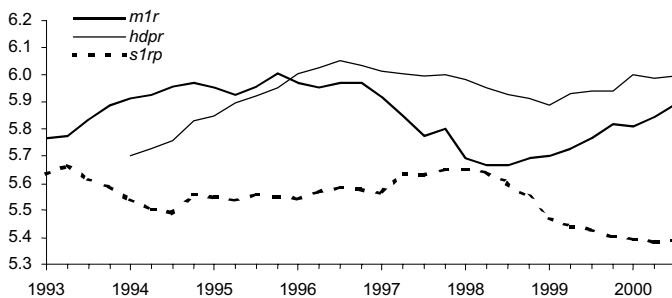
Estimates of model (13) parameters were acquired using the least square method as follows: $\hat{\alpha}_1 = 0.680[0.088]^{10}$, $\hat{\beta}_{01} = 0.387[0.104]$, $\hat{\beta}_{02} = -0.037[0.010]$. The estimates indicate the loading estimate of model (14) as $(\hat{\alpha}_1 - 1) = 0.32$, which is 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 multipliers are the following values: $\hat{\beta}_{01}^* = 1.209[0.011]$ and $\hat{\beta}_{02}^* = -0.114[0.026]$. These values correspond with the values of cointegration vector (10) and (12). 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 *hdp_r*. Nevertheless, even the single-equation analysis indicates that *m2r* develops in the long run in direct proportion to *hdp_r*, and in indirect proportion (reciprocally) to *s1rp*. Due to a missing constant member in the model, the Cambridge coefficient equals one.

3. 3. 2 Relationship of *m1r*, *hdp_r* and *s1rp* Time Series

VAR Model

Time series *m1r*, *hdp_r*, 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.

Figure 9
m1r, hdp_r, s1rp Time Series



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

10) Standard errors of coefficients are in parentheses.

Table 2
Johansen's Cointegration Test

Ho: rank = r	η_r	95% quantile	ξ_r	95% quantile
$r = 0$	22.36*	17.9	36.37**	24.3
$r \leq 1$	9.137	11.4	14.02*	12.5
$r \leq 2$	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). 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.

$$\hat{\gamma} = \begin{bmatrix} 0.05731 & 0.11102 & -0.00010 \\ 0.05073 & -0.00555 & -0.00005 \\ 0.18880 & -0.10491 & 0.00339 \end{bmatrix} \quad (15)$$

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:

$$m1r_t = \alpha_1 m1r_{t-1} + \beta_{02} s1rp_t + a_t \quad (16)$$

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:

$$\Delta m1r_t = \beta_{02} \Delta s1rp_t + (\alpha_1 - 1) \left[m1r_{t-1} - \frac{\beta_{02}}{1 - \alpha_1} s1rp_{t-1} \right] + a_t \quad (17)$$

Estimates of the parameters of model (16) were acquired using the least square method $\hat{\alpha}_1 = 1.029[0.008]$, $\hat{\beta}_{02} = -0.074[0.020]$. The estimates indicate that the estimate of model (17) 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.

3. 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:

$$m2r_t = \alpha_1 m2r_{t-1} + \beta_{01} hdp_r + \beta_{02} s1rp_t + \beta_{13} ek_{t-1} + a_t \quad (18)$$

Estimates of model (18) parameters were acquired using the least square method: $\hat{\alpha}_1 = 0.700[0.089]$, $\hat{\beta}_{01} = 0.363[0.106]$, $\hat{\beta}_{02} = -0.035[0.010]$, $\hat{\beta}_{13} = 0.103[0.092]$, and the *t*-test indicates the statistical insignificance of parameter β_{13} . It is not, therefore, a surprise when other estimates of the model parameters do not practically differ from estimates of model (13) 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:

$$m1r_t = \alpha_1 m1r_{t-1} + \beta_{01} s1rp_t + \beta_{12} ek_{t-1} + a_t \quad (19)$$

Estimates of model (19) parameters ($\hat{\alpha}_1 = 1.030[0.008]$, $\hat{\beta}_{01} = -0.075[0.020]$, $\hat{\beta}_{12} = -0.137[0.241]$) 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. Keynes and other scholars. After elimination of statistically insignificant variables, the following model came into existence, differing from models (13) and (16) 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:

$$m2_t = c + \alpha_1 m2_{t-1} + \beta_{01} hdp_t + \beta_{02} s1rp_t + a_t, \quad (20)$$

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: $\hat{c} = 0.355[0.089]$, $\hat{\alpha}_1 = 0.746[0.115]$, $\hat{\beta}_{01} = 0.250[0.145]$, $\hat{\beta}_{02} = -0.024[0.010]$.

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

$$m1_t = c + \alpha_1 m1_{t-1} + \beta_{01} s1rp_t + a_t, \quad (21)$$

where *m1* is a logarithm of nominal M1. Estimates of model (19) parameters were acquired using the least square method, as follows: $\hat{c} = 1.015[0.379]$, $\hat{\alpha}_1 = 0.862[0.061]$, $\hat{\beta}_{01} = -0.071[0.015]$.

4. Assessment of Econometric Analysis Results

4.1 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’s 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.

4. 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 move-

ment 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.¹¹⁾ 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.



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.

References

Arestis, Ph. (1988), "The Demand for Money in Small Developing Economies: An Application of the Error Correction Mechanism," in Arestis, Ph., ed., *Contemporary Issues in Money and Banking*. Cheltenham: Edward Elgar, pp. 184-205.

Arestis, Ph., Sawyer, M. C. (1998), *The Political Economy of Central Banking*. Cheltenham: Edward Elgar.

Arlt, J., Guba, M., Matalík, I., Stiller, V., Syrovátka, J. (1998), "Definition and Primary Relation Analysis of the Monetary Transmission Mechanism in the Czech Republic" (in Czech). Prague, Czech National Bank.

11) 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 emphasized 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.

- Arlt, J.** (1995), "The Problem of Cointegration." *Bulletin of the Czech Econometric Society*, (2), pp. 3-12.
- (1999), *Modern Methods of Economic Time Series Modelling* (in Czech). Prague: Grada.
- Banerjee, A., Dolado, J. J., Galbraith, J. W., Hendry, D. F.** (1993), *Cointegration, Error Correction and the Econometric Analysis of Non-stationary Data*. London: Oxford University Press.
- Baumol, W. J.** (1952), "The Transaction Demand for Cash: An Inventory Theoretic Approach." *The Quarterly Journal of Economics*, 66 (4), pp. 546-556.
- Bondt, G. J.** (1998), "Credit and Asymmetric Effects of Monetary Policy in Six EU Countries: an Overview." De Nederlandsche Bank, NV.
- CNB** (1997), "Influence of Selected Factors on Demand-for-Money Developments in the Period 1993 – 1996" (in Czech). Prague, Czech National Bank.
- Davidson, P.** (1994), *Post-Keynesian Macroeconomic Theory*. Cheltenham: Edward Elgar.
- Doornik, J. A., Hendry, D.** (1997), *Modelling Dynamic Systems Using PcFiml 9.0 for Windows*. London: International Thomson Business Press.
- Dornbusch, R., Fischer, S.** (1994), *Macroeconomics (in Czech)*. Prague: SPN and Economics Foundation.
- Engle, R. F., Granger, C. W. J.** (1987), "Cointegration and Error Correction: Representation, Estimation and Testing." *Econometrica*, 55, pp. 251-276.
- Hanousek, J., Tůma, Z.** (1995), "Demand for Money in the Czech Economy" (in Czech). *Finance a úvěr*, (5), pp. 249-267.
- Heyne, P.** (1991), *Economic Style of Reasoning*. Prague: University of Economics.
- Johansen, S.** (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica*, 59, pp. 1551-1580.
- (1995), *Likelihood-Based Inference in Cointegrated Vector Auto-Regressive Models*. London: Oxford University Press.
- Johansen, S., Juselius, K.** (1990), "Maximum Likelihood Estimation and Inference on Cointegration – with Applications to Simultaneous Equations and Cointegration." *Journal of Econometrics*, 69, pp. 169-210.
- Keynes, J. M.** (1953), *The General Theory of Employment, Interest, and Money*. San Diego, New York, London: Harcourt Brace Jovanovich.
- Keynes, J. M.** (1937), "The General Theory of Employment." *Quarterly Journal of Economics*, 51, pp. 209-223.
- (1937), "The Ex-Ante Theory of the Rate of Interest." *The Economic Journal*, 47, pp. 663-669.
- Klacek, J., Šmídková, K.** (1995), "The Demand-for-Money Function the Case of the Czech Economy." Prague, Institute of Economics of the Czech National Bank, Working Paper.
- Laidler, D. E. W.** (1966), "Some Evidence on Demand for Money." *Journal of Political Economy*, 74 (1), pp. 55-68.
- (1993), *The Demand for Money: Theories, Evidence and Problems* (4th ed). New York: Harper Collins College Publishers.
- Lavoie, M.** (1992), *Foundations of Post-Keynesian Economic Analysis*. Cheltenham: Edward Elgar.
- Moore, B. J.** (1998), "Money and Interest Rates in a Monetary Theory of Production," in Rotheim, R. J., *New Keynesian Economics/ Post-Keynesian Alternatives*. London and New York: Routledge.
- Rose, P. S.** (1992), *Money and Capital Markets* (in Czech). Prague: Victoria Publishing.
- Sojka, M.** (2000), *The History of Economic Theories* (in Czech). Prague: Karolinum.
- (1999), *John Maynard Keynes and Contemporary Economy* (in Czech). Prague: Grada.
- (1996), *Milton Friedman* (in Czech). Prague: Epoch.
- Sriram, S. S.** (1999), "Survey of Literature on Demand for Money: Theoretical and Empirical Work with Special Reference to Error-Correction Models." Washington, IMF.
- Stock, J. H.** (1987), "Asymptotic Properties of Least-Square Estimators of Cointegrating Vectors." *Econometrica*, 55, pp. 1035-1056.
- Tobin J.** (1956), "The Interest-Elasticity of Transactions Demand for Cash." *The Review of Economics and Statistics*, 38 (3), pp. 241-247.
- (1958), "Liquidity Preference as Behavior Towards Risk." *The Review of Economic Studies*, 25 (67), pp. 65-86.