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**CURRENCY SUBSTITUTION  
IN THE CZECH REPUBLIC  
1993-2001**

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## **Abstract**

Currency substitution appears to be an important issue affecting the design of monetary policy, especially in transition economies. Therefore, this paper strives to analyse the particular relevance of the currency substitution phenomenon in the Czech Republic's case. We initially discuss the various approaches and definitions of currency substitution that found in the literature. Subsequently, discussing the role of currency substitution in small open economies in transition with some illustrations relating to the Czech Republic, we distinguish and analyse a locally and globally substituting currency from a substituted one, as well as and analyse the consequences of euroisation. The empirical part of this paper presents estimations of a modified Branson and Henderson portfolio model for the Czech Republic. This provides a multi-perspective approach to currency substitution in the broad sense. Further, we attempt to intensify the robustness of our estimation by applying several cointegration techniques, namely the Johansen procedure, ARDL, DOLS and ADL. Finally, we discuss the potential implications of the currency and asset substitution present according to our estimates in the Czech economy.

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# 1 Introduction

Currency substitution is a very important concept in the history of economic thought and one of the most ambiguous concepts in economics. A closer look at the way currency substitution has been defined in the vast literature brings little clarity. There we can distinguish several main areas, problems and incentives of current research. First, we must deal with the lack of a clear definition of currency substitution (given that currency substitution has lately been hardly distinguishable from dollarisation, other “-isations” and the concept of capital mobility). Second, we see dollarisation as a concept often used to refer to currency substitution in Latin America. Third, we must analyse the substitutability concept and the phenomenon of substitution, as well as their respective determinants. This part also includes our description of a locally (regionally) and globally substituting currency and a substituted currency (the currency being substituted). Fourth, we deal with these issues by discussing transition phenomena of currency substitution (especially in the Czech Republic) and the problem of *euroisation* (by unilateral or bilateral decision), which is becoming very topical at the end of 2001.

Finally, we present an empirical analysis of currency substitution phenomena in the case of the Czech Republic. We introduce the portfolio balance model of Branson and Henderson (1985), which creates the basis for our multi-perspective analysis.

This model consists of four equations, two representing the demand for domestic and foreign currency and two describing the demand for domestic and foreign bonds. We modify this model somewhat for local Czech conditions and discuss the building of the estimated equations, substituting the variables suggested by theory with their factual equivalents or approximations. Finally, based on our estimates we discuss some of the implications stemming from economic theory and from the experience of other transitional countries.



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## 2 The Currency Substitution Phenomenon

The phenomenon of currency substitution simply refers to a situation in which economic agents begin to use the currency or money of another nation, usually because of macroeconomic instability at home. The definitions of currency substitution rest on views as to the role of money in the economy, ranging from very narrow to very broad. At one extreme in the literature, the work of Calvo and Végh (1992) defines, currency substitution as the use of different currencies as media of exchange. At the other end of the spectrum, McKinnon (1985) finds *direct currency substitution* involves two or more currencies competing as a means of payment within the same commodity domain, while *indirect currency substitution* refers to investors switching between non-monetary financial assets. Between these extremes we can identify many definitions of currency substitution. An excellent review of the literature is given by Giovannini and Turtelboom (1992). Some researchers have simplified the definition of currency substitution to an analysis of the demand for domestic money and how it is affected by foreign economic variables. Among these variables, Rogers (1990) includes foreign inflation, Thomas (1985) the real return differential, Bana and Handa (1990) the relative opportunity cost of holding different currencies, Rojas and Suarez (1992) exchange rate considerations, and Madhavi and Kazemi (1996) nominal interest rates. In the context of currency substitution,

Uribe (1997) describes the function of foreign currency as a medium of exchange and its links to the exchange rate hysteresis effect.<sup>1</sup> Our own definition of currency substitution resembles the definition given at the beginning of this section.

## 2.1 Dollarisation or Currency Substitution

As stated above, many authors employ different interpretations of dollarisation in the context of currency substitution. It is often used to refer to currency substitution phenomena in the Latin American arena. Giovannini and Turtelboom (1992) also provide this definition of dollarisation. Calvo and Végh (1992) present an important interpretation of currency substitution as normally constituting a late stage of the dollarisation process.<sup>2</sup> Latin American countries, including Argentina, Bolivia, Peru and Uruguay increasingly use dollars as a substitute for their domestic currencies. Experts debate whether the region should encourage or resist this trend. Topics include the effects of substitution on inflation, liquidity and exchange rates.

Discussions on Argentina, Peru and Brazil mainly focus on the ways in which currency boards have brought about stabilisation in these countries. They consider whether such boards can strengthen fiscal discipline and speed up economic adjustment. A currency board issues money which is converted into a foreign reserve currency at a fixed exchange rate. This independent institution takes over the central bank's role as the sole issuer of base money. It also manages the exchange rate to keep the currency stable and convertible.

Given the description above, it makes good sense to distinguish between the terms *currency substitution* or *dollarisation*. This distinction is especially relevant in the presence of hysteresis, which can accompany currency substitution. The former is defined as a process of substitution in the economy which is symmetric and reversible. This means that any amount of substitution can evoke a corresponding

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1 To see the exchange rate hysteresis effect analysed from the microeconomic point of view, refer to Komárek (2001).

2 This interpretation can be very encouraging for those countries which have adopted a currency board regime in the European context.

increase or decrease in the use of foreign currencies. On the contrary, dollarisation can be viewed as an asymmetric reaction to changeable determinants of the substitution process in the usage of foreign currency. Hence the demand for foreign currency ( $M_{DF}$ ) in a dollarised economy (i.e. after dollarisation of the currency) increases, but in the following phase of equivalent exchange rate appreciation the demand for foreign currency decreases to a lesser extent – the absolute value of first effect is greater than that of the second effect.

## **2.2 Currency Substitutability and Currency Substitution**

The other key problem of the currency substitution issue is the class distinction between the terms substitution and substitutability (i.e. the ability to be substituted). These two terms lead to different research streams. The study of currency substitutability explores its potential effect on domestic and foreign variables, which is mainly of interest to economists and policymakers. On the other hand, the analysis of substitution explores the dimension of and potential for partial displacement (substitution) of one currency with another currency. This analysis aims to improve understanding of the mechanism of money demand in the economy. Such separation makes sense because substitutability does not necessarily imply substitution, and vice versa. Substitution is initiated, then, by the right combination of shocks.

### **2.2.1 Currency substitutability**

When studying the determinants of currency substitutability, it is quite useful to distinguish the three traditional functions of money in the economy, namely as: *(i) a unit of account, (ii) a provider of transaction services, and (iii) a provider of store-of-value services.*

The habit of using a particular currency is considered a very important factor. This determines the ability of the currency to be substituted as a unit of account. The more prevalent the use of non-domestic currencies in transactions, the greater is their

potential to substitute for the domestic currency in the context of this function of money. Similarly, the longer people use different currencies in account transactions, the more these currencies will potentially be substituted in this context.

Most economists understand currency substitutability in terms of money as a provider of transaction services (because they have experience with currencies being mainly substituted by other assets in accordance with the provider of store-of-value services function of money). In this discussion they often touch upon externalities. The more acceptable the currency, the more it is used as a provider of transaction services. The theory of “vehicle currencies” in the international financial markets is built on the concept of currency substitutability (in the context of the function of money as a provider of transaction services) and tries to explain the process of adopting an internationally acceptable currency.<sup>3</sup> This type of externality can be also used to explain the hysteresis phenomenon. One example of hysteresis involves persistent holding of high foreign currency balances even after periods of higher inflation.

It is well known that, as a store of value, currency predominates in the form of nominal interest-bearing assets and shares. Liquid, non-interest-bearing currency has an important role in an investor’s portfolio. Generally, cash is held in investor portfolios because it is the most liquid of all assets. The degree of liquidity of individual assets is different in each country depending on its financial sophistication and capital market liberalisation. The concept of store of value is closely related to the concept of international capital mobility (McKinnon 1985). We also think that this conceptual focus on this particular function of money is the most relevant one for transition economies. Our three main arguments in favour of this are: (i) the existence of a relatively short period of higher inflation in transition economies; (ii) the lack of a developed financial market and the absence of other financial substitutes

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<sup>3</sup> Let us assume that the representative agent is solving the optimisation problem and his liquidity cost function is not only defined for the holding of real money balances and consumption flows, but also for the ratio between domestic and foreign currency in the overall money supply of the economy. The higher the ratio of domestic currency, the more likely it is that the consumer finds an opposite player who will accept this currency in payment for goods and services. The cross-partial derivative of the liquidity function with respect to domestic money balances and to the ratio of domestic currency holdings is negative in the overall monetary aggregate. This means that the costs of using either one or the other currency are a decreasing function of the ratio of these currencies in private portfolios.

(bonds, shares, etc.) in transition economies; and (iii) the existence of relatively quick and successful macroeconomic stabilisation programmes in many transition countries.<sup>4</sup>

### **2.2.2 Currency substitution**

Any discussion of the theoretical bases and fields of currency substitution also calls for discussing about the demand for money in a multi-currency economy. Such an economy can be characterised as: (i) a country where different currencies circulate, or (ii) two or more countries where two or more currencies can simultaneously circulate (in each country). In this context it is also useful to refer to Sahay and Végh (1995), who distinguish clearly between the currency substitution and asset substitution phenomena. They argue that the first term represents the use of foreign currency as a means of payment and unit of account, while the second term relates more to the use of foreign currency as a store of value.

The theoretical models for analysing currency substitution can be divided into three main categories: (i) *cash-in-advance models (i.e. portfolio-balance models, money-in-the-utility-function models)*, (ii) *models of transaction cost*, and (iii) *ad-hoc models*. The first two kinds of model are also called optimising models, because their solutions follow from static or dynamic optimisation. The ad-hoc models postulate the functional form of the currency substitution ratio with domestic demands. Discussions of these theoretical models further arbitrate between all the implications for the currency substitution phenomena. Currency substitution influences both the stability of monetary aggregates and nominal exchange rate development, and affects the dynamics and volatility of the real exchange rate and the authority revenues from inflation (especially in the case of a serious budget deficit). Each of these effects has a link to macroeconomic policy, especially in the context of stabilisation programmes and the general tendency of economic agents to substitute domestic currency with foreign currency.

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<sup>4</sup> Sahay and Végh (1995) reported that dollarisation ratios have tended to fall significantly in most transition economies.

From the basic versions of these models we can formulate the following generalisations. The higher the elasticity of substitution between domestic and foreign currencies, the more substitutable are the foreign and domestic currencies and the lower is the change in their relative prices in reaction to an increase in their supply. If this elasticity of substitution is greater than one, then the influence of money demand on the exchange rate will dominate.<sup>5</sup> An increase in domestic output will be reflected in a nominal appreciation of the domestic currency.

The liquidity phenomenon is especially important in countries where a low level of development of financial markets makes the easy purchase and sale of financial assets to individual subjects impossible. The importance of liquidity phenomena increases with these non-liquid financial assets. For this reason the demand for money as a provider of store-of-value services also increases. It can be concluded that if the domestic currency has a low expected revenue (yield), as in a country with a high rate of inflation, then the foreign currency will be a desirable liquidity investment for domestic entities.

Attempting to identify a better measure of currency substitution has interested many authors in the literature. The simplest measure of currency substitution is foreign currency deposits, i.e. the ratio of foreign currency deposits to M2 (broad money) as a proxy variable for the level of currency substitution or dollarisation in the economy. It is clear that this approximation represents only the lower bound for the actual level of currency substitution in the economy, remembering omission of foreign currency notes in circulation in the domestic country.<sup>6</sup> Therefore, the actual level of currency substitution has to be positively corrected for the value of these notes. Nevertheless, Bufman and Leiderman (1992) construct a special set of foreign currency deposits in commercial banks that are linked to the exchange rate (devaluation of the exchange rate induces a one-to-one increase in the account balance in terms of the domestic currency). They calculate these foreign deposits for Israel and call them "Patam

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<sup>5</sup> An increase in domestic output increases the demand for money (the direct exchange rate quotation, i.e. X domestic currency units / 1 unit of foreign currency). The relative price of domestic goods decreases at the same time with the rate: 1/the elasticity of substitution of these goods.

<sup>6</sup> These data are hard to collect, not only in transition economies, but also in developed countries.

accounts.” It can be concluded that the more foreign currency notes circulating in the domestic economy, the higher is the instability of the economy (more pertinent to dollarised economies) or the less developed is the financial sector (more pertinent to transition economies).

The econometric models for testing the presence of currency substitution can be divided, according to the summary presented by Sarajevs (2000), into indirect and direct methods. The indirect method implies calculation of the demand for domestic money and the behaviour of inflation. Sarajevs refers to studies which focus on the stability of domestic demand for money and a special financial innovation variable by Arrau et al. (1991), stability of inflation by McNelis and Asilis (1992), transmission of domestic fiscal and monetary policies by Rojas-Suarez (1992), the welfare effect of currency substitution by Sturzenegger (1992, 1997) and the disciplinary aspect of currency substitution by Canzoneri and Diba (1992), among others.





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## 3 Currency Substitution in Small Open Transition Economies

In most transition economies, the initial conditions and the process of transformation have been similar, i.e. for more than ten years there have been simultaneous periods of internal and external liberalisation and a process alignment with the more developed countries. Internal liberalisation has been brought about by price liberalisation in a higher inflation environment, restructuring of industries, adoption of new tax systems, etc. External liberalisation has been caused by trade liberalisation and, in particular, by external convertibility of national currencies and liberalisation of capital accounts. Generally it can be concluded that the launch of the reform process was coupled with greater economic uncertainty<sup>7</sup> (and in some countries by political instability) and the absence of developed financial markets. In this situation, can foreign currency, for a limited period of time, take on all three main functions of domestic money (store-of-value, medium-of-exchange and unit-of-account)?

All these transformation problems in transition countries can seriously obstruct the very effectiveness of the monetary policy on which the authorities heavily rely to achieve macroeconomic stabilisation. This is especially true for the process of setting

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<sup>7</sup> This implies a high and volatile nominal exchange rate and inflation, large budget and current account deficits, and the establishment of new national currencies (in the countries of the former Soviet Union, the new countries of the former Yugoslavia, and in the Czech Republic and Slovakia).

money supply targets, maintaining the stability of the exchange rate, ensuring that the state receives seigniorage, etc. In the presence of currency substitution, households can easily switch between domestic and foreign currencies. This, in turn, can make the money supply process endogenous and increase the instability of money demand, impairing the ability of the monetary authorities to conduct effective policies and destabilising the domestic banking system.

### **3.1 Macroeconomic Policy and Currency Substitution**

The implications of currency substitution for macroeconomic policy differ between developed and developing countries particularly, in two respects in particular. First are the effects of currency substitution on the efficiency of stabilisation programmes, and second are the effects of currency substitution on the authority revenues received from inflation.

One of the problems of developing countries is the credibility of their stabilisation programmes. The relevant question in this context is: “Does dollarisation help to stabilise an economy and increase the credibility of its policies?” Credibility can increase when foreign currency circulation eliminates the authorities’ incentives to manipulate the domestic currency. In the past, many stabilisation programmes have involved fixing nominal exchange rates or establishing crawling pegs. These arrangements have ensured the progressive appreciation of real exchange rates. The other issue relating to stabilisation programmes is the discussion between fixed and floating exchange regimes. Results of currency substitution models and other empirical observations indicate that the presence of a currency substitution exchange rate implies higher volatility, with a potentially distributed effect in the economy. These findings lead to the defence of fixed exchange rates (or exchange rate regimes with narrower fluctuation bands) during a “stabilising” period, when currency substitution plays a significant role in the economy.

Inflationary financing of a government deficit poses another relevant question relating to these issues. It can be intuitively said that the higher the substitutability of the

domestic currency with foreign currency, the more difficult it is for the government to finance its deficit by printing money. On the one hand, holding foreign currency balances makes it possible to get seigniorage. On the other hand, the demand for foreign currency may act as an inflationary tax. The resulting revenue will be (in the presence of currency substitution) lower for each level of this tax.<sup>8</sup>

Currency substitution also suggests a recommendation for the optimal rate of inflation. The transaction models of currency substitution imply that the marginal rate of transformation (represented by a relative price, i.e. the real exchange rate) between two goods (domestic and foreign) is different from the marginal rate of substitution for these two goods, owing to the costs of liquidity. These liquidity costs are influenced by the rates of inflation in both countries. This model then defines an optimal relative rate of inflation, existing when the marginal rate of transformation is equal to the marginal rate of substitution. If the foreign rate of inflation is known, then the domestic rate of inflation should be set in such a way as to minimise misrepresentation of the aforementioned relative prices.

### **3.2 Quantification of the Degree of Currency Substitution**

It is useful to look at how we can quantify or measure the degree of currency substitution. Sarajevs (2000) concludes that, ideally, the measure of currency substitution is the value of foreign currency notes circulating in the economy (as a means of payment and a store of value) and all checking accounts and short-term deposits in foreign currency held by residents in domestic banks and abroad. Available data is lacking not only for transition economies, but also for industrial countries. Therefore, most studies generally calculate currency substitution either as (i) the ratio of foreign currency deposits to M2 (broad domestic monetary aggregates), or as (ii) the ratio of foreign currency deposits to broad monetary

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<sup>8</sup> A discussion of the seigniorage and inflation tax phenomenon, applied in the Czech transition period without considering external influences, is presented by Hanousek, Kubin and Tůma (1995). The influence of currency substitution on revenues from seigniorage in Eastern European economies has been estimated by Aarle and Budina (1995).

aggregates, including foreign currency. The next part will show that these two measures of currency substitution have moved together in the case of the Czech Republic.

Which factors can explain currency substitution in the Czech Republic? A number of competing explanations come to mind:

- The Czech Republic, with its lack of restrictions on capital flows, is a safe place for foreign exchange dealers from many countries.
- A lag occurs as financial markets and economic agents adapt to an economic environment with large foreign exchange flows (as individuals and banks get used to dealing with high levels of currency substitution, there are extra costs associated with turning the situation back).
- A sharp increase in the openness of the Czech economy increased foreign exchange balances during the transformation.

Another interesting question is: For whom is currency substitution most relevant? In the presence of inflation, poor people suffer more from inflationary taxation than do others. The poor cannot afford to use financial market instruments (including foreign currency) to avoid the inflation tax. Currency substitution can also make it more difficult for the government to renege on its economic stabilisation programme and fall back on the use of the inflation tax.

### **3.3 Substituting and Substituted Currencies**

In this subsection we distinguish a locally (regionally) and globally substituting currency from a substituted one (the currency being substituted). The reason for our fragmentation follows. We think that a local and global dimension of currency substitution can generally be found. While the global currencies are definitely the US dollar (USD), the German mark (DEM), the Swiss franc (CHF) and the Japanese yen (JPY), other currencies act more locally than globally. The vast majority of the four global currencies is held by citizens of nations outside the borders of the issuing

states. Doyle (2000) presents the relevant research in this area – an estimation of worldwide currency substitution. Using a currency demand equation implied by cointegrating vectors for Canada, the Netherlands and Austria, he estimates for 1996 that only a surprising 30% of USD was held outside the United States, although as much as 69% of DEM was held outside Germany. It must be remembered that foreign holdings of these three main currencies (USD, DEM, CHF) have significantly increased international currency substitution in the world, which roughly tripled between 1986 and 1996.<sup>9</sup>

Of course, several other currencies might qualify to fulfil this role, most notably for historical reasons (the colonisation period). There are at least two candidates: the British pound (GBP) and the French franc (FRF). The best candidate countries for “*poundisation*” include either relatively successful or developed economies such as those of Australia, New Zealand, Canada, South Africa, the Asian tigers (Hong Kong, Singapore and Malaysia) and parts of Middle Eastern territories. The best candidates for “*francisation*” are French former colonies in Africa, which used the Central African franc. This currency was for long time pegged to the French franc. So, we see that worldwide currency substitution is not solely an American or German phenomenon.

Generally, we can specify the reasons for currency substitution, i.e. the reasons why a currency is being substituted:

- (i) Macroeconomic instability with a sizeable rate of inflation, exchange rate instability and volatility, and a less optimistic country rating.
- (ii) The existence of a large illegal or underground economy (especially when this sector produces tradable and export goods such as drugs). Examples are to be found in Europe’s former socialist bloc.
- (iii) A history of financial crisis and risk-averse behaviour by economic agents trying to eliminate this potential risk.
- (iv) The lack of higher-denomination bank notes issued by the central bank.

The largest increase in currency substitution occurred in the last decade, suggesting that the main reasons for this were the collapse of the former socialist bloc in Europe and the tendency toward dollarisation, especially in South America.

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<sup>9</sup> These estimations are adjusted for inflation.

### 3.4 The Czech Koruna – A Substituting Currency or Substituted Currency?

We see local substituting currencies as being those which are mostly used in a local environment within a specific economic region. It can be shown that the Czech koruna is not only a substituted currency, but has also for several years been the substituting currency for some post-socialist countries. The reasons for this collateral role of the Czech koruna as a substituting currency include the following:

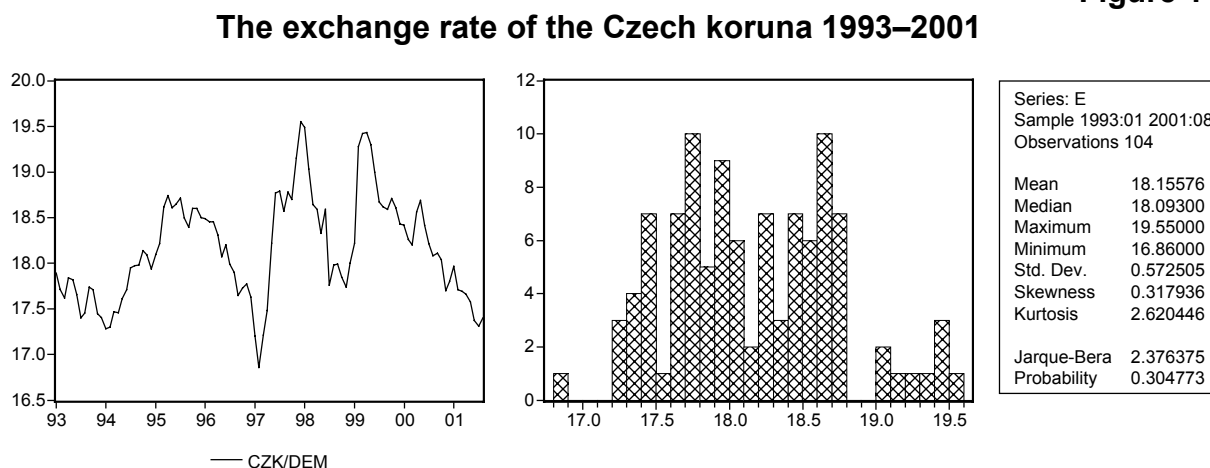
- a) Since its inception in 1993, the Czech koruna has remained very stable and not too volatile against the two main currency pairs (i.e. USD and DEM/EUR) (see Figure 1).
- b) The Czech koruna has not had an inflation rate higher than other transition countries (see Figure 2).
- c) The Czech koruna has quite a good general reputation abroad.
- d) The Czech koruna became externally convertible quite soon after 1993.
- e) The Czech economy has absorbed a fairly significant amount of post-socialist workers, for whom it is better to hold earned money in Czech koruna (rather than exchanging it for worldwide substituting currencies).
- f) The Czech National Bank issues bank notes with a relatively high nominal denomination of CZK 5000. Conversion from the highest GBP, FRF or USD<sup>10</sup> denominations yields a smaller amount of money than reflected in our highest note.<sup>11</sup> The new EUR notes will have two higher denominations compared to Czech notes and recalculated to CZK: the EUR 200 and EUR 500 notes.

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<sup>10</sup> Excluding the special issuance of notes between 1914 and 1923, when the FRB issued notes with nominal values of 500, 1,000, 5,000 and 10,000 USD.

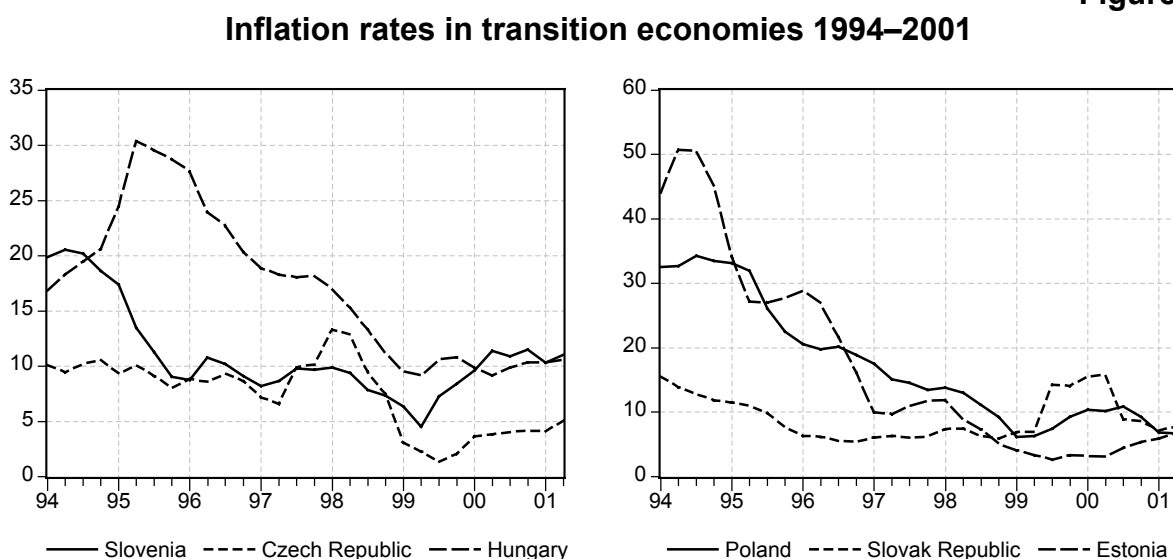
<sup>11</sup> See also the work presented by Feige, Faulend, Šonje and Šočič (2000).

Figure 1



Source: Author's calculation based on CNB database (<http://www.cnb.cz>).

Figure 2



Source: Author's calculation based on CNB database (<http://www.cnb.cz>) and IMF-IFS statistics.

The other relevant topic relating to the currency substitution issue (especially from the macroeconomic point of view) is the problem of *euroisation in non-eurozone countries*, which has become very topical in many transition countries at the end of 2001. Generally, we can distinguish the euroisation process as being based on either *a unilateral decision or a bilateral one*. The former involves adoption of the euro without the official agreement and permission of the EU authorities before a candidate country officially joins the eurozone (i.e. the EMU).

An accession country may generally see various advantages to adopting the euro, namely: (i) the stability of its exchange rate to the eurozone area is increased (incentives for international investment); (ii) the risk of speculative attacks on the domestic currency is virtually eliminated; (iii) the general necessity of holding foreign reserves is lessened (thanks to lower exchange risk); (iv) re-establishing the domestic currency and re-creating an independent central bank remain theoretically possible.<sup>12</sup>

The general disadvantages might include: (i) the higher probability of runs on commercial banks in the absence of a “national” central bank acting as a lender of last resort; (ii) the low official euroisation of most first-wave accession countries;<sup>13</sup> (iii) the general or probable lack of foreign reserves; (iv) non-compatibility of monetary policy instruments with the ECB (though not problematic for those in the first wave of accession); (v) the possibility of political feuding because monetary policy is much less independent of other countries.

The latter (bilateral) decision represents the stage of integration into the eurozone after accession to the EU and after fulfilment of all necessary conditions (the explicit nominal convergence criteria – here especially the ERM II criteria for the nominal exchange rate, real convergence, institutional convergence, etc.), leading to determination of the euro locking rates for the Czech koruna, for example. The main reason for adopting the euro as late as possible is the modification of the structure of real appreciation accompanying the real convergence process. This process will only be possible through higher inflation and no longer through appreciation (nominal and real) of the exchange rate. This has important implications for macroeconomic policy in the accession (catching-up) countries.<sup>14</sup>

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<sup>12</sup> The discussion between currency board countries (especially Estonia) and the ECB is also very important, given that the currency board regime is often the semi-final step before official euroisation.

<sup>13</sup> A related example exists in Argentina, where more than one half of deposits are denominated in USD.

<sup>14</sup> It can be shown that the effects for new EU member (catching-up) states in the single currency area and common monetary policy will be different from the effects for older EU member (developed) states. The single level of interest rates in the eurozone and different inflation rates will lead to decreases in interest rates in new member countries, i.e. monetary policy will be more expansionary than in the older (more developed] member countries. The importance of fiscal policy in macroeconomic policy instruments will automatically increase.



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## **4 Empirical Analysis of Currency Substitution under Conditions in the Czech Republic**

Giovannini and Turtleboom (1992) identify three main categories of empirical models in their paper reviewing theoretical and empirical literature concerning currency substitution, although some works do not fit their classification.

In the first category, demand functions for domestic and foreign moneys are part of a static (two period) portfolio balance model, where optimal holdings of domestic and foreign assets are chosen together with currencies. Giovannini and Turtleboom state that this strand of literature treats domestic and foreign interest rates, together with exchange rate changes, as jointly determined in a general financial equilibrium.

In the second category currency substitutability is estimated in a narrower setup. In these models, agents first decide on the optimal mix of monetary and non-monetary assets. In a second stage, they decide how to allocate the monetary assets between the different currencies in their portfolio. The latter decision is based only on the degree to which both currencies contribute to delivering money services and on the relative opportunity cost between the two currencies.

Finally, a more recent strand of literature starts from the first order conditions of the representative agent's dynamic optimisation problem. Applying some auxiliary

assumptions, it recovers the parameters of interest, which allow the estimation of the substitutability of different currencies.

Our analysis of currency substitution in the Czech Republic is based on the approach that falls into the third category. More specifically, we employ the portfolio approach suggested by Branson and Henderson (1985), which we further modify to the conditions prevailing in the Czech Republic. This portfolio approach enables us to focus on currency substitution phenomenon from several perspectives. It incorporates money demand for both domestic and foreign currencies, and capital mobility or demand for both domestic and foreign bonds. We consider this approach very useful, since it comprises several independent views on currency substitution analysis, examining the robustness of the estimates attained not only from the perspective of the estimation techniques applied, but also from that of different markets (relationships).

We follow Branson and Henderson (1985), without explicit solution of the optimisation problem, and assume that the domestic demand (i.e. that of domestic residents) for assets depends on their relative returns, satisfying the usual wealth constraints:

$$M = M(\bar{i}, (\bar{i}^* + e^{ex}), \bar{e}^{ex}, \bar{P}Y, \bar{P}^c, \bar{W}) \quad (1)$$

$$eM^* = M^*(\bar{i}, (\bar{i}^* + e^{ex}), \bar{e}^{ex}, \bar{P}Y, \bar{P}^c, \bar{W}) \quad (2)$$

$$B = B(\bar{i}, (\bar{i}^* + e^{ex}), \bar{e}^{ex}, \bar{P}Y, \bar{P}^c, \bar{W}) \quad (3)$$

$$eB^* = B^*(\bar{i}, (\bar{i}^* + e^{ex}), \bar{e}^{ex}, \bar{P}Y, \bar{P}^c, \bar{W}) \quad (4)$$

The first argument in equations (1) to (4),  $\bar{i}$ , is the return on holding bonds denominated in domestic currency relative to the return on domestic money (minus the rate of domestic inflation). It is assumed that all four assets are substitutes in the portfolio. Hence, an increase in  $\bar{i}$  raises the demand for domestic bonds but lowers the demand for their substitutes in the portfolio. The nominal return on bonds denominated in foreign currency is  $\bar{i}^*$ . Expressed in domestic currency, this return becomes  $\bar{i}^* + e^{ex}$ , with  $e^{ex}$  the expected change in the exchange rate. It affects the demand for foreign securities positively and that for other assets negatively. Once

again, this second argument is in fact a real return differential, where the return on domestic money is minus the rate of inflation.<sup>15</sup> Similarly, the third argument,  $e^{ex}$ , is the return on foreign money, converted into the domestic currency.<sup>16</sup>

The fourth argument,  $PY$ , represents the home currency value of domestic output and affects demand for all assets positively.  $P^c$  is the price of the domestic consumer's consumption bundle expressed in the home currency. An increase in  $P^c$  increases the demand for both moneys and lowers the demand for bonds denominated in domestic and foreign currency. The positive effect on domestic wealth  $W$ , the last argument, reflects the assumption that all assets are "normal assets".

Govannini and Turtleboom (1992) add that the discussion of the theoretical models of liquidity and the demand for domestic and foreign moneys as stores of value suggest a possible source of misspecification in this model. In the portfolio-balance equations the real returns from holding the domestic and foreign currencies, i.e. their liquidity services, have to be added to minus the rate of inflation, and are distinct from domestic and foreign interest rates and the rate of change in the exchange rate. Yet, they do not appear in the equations written above, raising questions about specification bias.

Indeed, in the absence of such liquidity services, it is not clear why domestic and foreign moneys are held at all. One potential way out is to assume that such liquidity services are constant, and thus independent of the other returns in the equations.

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<sup>15</sup> Indeed, the real return on the foreign bond in terms of domestic bonds equals the own real rate of interest on the foreign bond plus the expected rate of change in the real exchange rate – the expected rate of change of the nominal exchange rate plus the expected foreign price inflation, minus the expected domestic price inflation. Subtracting the real rate of return, we obtain the nominal return in the equation.

<sup>16</sup> Again, the real return on foreign money expressed in terms of foreign goods is minus the expected foreign rate of inflation. This can be transformed into a real return expressed in domestic goods by adding the expected rate of change of the exchange rate. Finally, adding the expected domestic rate of inflation (that is, subtracting the return on the domestic money stock expressed in terms of domestic goods) we are left with the expected change in the nominal exchange rate.

Such an assumption, however, is never invoked in the empirical papers surveyed by Govannini and Turtleboom.

We modify this portfolio approach to the local conditions of the Czech Republic. Specifically, we respect the characteristics of and institutions in the Czech economy, which stem both from historical aspects and from recent developments in this country. When we go through the portfolio balance approach, the first equation represents the traditional domestic money demand equation which has been estimated in slightly modified form and analysed by many authors with respect to the Czech economy (most recently e.g. Melecký, 2001 and Arlt, Guba, Radkovsky, Sojka and Stiller, 2001). The modification (or difference) lies in the fact that the Czech Republic's broad monetary aggregate (M2) includes foreign deposits. Therefore we will concentrate, as regards equation (1), on M2 adjusted for foreign deposits.

Equation (2) in our case describes domestic demand for foreign currency, i.e. foreign currency in circulation and foreign deposits in the Czech economy. However, monitoring foreign currency in circulation is very difficult and the estimation of such an aggregate would be worth a separate paper. We consider only the demand for foreign deposits. These are probably held in the Czech Republic mostly for their store-of-value purpose (although we would not omit the influence of foreign trade), as the Czech economy is not considerably dollarised (or D-markised) and therefore foreign currency is not commonly used as a medium of exchange or unit of account. However, this hypothesis needs to be tested by the empirical examination we undertake estimating equation (2).

The first problem arises when we look at residents' demand for domestic bonds. Historical development has predetermined the current situation in Czech financial markets whereby financial intermediation goes largely through the banking sector and the capital markets are generally either inaccessible or illiquid and inefficient. More specifically, owing to the prevalent credit system, the Czech bond market is underdeveloped, so we are left with government bonds and Treasury Bills only. However, these constitute a rather exclusive market that is accessible only to

selected large financial institutions.<sup>17</sup> A similar situation exists on the stock market. Furthermore, when considering the demand for credits we face the problem of credit rationing. This has been present in the Czech Republic for a half of our estimating period, at least. The above aspects make us exclude equation (3) from the portfolio approach.

Although an analysis of the demand for foreign bonds, or foreign portfolio assets generally, may be associated with some inconsistency in data series, we attempt to estimate the function capturing the demand for foreign portfolio assets in the case of the Czech Republic as proposed by equation (4). In addition, the constraints, or rather controls, on capital movement imposed by the Czech National Bank at the beginning of our estimated sample may result in lower significance of certain variables, so we increase somewhat the ranking of importance of all foreign variables in determining the development of portfolio investment abroad in our case.

## 4.1 Description of the Data Series Used

We use quarterly data spanning the period from the first quarter of 1994 to the second quarter of 2001. Where a particular variable is of discrete form we use a quarterly average calculated as the simple arithmetic average of the monthly end-of-period values for the three months in the current quarter and the last month of the previous quarter. We use seasonally adjusted data only in the case of the AE variable, which is the only one showing a marked seasonal pattern. (*Data source: CNB database, i.e.: <http://www.cnb.cz>.)*

### Dependent variables

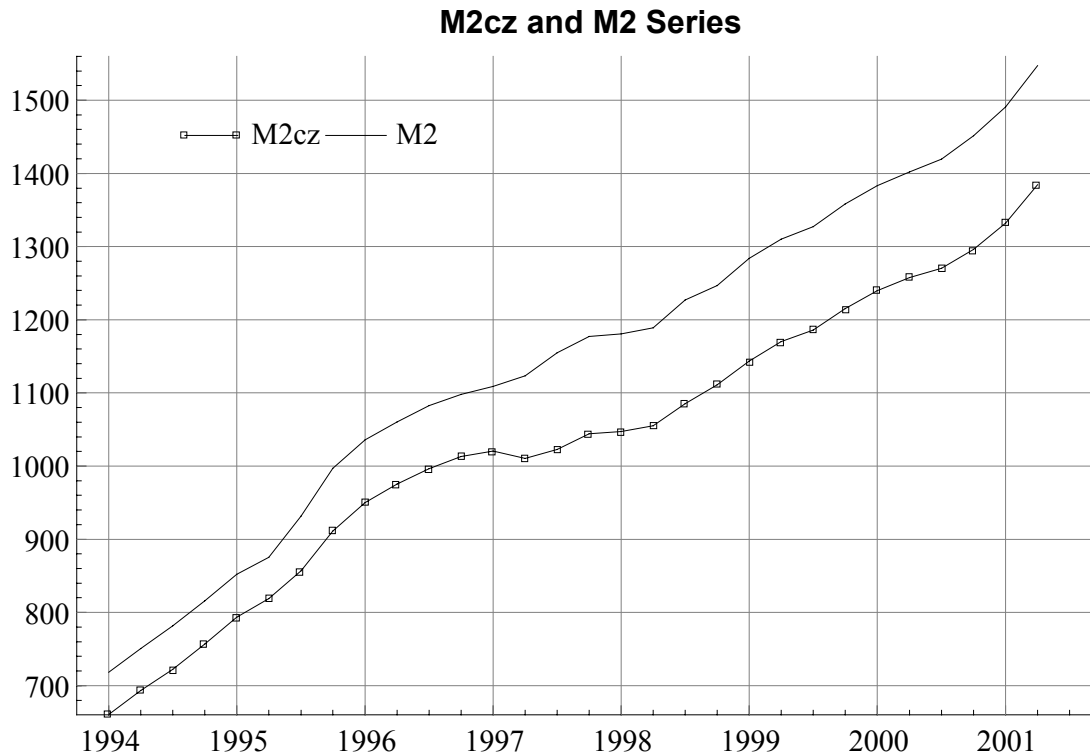
We first attempt to model the *Mcz* variable, representing deposits in the domestic banking system denominated in the Czech currency. This variable is calculated as the difference between the M2 monetary aggregate and deposits in the domestic

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<sup>17</sup> A thorough discussion on financial intermediation in transition countries and various aspects of its development can be found in Mishkin (2001).

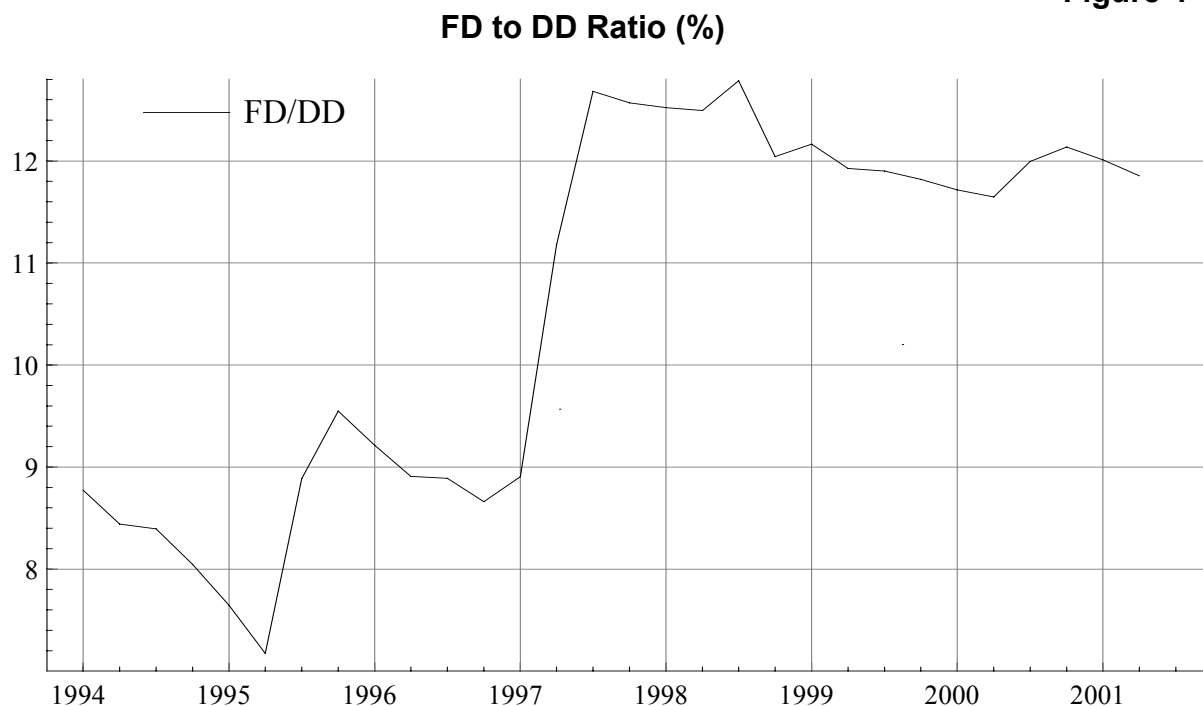
banking system denominated in foreign currencies. We further subtract Czech currency in circulation, since we cannot include foreign currencies in circulation in our analysis owing to a lack of data series.

**Figure 3**



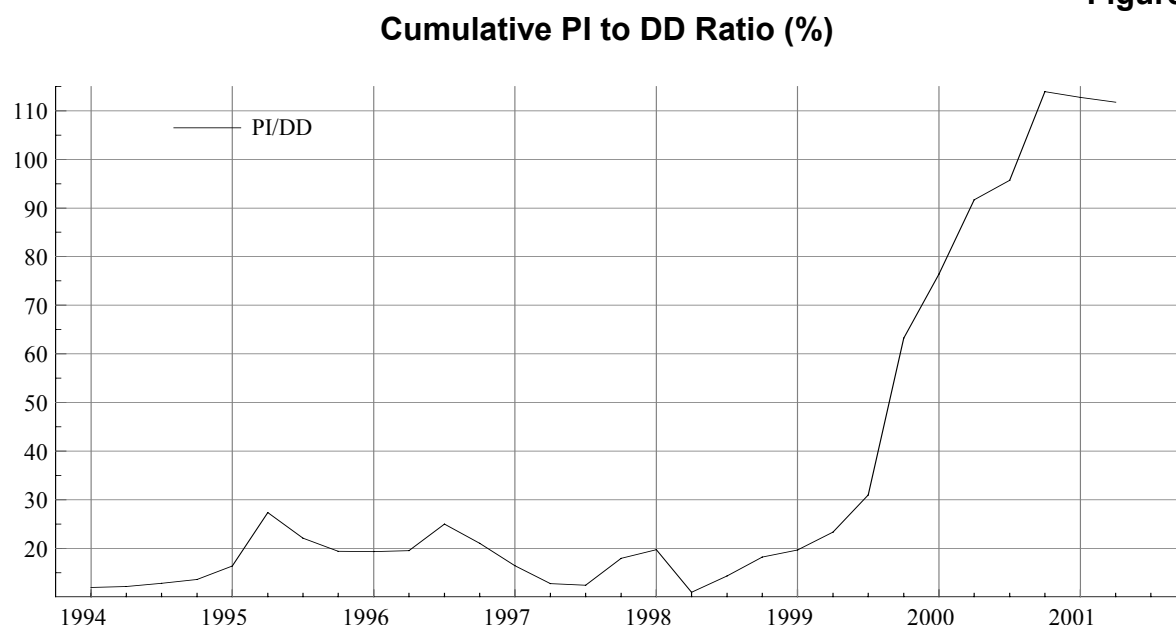
*Source:* Author's calculation based on CNB database (<http://www.cnb.cz>).

The next modelled variable is the ratio of foreign to domestic currency deposits ( $FD/Mcz$ ); we name this variable the  $FD/DD$  ratio in per cent. The modelled variable is similar to those proposed by Feige, Faulent, Šonje and Šošić (2000) in case of Croatia; and by Mongardini and Mueller (1999) in the case of the Kyrgyz Republic for analogous purposes. We do so to more precisely pursue the effect of changing relative prices of assets under consideration on domestic residents' behaviour. We thus differentiate between increases in foreign deposits resulting from an overall increase in wealth and the move from domestic deposits to foreign deposits for store-of-value purposes. Figure 4 shows a rapid increase in the  $FD/DD$  ratio during periods of currency crisis that seem to be persistent. This may point to dollarisation of the Czech economy from the store of value perspective.

**Figure 4**

*Source:* Author's calculation based on CNB database (<http://www.cnb.cz>).

The last dependent variable, that we attempt to explain, is the ratio of cumulative portfolio investment abroad to domestic deposits. We use this variable to properly evaluate the effect of changing relative prices of foreign assets and deposits in the domestic currency on wealth allocation. Further, we again attempt to eliminate the effect of rising wealth using DD as a denominator. We can see in Figure 5 that domestic agents have only recently started to use foreign assets for wealth allocation purposes. However, this increase appears to be quite strong.

**Figure 5**

*Source:* Author's calculation based on CNB database (<http://www.cnb.cz>).

### **Explanatory variables**

We use the consumer price index as the approximation of variable  $P^c$  in equations (1) to (4). This index should precisely describe consumption basket price development in the Czech Republic and so correctly deflate the nominal variables from the perspective of the domestic agent.

Furthermore, we approximate the variable  $PY$  in equations (1) to (4) using domestic absorption, which would measure the amount of transactions in the Czech economy and possibly an accumulation of wealth. We employ this variable, as it is more significant for such purposes according to Sommer (1997) and Melecký (2001).

Instead of the return on domestic bonds we use the interest rate on credits, since this seems to be the most significant opportunity cost of holding money and an alternative wealth allocation to money holdings.

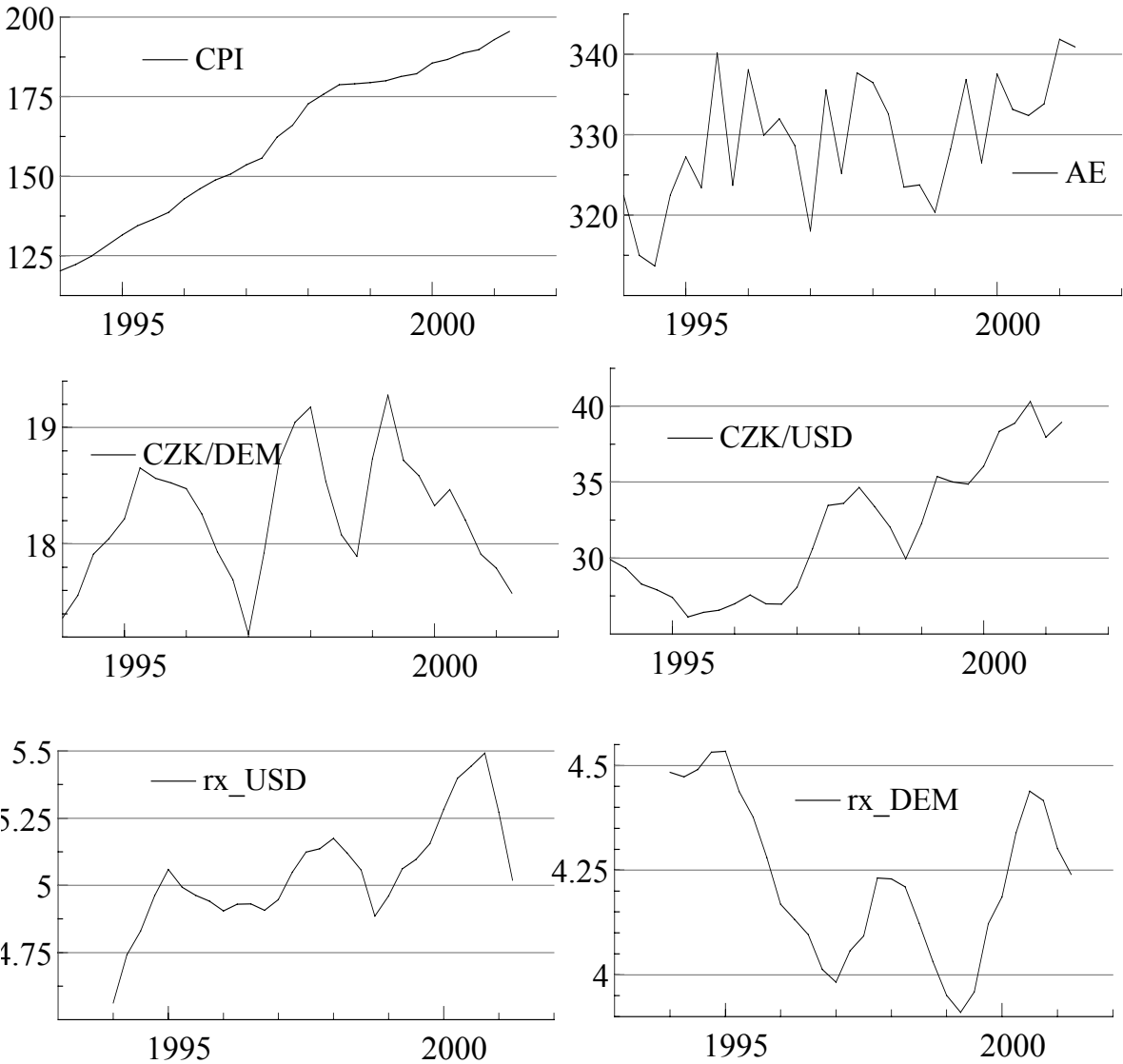
For the purpose of measuring return on foreign money we employ two bilateral exchange rates – CZK/USD and CZK/DEM – since they have experienced a somewhat different historical development. This could result in a rather different relative significance of the two variables. We use current and one-period-lagged



values of the exchange rate to approximate exchange rate expectations, since we assume that agents form their expectations mostly adaptively and the rest use the random walk process as the predictor. We do not use an inflation differential for such purposes, as PPP is likely to hold only in the longer run.

**Figure 6**

**Explanatory Variables**



*Source:* Author’s calculation based on CNB database (<http://www.cnb.cz>).

As in the above case we employ the return on both USD- and DEM-denominated assets to explicitly consider their relative importance in equations (1) to (4). We

calculate this return as the sum of the interest rate and the particular exchange rate after logarithmic transformation, i.e.  $i+e$  (see also Govannini and Turleboom, 1992).

Since the dependent variables are integrated of order  $I(1)$ , as are most of the explanatory variables (see Table 1A in the appendix to this paper),<sup>18</sup> we need to use cointegration analysis to prevent spurious regression phenomenon. For this purpose we use the Johansen technique (see Johansen and Juselius, 1990); the ARDL procedure developed by Pesaran (see Pesaran, Shin and Smith, 1996); the dynamic OLS estimation, DOLS (see e.g. Stock and Watson, 1993); and the ADL technique (see e.g. Arlt, Radkovský, Sojka and Stiller, 2001).

## **4.2 Empirical Analysis of Currency Substitution in the Czech Republic from the Demand-for-Money Perspective**

We analyse the potential presence of currency substitution in the Czech Republic using the demand for money approach. More specifically, we use equation (1), which describes demand for deposits and currency in circulation denominated in Czech koruna. If currency substitution is one of the important techniques of portfolio allocation, then the opportunity costs of holding deposits denominated in the Czech currency relative to foreign currency and foreign assets (i.e. either the nominal exchange rate or the return on foreign assets) are going to be significant determinants of the demand for the Czech currency (approximated by M2 monetary aggregate minus deposits in foreign currency).

The procedure for the empirical analysis of currency substitution in the Czech Republic is divided into three stages.<sup>19</sup> First, we explore the existence of currency

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<sup>18</sup> Although there are some indications that certain variables could have been integrated of order  $I(2)$ , we do not consider this higher degree, since for the case of our small finite sample of observations applied unit-root tests do not have much power and size. Therefore, the higher-order effectiveness of these tests is somewhat disturbed.

<sup>19</sup> We choose this approach since we want to consider a wide range of possible foreign variables that might be important determinants of currency substitution and we have only a small number of observations.

substitution concerning the effect of exchange rates. In this stage the particular currencies are assumed to compete as a store of value in domestic banking system. Second, we examine the potential existence of the extensive part of nominal exchange rate elasticity, since the first case considers only the intensive part. Finally, we extend this analysis to include the determinants relating to capital mobility.

#### 4.2.1 First stage model and its estimates

We inspect the possible existence of currency substitution in the Czech Republic in the first stage by estimating a base model similar to that presented in Govannini and Turtelboom (1992) under the portfolio balance approach. However, Branson and Henderson (1985) originally developed this type of model. Equation (5) represents the expression of this model in log-linear form.<sup>20</sup>

$$m_{cz} = \beta_0 + \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 e^{neer} + \xi \quad (5)$$

where  $m_{cz}$  is the M2 monetary aggregate adjusted for DFC (deposits in foreign currencies), i.e. (M2-DFC);  $cpi$  is the consumer price index, measuring price level development;  $ae$  is domestic absorption (GDP-NX), measuring the amount of transactions in the Czech economy;  $lr$  is the lending interest rate, representing domestic interest rates on alternative assets; and  $e$  is, respectively, the CZK/USD and CZK/DEM nominal exchange rates and the nominal effective exchange rate. We thus explicitly test the significance of the alternative approximation of the Czech koruna performance relative to foreign currencies, i.e. the opportunity cost of holding Czech currency.

We can conclude that the estimating methods applied indicate the presence of currency substitution in the Czech Republic, with the important variables accounting for this phenomenon being the current and lagged value of the CZK/USD exchange rate and the lagged value of the CZK/DEM exchange rate. These two bilateral exchange rates seem to be superior to the nominal effective exchange rate. This conclusion may reflect the fact that in certain periods the values of CZK/USD and

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<sup>20</sup> We begin with this narrower specification adding peaks of exchange rates (so-called ratchet variables) and returns on foreign assets subsequently.

CZK/DEM evolve in opposite directions, making the NEER less significant (CZK/USD and CZK/DEM are the main components of the NEER). Concerning the other variables, all these domestic determinants seem to be significant.

**Table 1**

Variable	First Stage Model Estimates				General Significance <sup>III</sup>
	Estimating Methods				
	JOH(1) <sup>I</sup>	ARDL(1,0,1,0) <sup>II</sup>	DOLS	ADL	
<b><i>m<sub>CZ</sub></i>(-1)</b>	-----	-----	-----	0.81 (0.06)***	0.81 (0.06)***
<b><i>cpi</i></b>	1.56 (0.07)***	2.10 (0.38)***	2.65 (0.09)***	1.21 (0.12)*	1.83 (0.11)***
<b><i>ae</i></b>	2.31 (0.21)***	1.50 (0.53)***	0	0	1.91 (0.37)**
<b><i>ae</i>(-1)</b>	-----	-----	-----	1.11 (0.10)**	0.21 (0.10)**
<b><i>lr</i></b>	-0.012 (0.002)**	-0.034 (0.008)***	-0.021 (0.002)	-0.02 (0.001)***	-0.021 (0.002)***
<b><i>czk/usd</i></b>	0	-0.79 (0.23)***	-0.67 (0.05)***	0	-0.73 (0.14)**
<b><i>czk/usd</i>(-1)</b>	-0.30 (0.06)***	0	-----	-0.32 (0.03)*	-0.31 (0.05)*
<b><i>czk/dem</i></b>	0	0	-0.71 (0.16)***	0	-0.71 (0.16)
<b><i>czk/dem</i>(-1)</b>	-0.66 (0.17)***	-1.14 (0.52)**	-----	0	-0.90 (0.35)**
<b><i>neer</i></b>	0	-1.24 (0.53)**	0	0	-1.24 (0.53)
<b>constant</b>	unrestricted	unrestricted	-----	-1.75 (0.87)**	-1.75 (0.87)**

- I. The number in brackets indicates the applied lag length of the endogenous variables included in VAR.
- II. Numbers in brackets indicate the applied lag length of the particular endogenous variables included in VAR.
- III. Although the provided generalisation of acquired estimates is considered to be of poor rigorousness we prefer to do such subjective summarisation, since none of the estimating methods seems to be superior under conditions of transition economy (i.e. low quality and consistency of data and only small sample of observations). We believe that the application of several methods is of key importance in this respect.

\*, \*\*, \*\*\* indicate significance at 10%, 5% and 1% probability levels respectively. The last column of the table indicates the overall significance of the particular variable and the median of its estimated coefficients. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) the variables *m<sub>CZ</sub>*, *cpi* and *ae* were assumed to be endogenous.

#### 4.2.2 Second stage model and its estimates

In the second stage, we consider the possible extensive part of the exchange rate's elasticity, including in the estimated equation two time-series that include peak values of the CZK/USD and CZK/DEM exchange rates. Following Mulligan and Sala-I-Martin (1996), we assume that when the actual value of the exchange rate hits the peak value during the analysed period, additional agents always decide to adopt financial technology to help them convert the domestic currency into foreign currency. They do so since they are facing the very level of opportunity costs that they consider too high and makes them react in this respect (see also Feige, Faulent, Šonje and Šošić, 2000 and Mongardini and Mueller, 1999). The estimated results are reported in Table 2:

As we can see, there is nearly no support from the estimation methods applied for the existence of an extensive part of exchange rate elasticity. We can thus conclude at this stage that currency substitution is probably present in the Czech Republic, but only through the "intensive" part of exchange rate elasticity.

We proceed to the third stage in the estimating model of Branson and Henderson (1985) which accounts capital mobility. According to this model we add a variable that should represent the impact of capital mobility, i.e. the return on foreign assets. We consider returns on U.S. Treasury Bills and German Treasury Bills expressed in Czech korunas, as perceived from the position of Czech residents<sup>21</sup>. The estimation results are presented in Table 3.

An inspection of the estimation results gives only poor support for the existence of significant effect of returns on foreign assets on the demand for Czech korunas from the perspective of domestic residents. We can infer from the above analysis that, on the aggregate level, the currency substitution phenomenon is only partially important. More specifically, currency substitution (its intensive part) is the only relevant pattern

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<sup>21</sup> In mathematical expression, the variable that represents the return on a particular foreign asset is given by the sum of the interest rate logarithm and the exchange rate logarithm ( $i+e$ ).

for Czech resident behaviour. Furthermore, in this respect money holdings in Czech currency were substituted by holdings denominated in both DDM and USD.

**Table 2**

Variable	Second Stage Model Estimates				General Significance
	Estimating methods				
	JOH(1)	ARDL(1,0,1,0)	DOLS	ADL	
$m_{cz}(-1)$	-----	-----	-----	0.81 (0.06)***	0.81 (0.06)***
$cpi$	2.11 (0.30)***	2.10 (0.38)***	3.56 (0.29)***	1.21 (0.12)*	2.11 (0.30)***
$ae$	2.71 (0.24)***	1.50 (0.53)***	0	0	2.11 (0.27)**
$ae(-1)$	-----	-----	-----	1.11 (0.10)**	0.21 (0.10)**
$lr$	-0.012 (0.002)***	-0.034 (0.008)***	-0.026 (0.003)***	-0.02 (0.001)***	-0.023 (0.003)***
$czk/usd$	0	-0.79 (0.23)***	-0.97 (0.13)***	0	-0.88 (0.18)**
$czk/usd(-1)$	-0.45 (0.10)***	0	-----	-0.32 (0.03)*	-0.39 (0.07)*
$czk/dem$	0	0	0	0	0
$czk/dem(-1)$	-0.42 (0.26)**	-1.14 (0.52)**	-----	0	-0.78 (0.39)*
$peak\_usd$	0	0	0	0	0
$peak\_usd(-1)$	0	0	0	0	0
$peak\_dem$	0	0	-2.50 (0.35)***	0	-2.50 (0.35)
$peak\_dem(-1)$	-1.72 (0.95)*	0	-----	0	-1.72 (0.92)
<b>constant</b>	unrestricted	unrestricted	-----	-1.75 (0.87)**	-1.75 (0.87)

\*, \*\*, \*\*\* indicate significance at 10%, 5% and 1% probability levels respectively. The last column of the table indicates the overall significance of the particular variable and the median of its estimated coefficients. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) the variables  $m_{cz}$ ,  $cpi$  and  $ae$  were assumed to be endogenous.

Table 3

## Third Stage Model Estimates

Variable	Estimating Methods				General Significance
	JOH(1)	ARDL(1,0,1,0)	DOLS	ADL	
$m_{cz}(-1)$	-----	-----	-----	0.80 (0.05)***	0.80 (0.05)***
<b>cpi</b>	1.42 (0.13)***	2.19 (0.56)***	2.11 (0.11)***	1.30 (0.02)***	1.77 (0.12)***
<b>ae</b>	2.42 (0.21)***	1.55 (0.60)***	0	0	1.91 (0.40)**
<b>ae(-1)</b>	-----	-----	-----	0.35 (0.03)***	0.07 (0.03)***
<b>lr</b>	-0.012 (0.002)**	-0.034 (0.008)***	-0.023 (0.003)***	-0.02 (0.001)***	-0.022 (0.003)***
<b>czk/usd</b>	0	-0.80 (0.24)***	-0.44 (0.08)***	0	-0.61 (0.16)**
<b>czk/usd(-1)</b>	-0.21 (0.08)***	0	-----	-0.40 (0.03)**	-0.19 (0.06)**
<b>czk/dem</b>	0	0	-0.71 (0.17)***	0	-0.71 (0.17)
<b>czk/dem(-1)</b>	-0.70 (0.16)***	-1.10 (0.65)**	-----	0	-0.90 (0.41)**
<b>neer</b>	0	-1.20 (0.56)**	0	0	-1.20 (0.56)
<b>rx_usd</b>	0	0	0	0	0
<b>rx_usd(-1)</b>	0	0	-----	0	0
<b>rx_dem</b>	0.064 (0.042)*	0	-0.15 (0.04)***	0	-0.17 (0.041)*
<b>rx_dem(-1)</b>	0	0	-----	0	0
<b>constant</b>	unrestricted	unrestricted	-----	0	0

\*, \*\*, \*\*\* indicate significance at 10%, 5% and 1% probability levels respectively. The last column of the table indicates the overall significance of the particular variable and the median of its estimated coefficients. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) the variables  $m_{cz}$ ,  $cpi$  and  $ae$  were assumed to be endogenous.

### 4.3 Empirical Analysis of Currency Substitution in the Czech Republic from the Perspective of Demand for Foreign Deposits

In this part, by estimating equation (2) we inspect the presence of currency substitution phenomenon characterising the domestic demand for foreign deposits. We do not consider the pure stock of foreign deposits in the domestic banking system but rather model the ratio of such stock to domestic deposits.

Using the same set of explanatory variables as in part 4.2, we estimate equation (2), is suggested by theory, after logarithmic transformation and application of the relevant approximation of the explanatory variables using factual variables, it takes the form of equation (6):

$$fd/dd = \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 rx^{usd} + \beta_7 rx^{dem} + \xi \quad (6)$$

where  $fd/dd$  is the ratio of foreign currency to domestic currency deposit stocks and, once again,  $cpi$  is the consumer price index, measuring domestic price level development;  $ae$  is domestic absorption (GDP-NX), measuring the amount of transactions in the Czech economy;  $lr$  is the lending interest rate, representing domestic interest rates on alternative assets;  $e$  is the nominal CZK/USD and CZK/DEM exchange rate respectively; and  $rx^{usd}$  and  $rx^{dem}$  are the respective returns on foreign assets denominated in USD and DEM in terms of the domestic currency. The results of our estimates of equation (6) using various cointegration techniques are presented in Table 4:



Table 4

**Estimates of Equation (6) Using Various Techniques  
Parsimonious Versions)**

Variable	Estimation methods				General Significance
	JOH(1)	ARDL	DOLS	ADL	
<b>fd/dd(-1)</b>	-----	0	-----	0.31 (0.15)**	0.31 (0.15)*
<b>cpi</b>	1.03 (0.19)***	1.13 (0.14)***	1.48 (0.13)***	1.03 (0.19)***	1.08 (0.14)***
<b>ae</b>	0	0	-2.05 (0.41)***	0	-2.05 (0.41)
<b>lr</b>	0.04 (0.008)***	0.04 (0.006)***	0	0.04 (0.007)***	0.04 (0.007)**
<b>e_usd</b>	0.74 (0.22)***	0.76 (0.14)***	0	0.74 (0.18)**	0.74 (0.18)**
<b>e_dem</b>	0	0	2.24 (0.83)**	0	2.24 (0.83)
<b>rx_usd(-1)</b>	0	-0.18 (0.074)**	0	0	-0.18 (0.074)
<b>rx_dem</b>	0	0	0	0	0
<b>constant</b>	Unrestricted	-5.56 (0.52)***	0	-3.01 (0.73)***	4.29 (0.63)**

\*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% probability levels respectively. The last column of the table indicates the overall significance of the particular variable and the median of its estimated coefficients. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) only the *fd/dd* variable is assumed to be endogenous.

We can infer from our estimates that there is only weak evidence of any significant persistence in the *fd/dd* ratio, at about 0.31 percent. Moreover, we believe that agents are concerned with the real value of the *fd/dd* ratio. The median of the estimated *cpi* coefficient lies at 1.08 and is highly significant. Thus we can nearly assume price homogeneity in the case of *fd/dd* ratio demand. The overall insignificance of the scale variable most probably suggests that foreign deposits are held solely for store-of-value purposes. The DOLS estimation might be associated with a somewhat similar explanation that views the increase in transaction amounts in the domestic economy as an impulse for the transfer of foreign deposits into domestic currency sight deposits for transaction (medium-of-exchange) purposes, although this hypothesis has no support from the other estimates. The estimates of the *lr* effect on the *fd/dd* ratio seem to be robust, even though it has the opposite sign than was originally expected.

To explain the  $lr$  effect we recall that  $lr$  stands for the interest rate on credits. In the case of the Czech Republic this means the cost of financing, assuming that financial intermediation goes mostly through the banking system. So if  $lr$  increases, agents probably look for an alternative source of financing. In the absence of effective domestic capital markets, this involves borrowing on foreign or international financial markets, resulting in an increase in foreign deposits in the domestic country when the funds are raised.<sup>22</sup> The mechanism described here is relevant for Czech corporations, as these made intensive use of international sources of financing between 1990 and 1997. This  $lr$  effect is highly significant in the Czech Republic's case, with the median of the estimates lying at 0.04.

When we move to the estimates of the returns on foreign currency, there is general support for the existence of a significant effect on the  $fd/dd$  ratio only from the CZK/USD exchange rate. This is significant at the 1% level and has its median at 0.74. Although the CZK/DEM exchange rate estimation seems to approximate this effect for DOLS, it is generally insignificant according to the techniques applied. Based on our estimates, we can nevertheless conclude that returns on foreign currency significantly affect the decisions of domestic agents in choosing between domestic- and foreign-currency-denominated deposits for store-of-value purposes. The higher significance of the CZK/USD exchange rate probably results from the higher volatility of this rate, which has made domestic agents more aware of the opportunity cost of holding domestic currency.

From the perspective of capital mobility or (more precisely, in our case) of portfolio investment abroad, there is generally no support for returns on foreign assets having any effects on foreign currency deposits in the Czech Republic. This inference may result from some capital movement constraint at the beginning of our sample and/or lower incentives from domestic residents to invest abroad caused by a lack of information concerning the international market and only slow adoption of the technology necessary for international investment.<sup>23</sup>

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<sup>22</sup> We are assuming, of course, that agents mostly use bond issues to raise the necessary funds and not credit lines that would exactly match the funds needed for a particular purchase.

<sup>23</sup> Nevertheless, we see this approach as a rather indirect method of estimating the demand for foreign assets. Precise inspection of such an effect should provide the estimation of equation (4) in the portfolio model.

Finally, we also include some additional ratchet variables to inspect various potential aspects of currency substitution. First, we employ the maximum level of the  $fd/dd$  ratio in the history of the estimated sample to inspect the possible dollarisation of the Czech economy. Nevertheless, this variable is significant only in reaction to the ARDL estimation, resulting in overall insignificance. Moreover, we again incorporate the historical peak values of the CZK/USD exchange rate to examine the possible presence of an extensive part of its elasticity, as in the second stage model estimation in part 4.2. Again this variable possesses no support from the estimation techniques applied. In the last step, we include historical peak values of inflation to inspect the effect of the creditworthiness of the Czech currency relative to foreign currency. Again, we find no backing for such an effect on the  $fd/dd$  ratio.

#### 4.4 Empirical Analysis of Currency Substitution in the Czech Republic from the Perspective of Demand for Foreign Assets

This part is dedicated to examination of portfolio capital movement and its determinants. In this respect we follow the expression of equation (4) in the portfolio model presented above. We approximate domestic demand for foreign bonds using cumulative gross outflow of portfolio investment. Again, instead of using the pure cumulative value of domestic portfolio investment abroad, we model its ratio to deposits in the domestic currency, as in part 3.3.

We estimate equation (4) after approximating the explanatory variables suggested by the theory, using factual variables similar to those in the two previous cases. We also apply various cointegration techniques to an equation in log-linear form as described by equation (7):

$$pi/dd = \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 rx^{usd} + \beta_7 rx^{dem} + \xi \quad (7)$$

where  $pi/dd$  is the ratio of cumulative domestic portfolio investment abroad to deposits in the domestic currency and, once again,  $cpi$  is the consumer price index, measuring domestic price level development;  $ae$  is domestic absorption (GDP-NX),

measuring the amount of transactions in the Czech economy;  $lr$  is the lending interest rate, representing domestic interest rates on alternative assets;  $e$  is the nominal CZK/USD and CZK/DEM exchange rate, respectively; and  $rx^{usd}$  and  $rx^{dem}$  are the respective returns on foreign assets denominated in USD and DEM in terms of the domestic currency.

Parsimonious versions of the estimation results involving the application of several cointegration techniques are presented in Table 5 below:

**Table 5**

**Estimates of Equation (7) Using Various Techniques  
(Parsimonious Versions)**

Variable	Estimation Methods				General Significance
	JOH(1)	ARDL	DOLS	ADL	
<b>pi/dd</b>	-----	0.40 (0.12)***	-----	0.40 (0.12)***	0.40 (0.12)***
<b>cpi</b>	0	0	2.36 (0.77)***	0	2.36 (0.77)
<b>ae</b>	0	0	0	0	0
<b>lr</b>	-0.28 (0.04)***	-0.27 (0.03)***	-0.41 (0.06)***	-0.27 (0.03)***	-0.28 (0.04)***
<b>e_usd</b>	-1.17 (0.70)*	-0.90 (0.53)*	-2.35 (1.26)*	-0.90 (0.33)*	-1.04 (0.61)*
<b>e_dem</b>	0	0	0	0	0
<b>rx_usd(-1)</b>	1.14 (0.38)***	1.21 (0.34)***	-----	1.20 (0.26)***	1.20 (0.34)***
<b>rx_dem</b>	0.71 (0.30)***	0.78 (0.27)***	0.77 (0.28)***	0.78 (0.17)***	0.78 (0.28)***
<b>constant</b>	Unrestricted	0	0	0	0

\*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% probability levels respectively. The last column of the table indicates the overall significance of the particular variable and the median of its estimated coefficients. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) only the  $fd/dd$  variable is assumed to be endogenous.

We can conclude from the results in Table 5 that the  $pi/dd$  ratio shows only mild persistence at about 40% in the Czech Republic, despite being highly significant. As the overall results of the coefficients on  $cpi$  and  $ae$  show that both the real value of foreign assets holdings and the alternative use of such funds for transaction purposes are no longer of general significance in determination of portfolio

investment abroad. Such a conclusion may reflect the possibly lower liquidity of such assets stemming from exchange rate risks and transaction costs. So we may suspect that once Czech residents invest their funds in foreign assets for store-of-value purposes, such funds are no longer used for prospective direct extension of medium-of-exchange stock. However, the return on foreign assets has somewhat lower effect on portfolio decision-making process in this case than the return on domestic assets. The generally high significance of the negative coefficient on the  $lr$  variable, which has its median at -0.28, well illustrates this finding.

Moreover, we can infer that there is significant influence of the return on foreign deposits held in the domestic banking system on holdings of foreign assets, which would offer domestic agents higher liquidity and lower risks, assuming they are better informed about the domestic macroeconomic situation. However, this effect does not yet reach the common level of significance (i.e. the 5% level). Finally, the significance of the returns on foreign assets is what we are most interested in regarding the inspection of capital mobility. According to the estimation techniques applied, the approximations of the returns on both USD- and DEM-denominated assets are highly significant. The effect of the return on USD-denominated assets seems to have its peak at around one lag and that of DEM-denominated assets at around the current value. In the Czech Republic's case, domestic agents perceive investment abroad as one possible alternative of wealth allocation, and we suppose it is a growing component in their portfolios.

## **4.5 Summary of the Results and their Implications**

We can conclude from our analysis that both currency substitution (i.e. substitution of deposits in the domestic currency by deposits in foreign currency) and the capital mobility effects (i.e. altering of deposits in the domestic banking system by holding foreign assets) are elements of Czech agents' behaviour concerning wealth allocation. To summarise, the results acquired by sequential estimation of the portfolio model presented in part 4, we present the likely form of equations (1), (2) and (4) for the Czech Republic. These representative equations are based on the

general significance of the estimates of the particular coefficients. The medians of these estimates were continuously reviewed in the last columns of the tables on the estimation of each equation:

$$m_{cz} = 1.77cpi + 1.91ae - 0.022lr - 0.61e^{usd} - 0.19e_{t-1}^{usd} - 0.90e_{t-1}^{dem} \quad (8)$$

$$fd / dd = 1.08cpi + 0.04lr + 0.74e^{usd} \quad (9)$$

$$pi / dd = 1.20rx_{t-1}^{usd} + 0.78rx^{dem} - 0.28lr - 1.04e^{usd} \quad (10)$$

When we consider the existence of currency substitution in the broad sense relating to the Czech Republic, we have to take into account several implications suggested by theory and/or experience from other transitional countries.

It is widely believed that allowing a foreign currency to coexist with the domestic one provides an opportunity for greater domestic intermediation, promotes financial sophistication by increasing the number of available assets, and increases credibility by raising the cost of poor monetary discipline. Moreover, the rapid development of foreign-currency denominated operations in the domestic banking system affects the stability of monetary aggregates, the dynamics of exchange rates and the government's revenues from seigniorage. Specifically, the higher the money demand elasticity of substitution between moneys, the larger is the shift from foreign to domestic currency as a result of a fall in expected relative inflation and, thus, the greater is the fall in the nominal exchange rate. Currency substitution also reduces monetary independence, which may then endanger the ability of central bankers to implement stabilisation programmes.

In other words, monetary and fiscal policies, the choice of exchange rate regime and interventions in foreign exchange markets are often undertaken in economies that experience "unofficial" or "*de facto*" dollarisation, i.e. where individuals and firms choose to use a foreign currency as a substitute for some of the monetary services of the domestic currency. Feige, Faulent, Šonje and Šošić (2000) suggest that under such circumstances the effective money supply may be much larger than the domestic money supply and may be subject to endogenous behavioural responses reflecting currency substitution on the part of the public. Similarly, the greater the extent and variability of dollarisation, the weaker is the central bank's knowledge of

and control over the effective money supply. Such scenarios are, however, of lesser importance in the case of the Czech Republic. On the other hand, unofficial dollarisation will tend to dampen government efforts to employ inflationary finance to impose implicit taxes on domestic monetary assets. And again somewhat similarly, growing unofficial dollarisation reduces the ability of the monetary authority to earn seigniorage from its own currency issue. Unofficial dollarisation also reflects citizens' perceptions of the stability of the domestic monetary regime, the credibility of monetary policies and the perceived stability of the domestic banking system. Nevertheless, this suggestion or assumption is related rather to currency substitution, which is according to our comments relatively weak or ineffective in the Czech Republic's case.





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## 5 Conclusion

In this paper we have discussed the possible presence of currency substitution and its resulting potential implications in transitional countries. After introducing various definitions of currency substitution found in the literature on this phenomenon, we have discussed the difference between the terms “currency substitution” and “dollarisation,” defining the former as a process of substitution in the economy which is symmetric and reversible, and the latter as an asymmetric reaction to changeable determinants of the substitution process in the use of foreign currency. Furthermore, we have distinguished between currency substitutability and substitution, with study of the former exploring its potential effect on domestic and foreign variables (of main interest to economists and policy makers) and analysis of the latter exploring the dimension of and potential for displacement of one currency with another currency.

In the next part we have analysed the performance of currency substitution in small open transition economies, stating the initial conditions and the process of transformation as similar for the countries considered. The first decade of the transformation process has been associated with simultaneous periods of internal and external liberalisation and alignment with developed countries. We have concluded that the launch of reforms was coupled with greater economic uncertainty, resulting in high and volatile exchange rates and inflation, large budget and current

account deficits and inducing the use of foreign money for monetary purposes. In this context we have proposed several explanations concerning the factors determining currency substitution in the Czech Republic's case. These are associated with a relative lack of restrictions on capital flow, early adoption of necessary financial techniques and a sharp increase in openness. Moreover, we have discussed perspectives of substituting and substituted currencies in the global and local context. We propose four reasons for currency substitution: macroeconomic instability, the existence of a large illegal or underground economy, the former occurrence of financial crisis, and a lack of higher-denomination bank notes issued by the central bank. We have shown that the Czech koruna is not only a substituted currency, but has also for several years been the substituting currency for some post-socialist countries. A set of arguments for (and against) unilateral and bilateral euroisation has also been included here.

The last part has been dedicated to an empirical analysis of the currency substitution phenomenon in the case of the Czech Republic during the period 1994–2001. We have based our analysis on a multi-perspective portfolio approach. However, we have first modified, or rather reduced, the system, excluding the equation describing the demand for domestic bonds or alternative assets since the capital market is somewhat underdeveloped or, in the case of bonds, generally inaccessible in the Czech Republic. We have thus been left with three equations to describe the demand for domestic and foreign currency and for foreign assets. In this respect we have modelled the demand for domestic currency in circulation plus deposits denominated in domestic currency; the ratio of deposits denominated in foreign currency in the domestic banking system to deposits denominated in the domestic currency; and the ratio of domestic portfolio investment abroad to domestic currency deposits. We have used a set of explanatory variables which approximate those suggested by theory, namely: the consumer price index, domestic absorption, the CZK/USD and CZK/DEM exchange rates, and the returns on U.S. and German Treasury Bills expressed in Czech currency. We have detected the presence of currency substitution in the domestic banking system and capital mobility. These findings should induce or affect further research related to the stability of monetary aggregates and demand for money, the revenues from seigniorage and the changing dynamics of exchange rates.

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# References

1. AARLE, VAN B. – BUDINA, N. (1995): Currency Substitution in Eastern Europe. *Tilburg University, Center for Economic Research, Discussion Paper Series No. 2*
2. ARLT, J. – GUBA, M. – RADKOVSKÝ, Š. – SOJKA, M. – STILLER, V. (2001): Vliv vybraných faktorů na vývoj poptávky po penězích v letech 1994-2000. ČNB, VP č. 34.
3. ARRAU, P. – DE GREGORIO, J. – REINHART, C. – WICKHAM, P. (1991): The Demand for Money in Developing Countries: Assessing the Role of Financial Innovation. *International Monetary Fund Working Paper, IMF Working Papers 91/45*, Washington, D.C.
4. BANA, I. M. – HANDA, J. (1990): Currency Substitution and Transaction Costs. *Empirical Economics*, vol. 15, No. 3, 1990.
5. BRANSON, W. H. – HENDERSON, D. W. (1985): The Specification and Influence of Assets Markets: in R. W. Jones and P. B. Kenen, eds. *Handbook of International Economics North-Holland*, Amsterdam, pp. 749-806.
6. BUFMAN, G. – LEIDERMAN, L. (1992): Simulating an Optimizing Model of Currency Substitution. *Revista de Analisis Economico*, vol. 7, No. 1, 1992.

7. CALVO, G. A. – VÉGH, C. A. (1992): A Model of Exchange Rate Determination Under Currency Substitution and Rational Expectations. *Journal of Political Economy*, vol. 85, No. 3, 1992.
8. CANZONERI, M. B. – DIBA, B. T. (1992): The Inflation Discipline of Currency Substitution. *European Economic Review*, vol. 36, No. 4, 1992.
9. DOYLE, B. M. (2000): „Here, Dollars, Dollars...” – Estimating Currency Demand and Worldwide Currency Substitution. *International Finance Discussion Papers No. 657, Board of Governors of the Federal Reserve System*.
10. FEIGE, E. L. – FAULEND, M. – ŠONJE, V. – ŠOŠIĆ, V. (2000): Currency Substitution, Unofficial Dollarization and Estimates of Foreign Currency Held Abroad: The Case of Croatia: in Blejer M. and Skreb M., eds. *Financial Vulnerability and the Exchange Rate Regime, MIT Press*.
11. GIOVANNINI, A. – TURTELBOOM, B. (1992): Currency Substitution. *National Bureau of Economic Research Working Paper Series*, No. 4232, Cambridge 1992.
12. HANOUSEK, J. – KUBIN, J. – TŮMA, Z. (1995): Poptávka po penězích a ražebné v období transformace. *Finance a úvěr*, č. 7, 1995.
13. HANOUSEK, J. – TŮMA, Z. (1995): Poptávka po penězích v české ekonomice. *Finance a úvěr* č. 5, 1995.
14. JOHANSEN, S. – JUSELIOUS, K. (1990): Maximum Likelihood Estimation and Inference on Cointegration - With Applications to Demand for Money. *Oxford Bulletin of Economics and Statistics*, vol. 52(2), pp. 169-210.
15. KLACEK, J. – ŠMÍDKOVÁ, K. (1995): The Demand-for-Money Function: the Case of the Czech Economy. *ČNB VP* č. 41 *Praha*.
16. KOMÁREK, L. (2001): Další pohled na mikroekonomickou dimenzi měnového kurzu. Zatím nepublikováno, 2001.
17. MADHAVI, M. – KAZEMI, H. B. (1996): Indeterminacy and Volatility of Exchange Rate under Imperfect Currency Substitution. *Economic Inquiry*, vol. 1, 1996.
18. MCKINNON, R. I. (1985): Two Concepts of International Currency Substitution. In.: *The Economics of the Caribbean Basin*, (eds.) Connolly, M.D. and J. McDermott, pp. 101-113.
19. MCNELIS, P. D. – ASILIS, C. (1992): A Dynamic Simulation Analysis of Currency Substitution in an Optimizing Framework with Transaction Costs. *Revista de Analisis Economico*, vol. 7, No. 1, 1992.

20. MELECKÝ, M. (2001): Stabilita dlouhodobé poptávky po široce definovaných penězích v otevřené ekonomice: případ ČR 1994-2000. *ČNB VP, mimeo*.
21. MISHKIN, F. S. (2001): Financial Policy and the Prevention of Financial Crises in Emerging Market Countries. *NBER Working Paper Series No. 8087*.
22. MONGARDINI, J. – MUELLER, J. (1999): Ratchet Effects in Currency Substitution: An Application to the Kyrgyz Republic. *IMF Working Paper, Wp/99/102*.
23. MULLIGAN, C. B. – SALA-I-MARTIN, X. X. (1996): Adoption of Financial Technologies: Implications for Money Demand and Monetary Policy. *NBER Working Paper Series No. 5504*
24. PESARAN, M. H. – SHIN, Y. – SMITH, R. J. (1996): Testing for the Existence of a Long-Run Relationship. *DAE Working Paper No. 9622, University of Cambridge*.
25. ROGERS, J. H. (1990): Foreign Inflation Transmission under Flexible Exchange Rates and Currency Substitution. *Journal of Money, Credit and Banking*, vol. 22, No. 2, 1992.
26. ROJAS-SUAREZ, L. (1992): The Currency Substitution and Inflation in Peru. *Revista de Analisis Economico*, vol. 7, No.1, 1992.
27. ROUBINI, N.-GRILLI, V. (1995). *Liquidity Models in Open Economies: Theory and Empirical Evidence*. NBER Working Paper Series No. 5313.
28. SAHAY, R. – VÉGH, C. A. (1995): Dollarization in Transition Economies: Evidence and Policy Implications. *International Monetary Fund Working Paper, 103/95/96, Washington, D.C.*
29. SARAJEVS, V. (2000): Econometric Analysis of Currency Substitution: A Case of Latvia. *Bank of Finland Discussion Papers, Institute for Economies in Transition, No. 4, 2000*.
30. SOMMER, M. (1997): Vazba mezi peněžní zásobou, agregátní nabídkou a nominálním domácím produktem ČR v letech 1992-1996. *Bankovníctví* č. 16, 1997.
31. STOCK, J. H. – WATSON, M. W. (1993). A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems. *Econometrica* 61, pp. 1035-1056.
32. STURZENEGGER, F. (1992): Currency Substitution and the Regressivity of Inflationary taxation. *Revista de Analisis Economico*, vol. 7, No. 1, 1992.

33. STURZENEGGER, F. (1997): Understanding the Welfare Implications of Currency Substitution. *Journal of Economic Dynamic and Control*, vol. 21, No. 2-3, 1997.
34. THOMAS, L. R. (1985): Portfolio Theory and Currency Substitution. *Journal of Money, Credit and Banking*, vol. 17, No. 3, 1985.
35. URIBE, M. (1997): Hysteresis in a Simple Model of Currency Substitution. *Journal of Monetary Economics*, vol. 40, No. 1, 1997.

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# Appendix





Table 1A

## Unit Root Tests of Time Series Applied

Variable	Unit Root Tests		Likely Degree of Integration
	ADF	PP	
<b>m_cz</b>	3.07 (c,t,3)	2.67 (c,t) !!	Rather I(2)
<b>d(m_cz)</b>	1.98 (c,3)	2.18 (c)	
<b>d2(m_cz)</b>	2.56 (2)**	5.45 ***	
<b>fd/dd</b>	1.22 (c,2)	1.96 (c,t) !	I(1)
<b>d(fd/dd)</b>	4.41 (c,t,4)***	3.84 ***	
<b>pi/dd</b>	1.39 (c,t,1)	1.24 (c,t) !	I(1)
<b>d(pi/dd)</b>	3.81 (c,1)***	4.31 ***	
<b>cpi</b>	1.71 (c,3)	2.34 (c) !	I(1) or I(2)
<b>d(cpi)</b>	3.07 (c,t,2)	4.07 (c,t)**	
<b>d2(cpi)</b>	3.27 (4)***	9.7 *** !	
<b>ae</b>	3.53 (c,t,3)*	4.63 (c,t) ***	I(0) or I(1)
<b>d(ae)</b>	3.62 (c,4)**	10.60 ***	
<b>lr</b>	2.40 (c,t,3)	1.39 (c,t) !!	I(1) or I(2)
<b>d(lr)</b>	1.55 (c,2)	3.19 (c)**	
<b>d2(lr)</b>	5.89 (1)***	7.48 *** !	
<b>czk/usd</b>	3.34 (c,t,1)*	2.69 (c,t) !	I(1)
<b>d(czk/usd)</b>	3.63 (c,1)**	3.69 ***	
<b>czk/dem</b>	3.74 (c,1)***	2.56 (c) !	I(0) or I(1)
<b>d(czk/dem)</b>	3.59 (3)***	3.53 ***	
<b>rx_usd</b>	4.02 (c,t,3)**	2.71 (c)* !	I(0) or I(1)
<b>d(rx_usd)</b>	3.07 (3)***	2.49 **	
<b>rx_dem</b>	2.79 (c,4)*	1.88 (c) !!	Rather I(1)
<b>d(rx_dem)</b>	4.99 (c,t,4)***	2.68 ***	

\*, \*\* and \*\*\* indicate rejection of the null hypothesis of unit root existence. Numbers in brackets indicate the number of lags included in the ADF test and letters c and t indicate that constant and trend are involved in the particular test.