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Currency Substitution in a Transitional Economy with an Application to the Czech Republic

ABSTRACT: Currency substitution appears to be an important issue affecting the design of monetary policy, especially in transition economies. This article strives to analyze the particular relevance of the currency substitution phenomenon in the Czech Republic. We initially discuss the role of currency substitution in small open economies in transition with some illustrations relating to the Czech Republic. We distinguish and analyze a locally and globally substituting currency from substituted ones and discuss the consequences of euroization. Further, we estimate a modified Branson and Henderson portfolio model for the Czech Republic. This provides a multiperspective approach to currency substitution in the broad sense. We attempt to improve the robustness of our estimations by applying several cointegration techniques, namely, the Johansen procedure, ARDL, DOLS, and ADL. Finally, we discuss the potential implications of currency and asset substitution according to our estimates for the Czech economy.

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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 literature brings little clarity. We discuss the idea of a locally (regionally) and globally substituting currency and a substituted currency (the currency being substituted). Furthermore, we deal with these issues by discussing transition phenomena of currency substitution, especially in the Czech Republic, and the problem of euroization—by unilateral or bilateral decision—which had become very topical by the end of 2001.

This article presents 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 of our multiperspective 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 for local Czech conditions and discuss the construction of the estimated equations, substituting for the variables suggested by theory 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.

Currency Substitution in Small Open Transition Economies

In most transition economies, the initial conditions and the process of transformation have been similar, that is, for more than ten years, there have been simultaneous periods of internal and external liberalization and a process of alignment with the more developed countries. Internal liberalization has been brought about by price liberalization in a higher inflation environment, restructuring of industries, adoption of new tax systems, and so forth. External liberalization has been caused by trade liberalization, and, in particular, by the external convertibility of national currencies and the liberalization of capital accounts. Generally, it may be concluded that the launch of the reform process was coupled with greater economic uncertainty,¹ and in some countries by political instability, and the absence of developed financial markets.

Macroeconomic Policy and Currency Substitution

The implications of currency substitution for macroeconomic policy differ between developed and developing countries, and, in two respects, in particular: first, the effects of currency substitution on the efficiency of stabilization programs, and second, the effects of currency substitution on the government revenues received from inflation.

One problem of transition countries is the credibility of their stabilization programs. The relevant question in this context is: Does dollarization, euroization, or other-ization help to stabilize 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 stabilization programs involved fixing nominal exchange rates or establishing crawling pegs. These arrangements ensured the progressive appreciation of real exchange rates. The other issue relating to stabilization programs is the choice 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 potential distribution effects on the economy. These findings lead to a preference for fixed exchange rates, or exchange rate regimes with narrower fluctuation bands, during a "stabilizing" 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 would seem 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, so that the demand for foreign currency may act as an inflationary tax. In the presence of currency substitution, the resulting revenue will be lower for each level of this tax.²

Currency substitution also has implications for the optimal rate of inflation. The transaction models of currency substitution imply that the marginal rate of transformation—represented by a relative price, that is, 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 that exists 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 minimize misrepresentation of the aforementioned relative prices.

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 are lacking not only for transition economies but also for industrial countries. Therefore, most studies generally calculate currency substitution either as (1) the ratio of foreign currency deposits to M2, broad domestic monetary aggregates, or as (2) the ratio of foreign currency deposits to broad monetary aggregates, including foreign currency. Below we 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: (1) The Czech Republic, with its lack of restrictions on capital flows, is a safe place for foreign exchange dealers from many countries. (2) 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. (3) 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 stabilization program and fall back on the use of the inflation tax.

Substituting and Substituted Currencies

In this section, we distinguish a locally/regionally and globally substituting currency from a substituted one, that is, the currency being substituted. The reason for our terminology is as follows. We think that a local and global dimension of currency substitution can generally be found. While the global currencies are definitely the U.S. 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 percent of USD was held outside the United States, although as much as 69 percent 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 1996.³

Of course, several other currencies might qualify to fill this role, most notably for historical reasons—the colonization period. There are at least two candidates: the British pound (GBP) and the French franc (FRF). The best candidate countries for “poundization” 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 “francization” are former French colonies in Africa, which used the Central African franc. This currency was pegged to the French franc for a long time. So, we see that worldwide currency substitution is not solely an American or German phenomenon.

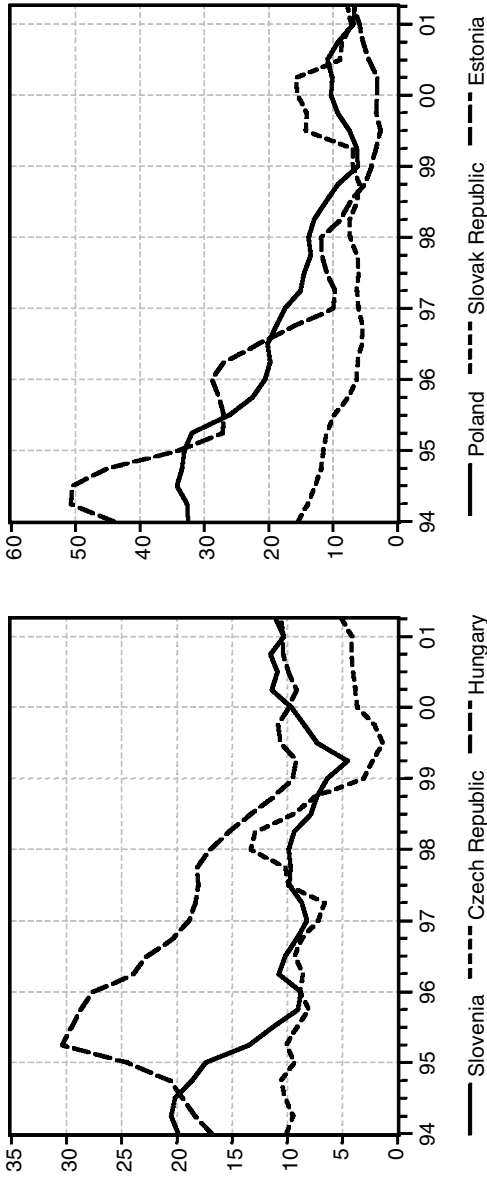
Generally, we can specify the reasons for currency substitution, that is, the reasons why a currency is being substituted: (1) Macroeconomic instability with a high rate of inflation, exchange rate instability, and volatility, and a less optimistic country rating. (2) The existence of a large illegal 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. (3) A history of financial crisis and risk-averse behavior by economic agents trying to eliminate this potential risk. (4) The lack of higher-denomination banknotes issued by the central bank.

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

The Czech Koruna—A Substituting Currency or Substituted Currency?

We see local substituting currencies as being those that are mostly used in a local environment within a specific economic region. It can be shown that the Czech koruna (CZK) 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: (1) Since its inception in 1993, the Czech koruna has remained very stable against the USD and DEM/EUR). (2) The Czech koruna has not had an inflation rate higher than other transition countries (Figure 1). (3) The Czech koruna has quite a good general reputation abroad. (4) The Czech koruna became externally convertible quite soon after 1993. (5) The Czech economy has workers for whom it is better to hold money in Czech korunas, rather than exchanging them for worldwide substituting currencies. (6) The Czech

Figure 1. Inflation Rates in Transition Economies, 1994–2001



Source: Author's calculations based on the Czech National Bank database, available at www.cnb.cz, and International Monetary Fund, *International Financial Statistics*.

National Bank issues banknotes with a relatively high nominal denomination of CZK 5,000. Conversion from the highest GBP, FRF, or USD⁴ denominations yields a smaller amount of money than reflected in our highest note.⁵ The new EUR notes will have two higher denominations compared to Czech notes: the EUR 200 and EUR 500 notes.

Currency Substitution, Euroization, and the Enlargement Process

The other relevant topic relating to the currency substitution issue, especially from the macroeconomic point of view, is the problem of euroization in non-eurozone countries, which is very topical in many transition countries since the end of 2001. Generally, we can distinguish the euroization process as being based on either a unilateral or a bilateral decision.

The former, unilateral, decision involves adoption of the euro without the official agreement and permission of the EU/European Monetary Union authorities before a candidate country officially joins the eurozone.

An accession country may generally see various advantages to adopting the euro, namely: (1) the stability of its exchange rate to the eurozone area is increased, which provides incentives for international investment; (2) the risk of speculative attacks on the domestic currency is virtually eliminated; (3) the general necessity of holding foreign reserves is lessened, thanks to lower exchange risk; (4) lower interest rates and lower inflation; (5) lower transaction costs, which are larger for small open economies; and (6) reestablishing the domestic currency and recreating an independent central bank remain theoretically possible, that is, only for unilateral euroization.

The general disadvantages, or risk and costs, might include: (1) the higher probability of runs on commercial banks in the absence of a "national" central bank acting as a lender of last resort and risk of boom-bust cycles, as interest rates become very low and the central bank loses this lender-of-last-resort function; (2) the actual or probable lack of foreign reserves; (3) the low official euroization of most first-wave accession countries; (4) as the independence of monetary and exchange rate policy is lost, these could overburden other policies, especially fiscal policy; plus there is the possibility of political feuding because monetary policy is much less independent of other countries; (5) noncompatibility of monetary policy instruments with the European Central Bank, although this is not problematic for those countries in the first wave of accession; (6) the record of dollarized economies has shown that dollarized nations had a lower rate of economic growth than others; and (7) loss of seignorage income. The European authorities have made clear that unilateral euroization is not a legally and economically sound option for accession countries on their way to the EU and the eurozone.

The latter, bilateral, decision represents the stage of integration into the eurozone after accession to the EU and after fulfillment of all necessary conditions. The candidate states: (1) will join the EU; (2) then they will participate in ERM2 (exchange rate mechanism) for at least two years; (3) have to fulfill the other four nominal convergence criteria, the Maastricht criteria; and (4) in a last step, they will introduce the euro as their national currency. This will include a nontrivial process of determination of the euro locking rates for the currencies of transition countries.

The main reason for adopting the euro as late as possible is that a modification of the structure of real appreciation accompanies the real convergence process. This process will be possible only through higher inflation and no longer through nominal and real appreciation of the exchange rate. This has important implications for macroeconomic policy in the accession, or catching-up, countries.

Empirical Analysis of Currency Substitution in the Czech Republic

Our analysis of currency substitution in the Czech Republic is based on a portfolio model developed by Branson and Henderson (1985), which we further modify to correspond to the conditions in the Czech economy. This portfolio approach enables us to focus on the phenomenon of currency substitution from several perspectives. It incorporates money demand for both domestic and foreign currencies, and capital mobility, that is, demand for both domestic and foreign bonds. We consider this approach very useful because it comprises several independent views on currency substitution analysis, examining the robustness of estimates not only from the perspective of the applied estimation techniques but also from that of different market relationships.

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

$$M = M(i, (i^* + e^{ex}), e^{ex}, PY, P^c, W) \tag{1}$$

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

$$B = B(i, (i^* + e^{ex}), e^{ex}, PY, P^c, W) \tag{3}$$

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

The first argument in equations (1) to (4), i , is the return on holding bonds denominated in domestic currency relative to the return on domestic money, that is, minus the rate of domestic inflation. It is assumed that all four assets are substitutes in the portfolio. Hence, an increase in 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 i^* . Expressed in domestic currency, this return becomes $i^* + e^{ex}$, 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.⁶ Similarly, the third argument, e^{ex} , is the return on foreign money, converted into the domestic currency.⁷

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."

We modify this portfolio approach to the local conditions of the Czech Republic. Specifically, we take account of the institutional features of the Czech economy, which arise from both historical and 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 analyzed by several authors with respect to the Czech economy (most recently, e.g., Melecký 2001 and Arlt, Guba, Radkovský, 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, that is, foreign currency in circulation and foreign deposits in the Czech economy. However, monitoring foreign currency in circulation is very difficult and is left for future research. 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 dollarized or D-markized, and, therefore, foreign currency is not commonly used as a medium of exchange or unit of account.

The first problem arises when we look at residents' demand for domestic

bonds. In the Czech Republic, as a consequence of historical developments, 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.⁸ 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 at least half of our sample period. The above considerations lead us to 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 sample may influence the results, in the sense of increasing the importance of all foreign variables in determining portfolio investment abroad in our case. We take into account this aspect in estimating the demand for foreign assets.

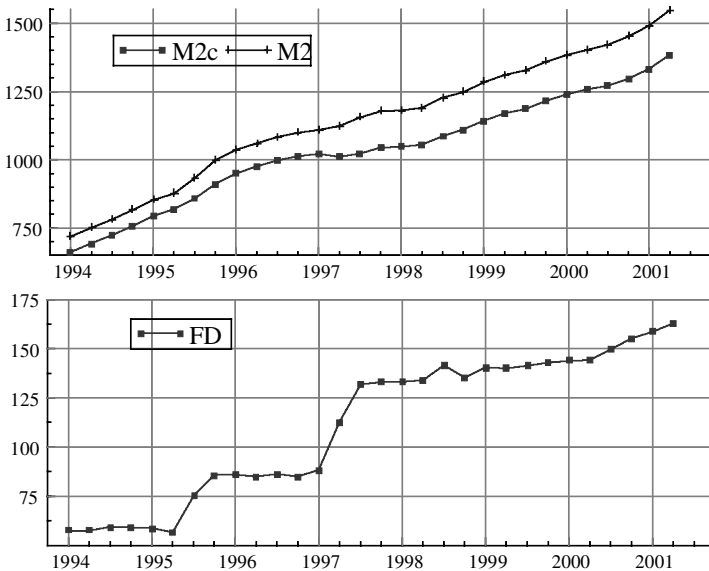
Description of the Data Series Used

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 scale variable, which is the only one showing a marked seasonal pattern.⁹

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 banking system denominated in foreign currencies. We further subtract Czech currency in circulation insofar as we cannot include foreign currencies in circulation in our analysis owing to a lack of data series. Figure 2 depicts the development of the M2 and M2cz series, as well as of FD, foreign currency deposits.

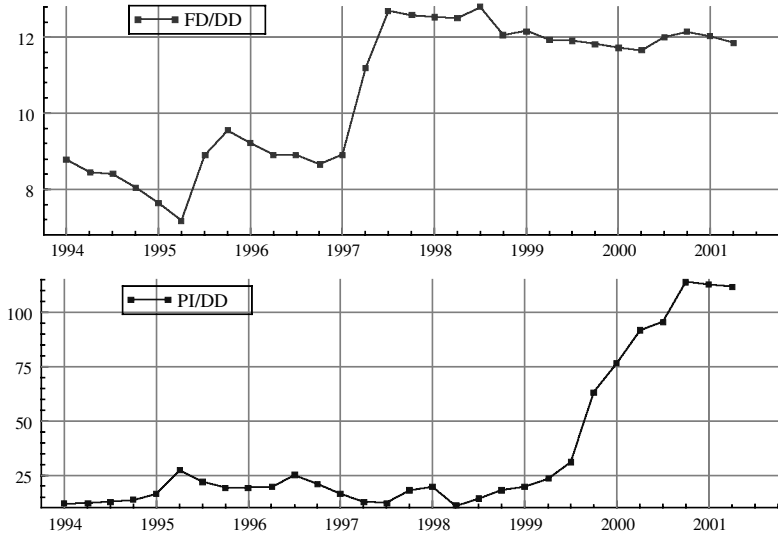
Figure 2. M2cz and M2 Series



Source: Author's calculations based on the Czech National Bank database, available at www.cnb.cz.

The next modeled variable is the ratio of foreign to domestic currency deposits (FD/Mcz); we name this variable the FD/DD ratio. The modeled variable is similar to those proposed by Feige, Faulend, Šonje, and Šošić (2000) in the case of Croatia; and by Mongardini and Mueller (1999) in the case of the Kyrgyz Republic for analogous purposes. We use this ratio to precisely pursue the effect of changing relative prices of assets under consideration on domestic residents' behavior. We thus differentiate between increases in foreign deposits resulting from an overall increase in wealth and the move from domestic deposits to foreign deposits induced by changes in relative returns. Figure 3 shows a rapid increase in the FD/DD ratio during the period of currency crisis that seems to be persistent. This may point to dollarization of the Czech economy from the store of value perspective.

The last dependent variable that we attempt to explain is the ratio of cumulative portfolio investment abroad (PI) to domestic deposits. We use this variable to 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

Figure 3. **FD to DD Ratio (percent) and Cumulative PI to DD Ratio (percent)**

Source: Author's calculations based on the Czech National Bank database, available at www.cnb.cz.

can see in Figure 3 that domestic agents have only recently begun to use foreign assets for wealth allocation purposes. However, this utilization now appears to be highly significant.

Explanatory Variables

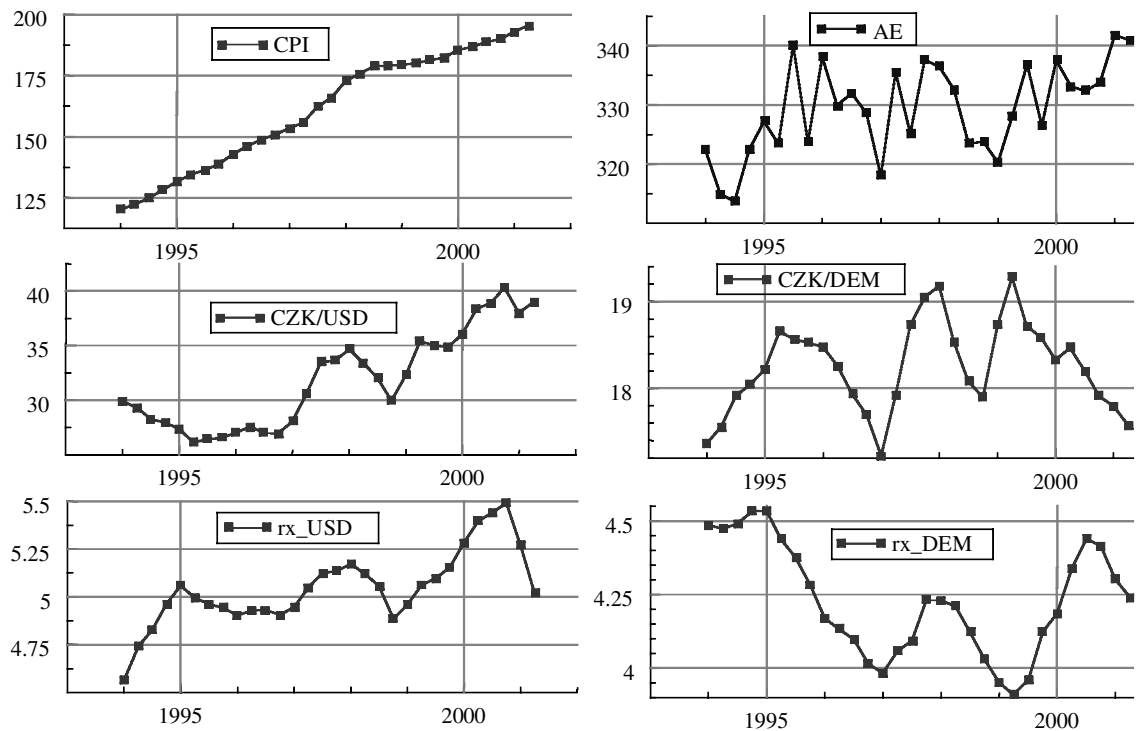
We use the consumer price index (CPI) as an approximation of the variable P^c in equations (1) to (4). This index should describe consumption basket price development in the Czech Republic and thus correctly deflate nominal variables from the perspective of the domestic agent. Furthermore, we approximate the variable PY in equations (1) to (4) using domestic absorption (AE), 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 measure of the opportunity cost of holding money and represents an alternative vehicle for wealth creation. For the purpose of measuring return on foreign money, we employ two bilateral exchange rates—CZK/USD and CZK/DEM—because they have experienced

a somewhat different historical development.¹⁰ 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 because we assume that most agents form their expectations adaptively and the rest base their forecast on the random walk process. This approach is, in our opinion, reasonable because the structure of the economy changed considerably during transition. Thus, we do not use purchasing power parity or uncovered interest rate parity to approximate “rational” expectations of changes in the exchange rate. Finally, we consider 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 log of the particular exchange rate, that is, $I + e$ (see also Giovannini and Turtelboom 1992). Figure 4 describes the development of our core explanatory variables.

Some readers may notice a certain inconsistency between the model introduced and the explanatory variables used. Specifically, although the model implies a use of first differences of nominal exchange rates, we use levels of that variable for three particular reasons. First, cointegration techniques comprise or deal with those first differences either implicitly, as in the case of the Johansen procedure, or explicitly, as in the case of DOLS. Second, given the I(1) order of integration of nominal exchange rates (see Table 1 on p. 88), we would have to find two cointegration vectors when including the change in the exchange rate instead of its levels, as we do. In another words, because the first difference of nominal exchange rate is stationary itself, we have to find two cointegration vectors to be able to justify the existence of stationary linear combination of the remaining I(1) variables.

Third, except for these rather technical reasons, there is another one related to the institutional features and historical development of the Czech Republic’s external conditions. Given the identity that expresses the expected change in exchange rate as a result of interaction of capital flows and trade balance (see, e.g., Goldberg 2000), we can accept the following assumption in the Czech Republic’s case. Given the fact that we have interest rate differential that drives the capital portfolio flows already incorporated in the model, it remains to consider the effect of overvaluation of the real exchange rate. The factors responsible for the fluctuation in the real exchange rate differed between the first and second halves of our sample period. In the first half, the fluctuation and thus overvaluation of the real exchange rate was nearly exclusively determined by movements in the domestic price level, given the fixed exchange rate regime prevailing at that time. In the second half, these fluctuations were the result of both price level and nominal exchange rate movements. And concerning the

Figure 4. Explanatory Variables



Source: Author's calculations based on the Czech National Bank database, available at www.cnb.cz.

very end of our sample, the real exchange rate movement was driven mainly by the nominal exchange rate as the Czech Republic adopted the convergence criteria for EU accession and the subsequent adoption of the euro. Because we have the domestic price level already included in our model, inclusion of the nominal exchange rate would complete our set of explanatory variables, given our small sample of observations.

Conventionally, we first explore the stationary properties of the time series, as they are expected to be integrated of order I(1). Results of applied augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are summarized in Table 1.

Because the dependent variables are integrated of order I(1), as are most of the explanatory variables,¹¹ we need to use cointegration analysis to prevent spurious regression phenomena. 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).

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

We analyze 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 denominated in Czech korunas. If currency substitution is one of the important techniques of portfolio allocation, then the opportunity costs of holding Czech deposits with respect to deposits in foreign currency or foreign assets are to be significant determinants of the demand for Czech deposits.

The procedure for the empirical analysis of currency substitution in the Czech Republic is divided into three stages.¹² First, we explore the existence of currency substitution concerning the effect of exchange rates. In this stage, the particular currencies are assumed to compete as a store of value in the domestic banking system. Second, we examine the potential existence of the extensive part of nominal exchange rate elasticity insofar as the first case considers only the intensive part (see below). Finally, we extend this analysis to include the determinants relating to capital mobility.

Analyzing the demand for deposits denominated in Czech korunas we estimate equation (5) of the following form:

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

Table 1

Unit Root Tests of Time Series Applied

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

Notes: *, **, 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. ! indicates violation of the assumption of no serial correlation of residuals.

where m_{cz} is the M2 monetary aggregate adjusted for deposits in foreign currencies (DFC), that is, (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, that is, the opportunity cost of holding Czech currency.

In the second stage, we consider the possible extensive part of the exchange rate's elasticity, including in the estimated equation two so-called ratchet variables that consist of 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 analyzed period, additional agents always decide to adopt financial technology to help them convert the domestic currency into foreign currency. They do so because they are facing the very level of opportunity costs that they consider too high to accept, given current wealth allocation, and that makes them react in this respect (see also Feige, Faulend, onje, and ošić 2000; Mongardini and Mueller 1999).

We proceed to the third stage by adding variables that should represent the impact of capital mobility, that is, 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. The final estimation results using the Johansen procedure are as follows:¹³

$$m_{cz} = 1.08cpi + 2.52ae \uparrow 0.012lr \uparrow 0.34e_{t\uparrow 1}^{usd} \uparrow 0.62e_{t\uparrow 1}^{dem} \quad (6)$$

(0.06)*** (0.24)*** (0.002)*** (0.07)*** (0.19)**

Summarizing our three-stage estimation, we can conclude that the estimation methods applied indicate the presence of currency substitution in the Czech Republic. The important variables accounting for this phenomenon are the 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 CZK/DEM evolve in opposite directions, making the nominal effective exchange rate (NEER) less significant. The CZK/USD and CZK/DEM are the main components of the NEER.

We find no support for the existence of an extensive part of exchange rate elasticity when using either the Johansen or the other estimation techniques. We can thus conclude that currency substitution performs only through the "intensive" part of exchange rate elasticity.

An inspection of the estimation results gives no support for the existence of significant effect of returns on foreign assets, that is, capital mobility, on the demand for Czech korunas from the perspective of domestic residents.

We can thus conclude that substitution of currency within the domestic banking system—its intensive part—is the only relevant pattern for Czech resident behavior. Furthermore, in this respect, money holdings in Czech currency were substituted by holdings denominated in both deutschemarks and U.S. dollars.

Finally, all the domestic determinants are highly significant. The coefficient on the *cpi* variable supports linear homogeneity of deposits in Czech currency with respect to the price level. The high coefficient on the *ae* variable then points to the wealth accumulation effect. In other words, deposits are perceived to be a luxury good, that is, as agents reach higher income levels they start to save by holding more of their funds as deposits. In terms of the poorest part of population, it implies that after attaining a certain level of income the impecunious agents not only consume but also start to save.

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

In this section, by estimating equation (2), we inspect the presence of currency substitution estimating 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 the previous case, we estimate equation (7) of the following form:

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

where *fd/dd* is the ratio of foreign currency to domestic currency deposit stocks and the explanatory variables are the same as for the money demand. The results of our estimates of equation (7) using the Johansen technique are as follows:

$$fd/dd = 1.03cpi + 0.04lr + 0.74e^{usd} \quad (8)$$

(0.19)*** (0.01)***(0.22)***

Given our results, we conclude that agents are concerned with the real value of the *fd/dd* ratio. Thus, we can justifiably 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 estimates of the *lr* effect on the *fd/dd* ratio seem to be robust and significant, although it has the opposite sign than was originally expected.¹⁴

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. The mechanism described here is relevant for Czech corporations, which made intensive use of international sources of financing between 1990 and 1997.

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. 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 be the result of some capital movement constraints at the beginning of our sample 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.¹⁵

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 dollarization of the Czech economy. This variable is significant only in the equation estimated by ARDL, leading us to conclude that it is generally not important. 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. Again, there is no support for this variable across the estimation techniques used. 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 support for such an effect on the fd/dd ratio.

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

This section is concerned with an examination of portfolio capital movement and its determinants. As a framework, we use 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.

We apply various cointegration techniques to equation (9) in log-linear form:

$$pi / dd = \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 rx^{usd} + \beta_7 rx^{dem} + \xi \quad (9)$$

where pi / dd is the ratio of cumulative domestic portfolio investment abroad to deposits in the domestic currency and the set of explanatory variables is defined similarly as in the two previous cases.

The estimation results using the Johansen technique are presented below:

$$pi / dd = 1.14 rx_t^{usd} + 0.71 rx_t^{dem} \uparrow 0.28 lr \uparrow 1.17 e^{usd} \quad (10)$$

(0.38)** (0.30)** (0.04)*** (0.70)*

The insignificance of coefficients on cpi and ae show that both the real value of foreign asset holdings and the alternative use of such funds for transaction purposes are unimportant in the determination of portfolio investment abroad. Such a conclusion may reflect the possible lower liquidity of such assets stemming from exchange rate risks and transaction cost. 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. We find a highly significant, negative coefficient on the lr variable entering the decision-making process related to the demand for foreign assets.

Moreover, we can infer that there is significant influence of the return on foreign deposits held in the domestic banking system on the 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 is not significant at the 5 percent level. Finally, the significance of the returns on foreign assets is what we are most interested in regarding the determination 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. We suppose that this pattern will promote itself even more in the near future.

Summary of the Results and Their Implications

We can conclude from our analysis that both currency substitution, that is, the substitution of deposits in the domestic currency by deposits in foreign currency, and capital mobility effects, that is, the altering of deposits in the domestic banking system by holding foreign assets, are elements of Czech

agents' behavior concerning wealth allocation. 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 by 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 is, the larger the shift from foreign to domestic currency as a result of a fall in expected relative inflation, and, thus, the greater the fall in the nominal exchange rate. Currency substitution also reduces monetary independence, which may then endanger the ability of central bankers to implement stabilization programs.

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" dollarization, that is, where individuals and firms choose to use a foreign currency as a substitute for some of the monetary services of the domestic currency. Feige, Faulend, 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 behavioral responses reflecting currency substitution on the part of the public. Similarly, the greater the extent and variability of dollarization are, the weaker the central bank's knowledge of and control over the effective money supply. Such scenarios are, however, of less importance in the case of the Czech Republic. On the other hand, unofficial dollarization will tend to dampen government efforts to employ inflationary finance to impose implicit taxes on domestic monetary assets. And again, somewhat similarly, growing unofficial dollarization reduces the ability of the monetary authority to earn seigniorage from its own currency issue. Unofficial dollarization 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.

Conclusion

We have discussed the possible presence of currency substitution and its resulting potential implications in a transitional country. First, we analyzed the perfor-

mance 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 liberalization and alignment with developed countries. We conclude that the launch of reforms was coupled with greater economic uncertainty, resulting in high and volatile exchange rates and inflation and large budget and current account deficits and inducing the use of foreign money for monetary purposes. In this context, we propose 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 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 banknotes issued by the central bank. We demonstrated that the Czech koruna is not only a substituted currency but also, for several years, has been the substituting currency for some post-socialist countries. We included a set of arguments for and against unilateral and bilateral euroization.

The final section was dedicated to an empirical analysis of the currency substitution phenomenon in the case of the Czech Republic during the period 1994–2001. We based our analysis on a multiperspective portfolio approach. However, we first modified, or rather reduced, the system, excluding the equation describing the demand for domestic bonds or alternative assets because the capital market is somewhat underdeveloped, or, in the case of bonds, generally inaccessible in the Czech Republic. We were thus left with three equations to describe the demand for domestic and foreign currency and for foreign assets. In this respect, we modeled 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 used a set of explanatory variables that 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 detected the presence of currency substitution in the domestic banking system and capital mobility. Exploring the full implication of these for the stability of monetary aggregates and demand for money, the revenues from seigniorage, and the changing dynamics of exchange rates is left for further research.

Notes

1. 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.

2. 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 East European economies has been estimated by Aarle and Budina (1995).

3. These estimations are adjusted for inflation.

4. Excluding the special issuance of notes between 1914 and 1923, when the FRB issued notes with nominal values of USD500, 1,000, 5,000 and 10,000.

5. See also the work presented by Feige, Faulend, Šonje, and Šošić (2000).

6. 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 minus the expected rate of change in 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.

7. 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.

8. A thorough discussion on financial intermediation in transition countries and various aspects of its development can be found in Mishkin (2001).

9. Data are from the Czech National Bank database, available at www.cnb.cz.

10. We also check for the significance of nominal effective exchange rate (NEER) to possibly reduce the number of explanatory variables (see below).

11. Although there are some indications that certain variables could have been integrated of order I(2), we do not consider this higher degree, because, in 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 problematic.

12. We chose this approach because 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.

13. See Table A1 in the Appendix for the final estimation results using ARDL, DOLS, and ADL.

14. See Table A2 in the Appendix.

15. Nevertheless, we may still see this approach as a rather indirect method of estimating the demand for foreign assets. More precise insights concerning the effectiveness of the demand for foreign assets would provide an estimation of equation (4) in the portfolio model.

References

- Aarle, Van B., and N. Budina. 1995. "Currency Substitution in Eastern Europe." Tilburg University, Center for Economic Research, Discussion Paper Series, no. 2.
- Arlt, J.; M. Guba; Š. Radkovský; M. Sojka; and V. Stiller. 2001. "Vliv vybraných faktorů na vývoj poptávky po penězích v letech 1994–2000" [Influence of Selected Factors on the Development of the Demand for Money in 1994–2000]. Czech National Bank, Working Paper, no. 34.
- Branson, W.H., and D.W. Henderson. 1985. "The Specification and Influence of Assets Markets." In *Handbook of International Economics*, ed. R.W. Jones and P.B. Kenen, 749–806. Amsterdam: North-Holland.
- Doyle, B.M. 2000. "Here, Dollars, Dollars . . . Estimating Currency Demand and Worldwide Currency Substitution." Board of Governors of the Federal Reserve System, International Finance Discussion Papers, no. 657.
- Feige, E.L.; M. Faulend; V. Šonje; and V. Šošiae. 2000. "Currency Substitution, Unofficial Dollarization and Estimates of Foreign Currency Held Abroad: The Case of Croatia." Economics Working Paper Archive at Washington University in St. Louis, no. 0106001.
- Giovannini, A., and B. Turtelboom. 1992. "Currency Substitution." National Bureau of Economic Research Working Paper Series, no. 4232, Cambridge, MA.
- Goldberg, M. 2000. "On Empirical Exchange Rate Models: What Does a Rejection of the Asymmetry Restriction on Short-Run Interest Rates Mean?" *Journal of International Money and Finance* 19: 673–88.
- Hanousek, J., and Z. Tůma. 1995. "Poptávka po penězích v české ekonomice" [Demand for Money in the Czech Economy] *Finance a úvěr*, no. 5: 249–68.
- Hanousek, J.; J. Kubin; and Z. Tůma. 1995. "Poptávka po penězích a ražebné v období transformace" [Demand for Money and Substitutes in the Period of Transformation]. *Finance a úvěr*, no. 7: 352–68.
- Johansen, S., and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration—with Applications to Demand for Money." *Oxford Bulletin of Economics and Statistics* 52, no. 2: 169–210.
- Melecký, M. 2001. "Stabilita dlouhodobé poptávky po široce definovaných penězích v otevřené ekonomice: případ ČR 1994–2000" [Stability of Long-Run Demand for Broadly Defined Money in an Open Economy: The Case of the Czech Republic 1994–2000]. Czech National Bank, Working Paper, no. 38.
- Mishkin, F.S. 2001. "Financial Policy and the Prevention of Financial Crises in Emerging Market Countries." National Bureau of Economic Research Working Paper Series, no. 8087.
- Mongardini, J., and J. Mueller. 1999. "Ratchet Effects in Currency Substitution: An Application to the Kyrgyz Republic." International Monetary Fund Working Paper, no. Wp/99/102.
- Mulligan, C.B., and X.X. Sala-i-Martin. 1996. "Adoption of Financial Technologies: Implications for Money Demand and Monetary Policy." National Bureau of Economic Research Working Paper Series, no. 5504.
- Pesaran, M.H.; Y. Shin; and R.J. Smith. 1996. "Testing for the Existence of a Long-Run Relationship." University of Cambridge, DAE Working Paper, no. 9622.
- Sarajevs, V. 2000. "Econometric Analysis of Currency Substitution: A Case of

- Latvia.” Bank of Finland Discussion Papers, no. 4, Institute for Economies in Transition.
- Sommer, M. 1997. “Vazba mezi peněžní zásobou, agregátní nabídkou a nominálním domácím produktem ČR v letech 1992–1996” [Connection Between Money Supply, Aggregate Demand, and Nominal Domestic Product of the Czech Republic 1992–1996]. *Bankovníctví* 16: 12–13.
- Stock, J.H., and M.W. Watson. 1993. “A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems.” *Econometrica* 61: 1035–56.

Appendix

The only dissimilarities compared to the Johansen estimates reported in the main text are the significance of nominal effective exchange rate in the ARDL estimates and the significance of CZK/DEM exchange rate and return on German assets in the DOLS estimates. Nevertheless, the results presented in the main text are consistent with the results of the other estimation methods.

We can account for the significant negative coefficient on the *ae* variable in the DOLS estimated equation with following explanation. The increase in transaction amounts in the domestic economy is 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.

Although the CZK/DEM exchange rate estimation seems to approximate the own rate of return on FD in the case of the DOLS estimation, this variable is not significant when the other estimation methods are used. We can, however, conclude that returns on foreign currency significantly affect the demand of domestic agents for foreign-currency-denominated deposits.

The results in Table A3 support findings presented in the main text. The only additional finding is the significant positive coefficient on the *ae* variable in the DOLS-estimated equation. As expected, this variable approximates the positive effect of increasing wealth on the demand for foreign assets.

Table A1

Final Estimates of the Demand for Deposits Denominated in Czech

Variable	Estimation Methods			
	JOH(1)	ARDL(1,0,1,0)	DOLS	ADL
$m_{cz}(-1)$	----	----	----	0.80 (0.05)***
cpi	1.08 (0.058)***	2.19 (0.56)***	2.11 (0.11)***	1.30 (0.02)***
ae	2.52 (0.24)***	1.55 (0.60)***	0	0
$ae(-1)$	----	----	----	0.35 (0.03)***
lr	-0.012 (0.002)**	-0.034 (0.008)***	-0.023 (0.003)***	-0.02 (0.001)***
czk / usd	0	-0.80 (0.24)***	-0.44 (0.08)***	0
$czk / usd(-1)$	-0.34 (0.07)***	0	----	-0.40 (0.03)**
czk / dem	0	0	-0.71 (0.17)***	0
$czk / dem(-1)$	-0.62 (0.19)**	-1.10 (0.65)**	----	0
$neer$	0	-1.20 (0.56)**	0	0
rx_usd	0	0	0	0
$rx_usd(-1)$	0	0	----	0
Rx_dem	0	0	-0.15 (0.04)***	0
$rx_dem(-1)$	0	0	----	0
Constant	unrestricted	unrestricted	----	0

Notes: *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent probability levels, respectively; 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 A2

Estimates of Equation (7) Using Various Techniques

Variable	Estimation methods			
	JOH(1)	ARDL	DOLS	ADL
<i>fd / dd(-1)</i>	-----	0	-----	0.31 (0.15)**
<i>cpi</i>	1.03 (0.19)***	1.13 (0.14)***	1.48 (0.13)***	1.03 (0.19)***
<i>ae</i>	0	0	-2.05 (0.41)***	0
<i>lr</i>	0.04 (0.008)***	0.04 (0.006)***	0	0.04 (0.007)***
<i>E_usd</i>	0.74 (0.22)***	0.76 (0.14)***	0	0.74 (0.18)**
<i>E_dem</i>	0	0	2.24 (0.83)**	0
<i>rx_usd(-1)</i>	0	-0.18 (0.074)**	0	0
<i>rx_dem</i>	0	0	0	0
constant	unrestricted	-5.56 (0.52)***	0	-3.01 (0.73)***

Notes: *, **, and *** indicate significance at 10 percent, 5 percent, and 1 percent probability levels, respectively; 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.

Table A3

Estimates of Equation (9) Using Various Techniques

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

Notes: *, **, and *** indicate significance at 10 percent, 5 percent, and 1 percent probability levels, respectively; 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 *pi / dd* variable is assumed to be endogenous.