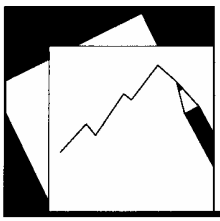
WP/04/218



IMF Working Paper

Capital Inflows, Sterilization, and Commercial Bank Speculation: The Case of the Czech Republic in the Mid-1990s

Jakob Christensen

INTERNATIONAL MONETARY FUND

 WP/04/218

IMF Working Paper

African Department

Capital Inflows, Sterilization, and Commercial Bank Speculation: The Case of the Czech Republic in the Mid-1990s

Prepared by Jakob Christensen[1]

Authorized for distribution by Godfrey Kalinga

November 2004

Abstract

The paper analyzes the relationship between large-scale capital inflows and sterilization efforts in the Czech Republic during 1993–96 using a vector autoregression (VAR) model, which consists of domestic credit, foreign reserves, and domestic and foreign interest rates. The analysis finds that despite initial success in sterilizing capital inflows, this strategy proved increasingly costly and ultimately unsustainable as domestic interest rates attracted more capital inflows. The commercial banks exploited a profitable sterilization game, whereby they borrowed cheaply abroad and invested the funds domestically in high-yielding sterilization bonds.

JEL Classification Numbers: E32, E44, E52

Keywords: capital inflows, sterilization, exchange rate policy, Czech Republic

Author(s) E-Mail Address: jchristensen@imf.org

[1] The author wishes to thank William Rogers, Ayumu Yamauchi, Martin Schindler, and Niels Mahle for their thoughtful remarks on the paper.

Contents Page

I. INTRODUCTION

The Czech economy experienced almost three years of severe recession following the dual currency and banking sector crisis in May 1997. This crisis mirrored closely the Asian ones: first, it was preceded by a period of very large private capital inflows under fixed exchange rates and sterilization efforts by the authorities to absorb liquidity. Second, despite these sterilization attempts, the sheer size of capital inflows that leaked into the money supply and fueled an investment and consumption boom added to inflation pressures and caused a significant appreciation of the real exchange rate. Third, the current account deficits deteriorated owing to strong import growth and weakening export performance, which, in the end, triggered a run on the currency.[2]

However, the Czech experience with capital inflows and sterilization during 1993–95 is unique in several respects. First, the capital inflows were extremely large. At their peak in 1995, these inflows amounted to almost 18 percent of GDP, which by far exceeded the ratios in Asian countries. Second, unlike many of the Asian countries, the Czech Republic aggressively attempted to sterilize the capital inflows and meet money and exchange rate targets simultaneously. Third, the commercial banks in the Czech Republic played a very prominent role during this period by speculating heavily against the central bank's strategy of targeting both money and the nominal exchange rate.

The subsequent foreign exchange crisis in the Czech Republic in 1997 can, to a large extent, be attributed to the sizable capital inflows during the fixed exchange rate system that was in effect from 1993 to 1995. First, the inability of monetary authorities to stem the monetary impact of these inflows caused high money growth, which fueled an economic boom. Second, as a result of these developments, disinflation ceased and the real exchange rate appreciated, as wage growth remained high. Third, this caused a sharp deterioration in the current account, which, in the end, was perceived by the market as unsustainable and triggered the crisis.

Given the importance of the developments during the fixed exchange rate period from 1993 to 1995, the paper will attempt to answer the following questions. First, how successful were the Czech monetary authorities in maintaining monetary independence? Second, to what extent did domestic or foreign interest rates cause capital inflows? Third, did the sterilization policy of the central bank actually induce more inflows? And was this achieved through a so-called sterilization game in which commercial banks borrowed abroad and speculated in the high-yielding sterilization bonds that were implicitly guaranteed by the fixed exchange rate regime? Fourth, was the policy mix of monetary and fiscal policies appropriate in the wake of large-scale capital inflows?

---

[2] The policy dilemmas relating to pursuing a fixed exchange rate system with relative open capital accounts are discussed in a number of studies: for transition countries, see Lipschitz, Lane, and Mourmouras (2002); for Asian countries, see Boorman and others (2000).

In order to examine these questions, the paper uses a vector autoregression (VAR) model containing three endogenous variables (domestic interest rate, growth in domestic credit, and foreign reserves) and one exogenous variable (foreign interest rate) based on monthly data from January 1993 to January 1996 to estimate the results. On the basis of the model's findings, impulse response functions are generated to examine the impact of various shocks to the endogenous variables. The stability of the model is tested for 1995, when shorter-term capital inflows accelerated. The results are then compared with the commercial banks' balance sheets to examine to what extent banks took advantage of the favorable sterilization situation and borrowed abroad to invest in high-yielding sterilization bonds.

The paper is organized as follows. Section II gives a brief account of economic developments in the Czech Republic from the splitting of Czechoslovakia into the Czech Republic and the Slovak Republic in January 1993 until the currency crisis in 1997, in particular focusing on the nature and composition of capital inflows, the sterilization policy, the monetary outcome, and the currency crisis. Section III uses the monetary approach to the balance of payments to examine the interaction among the capital inflows, sterilization policies, and monetary aggregates and to derive the foundation for the empirical model. Section IV formulates the hypotheses and discusses the appropriate econometric model. Section V presents the results of the VAR regression, impulse response analysis, and structural break tests, and examines to what extent commercial banks took advantage of the profitable sterilization game. Section VI concludes the paper and discusses some policy implications.

II. Capital Inflows, Policy Responses, and the Currency Crisis, 1993–97

A. Large-Scale Capital Inflows, 1993–95

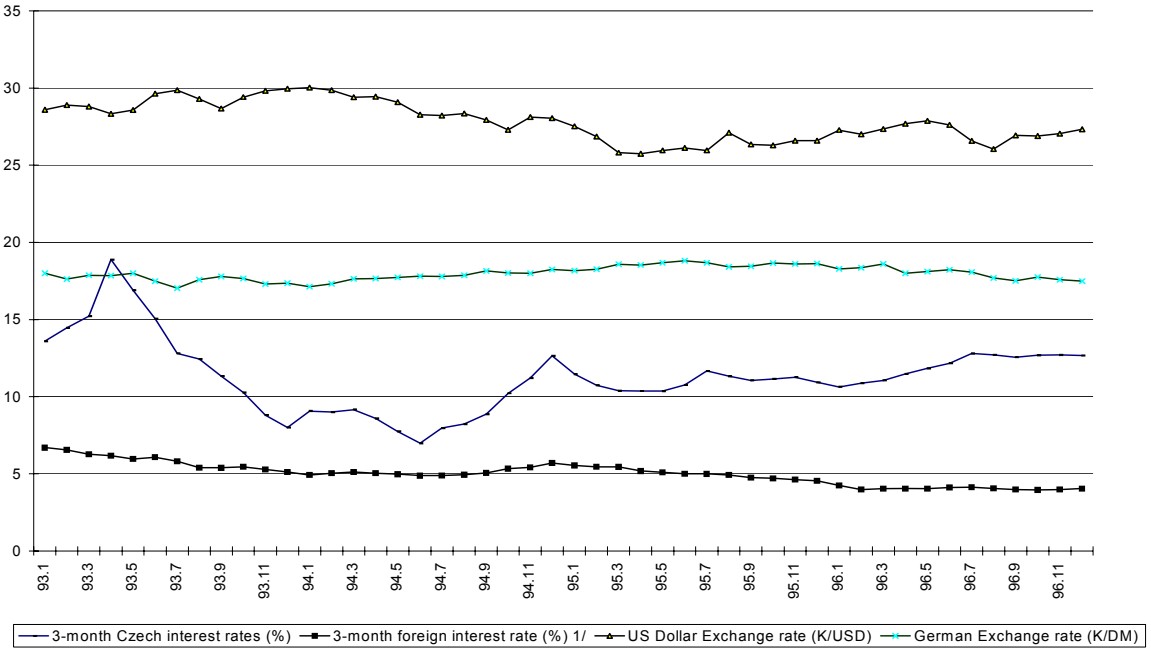
In the period following the country's separation from the Slovak Republic on January 1, 1993, the Czech Republic became the Eastern European favorite destination for foreign capital, as it quickly established a reputation for firm commitment to comprehensive market reforms and achieved promising economic results. On both internal and external policy matters, the government, headed by Vaclav Klaus, strived to transform the Czech economy from a centrally planned economy to a more market-based system. Toward this end, the government implemented a voucher-based privatization program and kept its finances in balance with spending at a relatively modest level compared to GDP. Following a 100 percent devaluation of the koruna in 1990, the Czech authorities pegged the Czech koruna to a currency basket consisting of 65 percent deutsche mark and 35 percent U.S. dollars. The authorities were fairly successful at managing the peg (Figure 1).[3] The government also quickly introduced current account convertibility, which was gradually expanded to convertibility in the capital account (Dêdek, 1997). Sound results were soon

[3] Many observers argued that the devaluation calculated in terms of purchasing power parity was excessive, making the koruna highly undervalued. The authorities sought and obtained credibility and stability before and after convertibility.

achieved; already in 1994, inflation dropped to 10 percent and positive real growth resumed (Table 1).

While the current account deficit deteriorated from a surplus in 1993 to a deficit in 1994 and 1995, foreign reserves more than tripled over the period because of large-scale capital inflows. These capital flows were much larger, relative to GDP, than those recorded in other countries with high-inflows, such as Thailand, Indonesia, Korea, and Chile.

Figure 1. Exchange Rate and Interest rate Developments, 1993-1996.



Source: International Monetary Statistics (IMF).
1/ The units are given in the variable description. An increase in the graphs for the exchange rates represents a depreciation.
2/ The foreign interest rate is a weighted average of the 3-month US (bond) and German (money market) interest rates using the weights in the exchange rate basket.

Table 1. Selected Economic Indicators, 1992-99

Year	1992 1/	1993	1994	1995	1996	1997	1998	1999
Inflation (period average, percent)	11.1	20.8	10.0	9.1	8.8	8.5	10.7	2.1
Real GDP growth (percent)	-6.4	0.6	2.7	5.9	4.8	-1.0	-2.2	-0.2
Fiscal Balance (in percent of GDP) 2/	0.4	0.6	-1.3	-2.1	-2.1	-1.9	-3.0	-3.7
Balance of Payment (US$ billion)								
Current account	...	0.5	-0.7	-1.4	-4.3	-3.2	-1.3	-1.6
Capital and financial account *of which*	...	2.5	3.1	8.8	3.5	1.5	3.3	3.2
Foreign direct investment (FDI)	...	0.6	0.7	2.5	1.3	1.3	2.6	6.2
Portfolio investment	...	1.0	0.9	1.4	0.7	1.1	1.1	-1.4
Other long term capital	...	0.8	1.1	3.4	3.1	0.4	-2.0	-0.7
Short-term inflows 3/	...	0.1	0.4	1.6	-1.6	-1.3	0.6	-0.9
Change in foreign reserves 4/	...	-3.0	-2.4	-7.5	0.8	1.8	-1.9	-1.7
Current account deficit (in percent of GDP)	...	1.5	-1.9	-2.6	-7.4	-6.1	-2.4	-2.0
Exchange rate (period average)								
Nominal effective	...	4.2	-0.2	-0.9	1.0	-3.5	0.7	0.1
Real effective (ULC-based)	...	15.1	9.1	3.9	5.8	-2.4	8.5	3.4

Sources: Czech National Bank; and IMF, *International Financial Statistics.*

1/ Data for Czechoslovakia.

2/ Includes central government, local authorities, National Health Fund, and (in 1992) Czech share of federal operations. Excluding use of privatization revenues.

3/ Includes errors and emission.

4/ A minus sign is equivalent to an increase in foreign reserves.

Furthermore, the composition of the capital inflows changed markedly over the period:

- Portfolio investment declined in relative importance from 1993 to 1995. This type of inflow accounted for more than about 40 percent of total inflows in 1993, but dropped in relative importance to 15 percent in 1995.

- In 1993, foreign direct investment (FDI) accounted for 22 percent of all inflows, while by 1995, its share had increased to 30 percent. The latter figure, however, was highly influenced by the sale of SPT Telecom shares (for US$1.4 billion), accounting for more than 50 percent of FDI in that year.

- Short- and long-term foreign borrowing increased from a third to more than a half of total inflows. In the wake of independence in 1993, short term loans were virtually non-existent, but by 1994 they accounted for 20 percent of all inflows. In response to this acceleration, the Czech parliament passed a new law in the summer of 1995 requiring that short-term borrowing of domestic banks should not exceed 30 percent of all claims on nonresidents. The commercial banks, however, easily circumvented this restriction by obtaining loans lasting one year and a day, thus technically making them “long-term” loans. A calculation shows that 20 percent of the inflows being recorded as long term ones in 1995 were, in actuality, of a short-term nature, increasing the proportion of short-term inflows to 34 percent.

These numbers clearly reveal that the composition of Czech capital inflows changed substantially throughout the three-year period, while at the same time FDI, rewarding strong fundamentals in the economy together with promising industry forecasts, remained an important financing source. As it happened, more than two thirds of the capital inflows were related to monetary factors, especially as short-term loans became the dominant type of inflows in 1995.

B. Policies Responses and Economic Outcomes, 1993–95

With foreign capital flowing into the country on a massive scale, the Czech authorities decided to implement several sterilization measures to avoid excessive money growth and a potential overheating of the economy that could impede further reductions in the inflation rate. The fixed exchange rate system compelled the Czech National Bank (CNB) to sell koruny given the net surplus on the balance of payments. However, this operation increased reserve money and, at the same time, allowed banks to extend new credit, which undermined the CNB's second objective of controlling money growth. Through the use of sterilization measures, the CNB attempted to solve this classic "impossible trinity" problem of dealing with open financial markets, a fixed exchange rate, and monetary independence.

The monetary authorities applied several instruments to sterilize the capital inflows. The main instrument entailed sales of bonds to the public. Other measures included transfers of privatization receipts to accounts in the CNB and higher reserve requirements.[4] The increasingly close relationship between sterilization measures and international reserve changes is revealed in Table 2, which reports the simple correlation coefficients between monthly changes in international reserves (ΔR) and monthly resources used for sterilization purposes (ΔS). The coefficient for the full period 1993–96 shows that the CNB applied sterilization measures fairly extensively to changes in reserves. It can also be seen that the year-specific correlation coefficients increase significantly over the three-year period. In other words, the CNB increasingly responded to capital inflows by using sterilization measures. These operations peaked in 1995 where the correlation coefficient increased to 0.8. Interestingly, the intensified sterilization operations coincided with the shortening in the maturity structure of the capital inflows, as mentioned in Section II.A, although this simple correlation coefficient cannot reveal the direction of causality.

[4] The active use of reserve requirements reflected the Czech authorities increasing concerns with the accelerating inflows. After continued strong inflows in the first half of 1995, reserve requirements were raised on time deposits to 8.5 (from 3 percent) in August 1995, while the requirement for demand deposits fell to unify requirement rates on demand and time deposits. This policy change amounted to a 2 percent tightening on bank lending relative to total bank deposits (own calculation). The Czech financial market correspondingly raised domestic interest rates. At the same time, the money multiplier fell from 1993 to 1995 (Begg, 1998).

Table 2. Simple Correlation Between Monthly Changes in Reserves and Sterilization Measures 1/

Period	Correlation between ΔR and ΔS
1993.1–1995.12	0.56
1993	-0.49
1994	0.14
1995	0.82

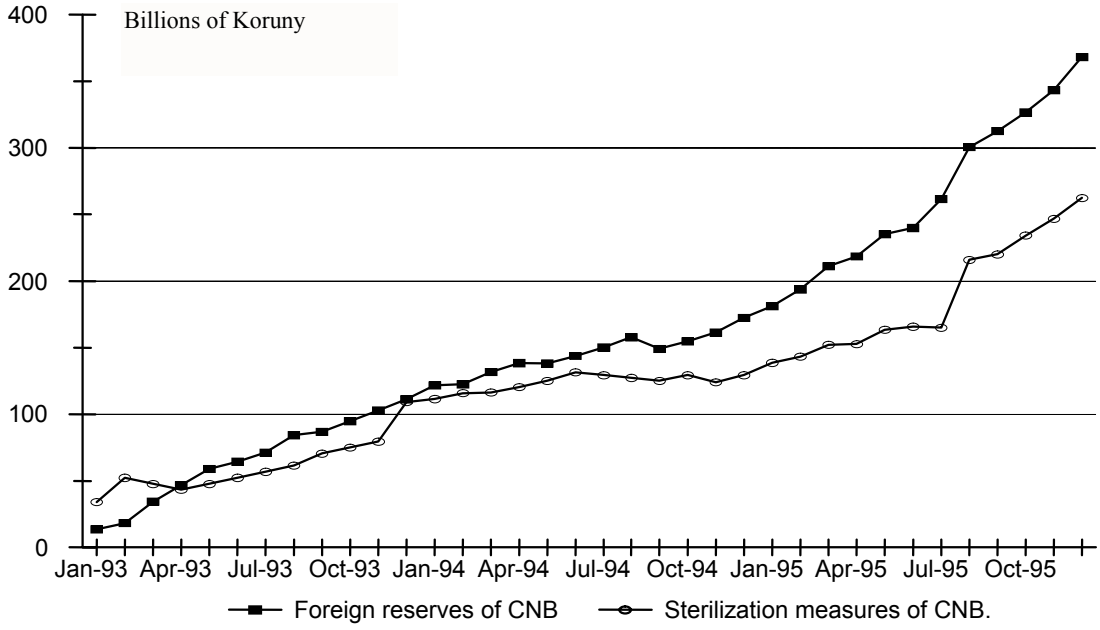
Source: Author's own calculations.

1/ Monthly changes in international reserves – (ΔR): Monthly resources used for sterilization measures – (ΔS). The resources used include outstanding the CNB bills, the transfers of deposits in the National Property Fund to the CNB, revenues from SPT Telecom partial privatization, and other measures.

Despite the large-scale sterilization operations by the central bank, they were overwhelmed by the rapid surge in capital inflows in 1995. Figure 2 shows the magnitude of the sterilization operations from 1993–95 together with the growth in foreign reserves holdings of the CNB. The figure reveals that the CNB's sterilization policy to a large degree matched the growth in foreign reserves during 1993 and 1994, despite a small correlation coefficient between changes in reserves and sterilization. When short-term borrowing accelerated in 1995, the CNB's sterilization policy responded more closely to the change in reserves, but the scale of this operation in absolute terms became increasingly inadequate (evident from a divergence of the two curves from the middle of 1994 through 1995).

The growing monetary pressures resulted in larger-than-expected broad money growth. In 1994 and 1995, the CNB declared an interval of 14–17 percent growth rate of M2 consistent with the targeted inflation. However, actual growth rates exceeded these targets as broad money grew by 21 percent and 20 percent in 1994 and 1995, respectively. It was clear that curtailing monetary expansion using sterilization measures was becoming increasingly difficult.

Figure 2. Foreign Reserves and Sterilization Measures, 1993–96



Source: OECD (1996); and IMF, *International Financial Statistics*.

The weakening of monetary control in 1994–95, owing to the large capital inflows, mainly accounted for the rapid rise in domestic demand and wages. Real domestic demand grew on average by 10 percent in 1994 and 1995 outpacing real GDP, which itself rose by a record 5 percent in 1995. The expansion in domestic demand was mainly driven by increased fixed investment in transportation, energy, and telecommunication while investment in manufacturing remained sluggish. Furthermore, private consumption was buoyant, growing by about 5 percent, and unemployment was low at 3 percent.

Monetary expansion, coupled with weak corporate governance, also added to wage and inflation pressures. Average nominal wages ran well in excess of labor productivity—by 18 percent in 1994–95 (wage controls were abolished in June 1995)—increasing inflation pressures especially in the nontraded sector. Despite the growth in labor productivity in the traded sector (especially manufacturing), it did not prevent a continued rise in relative unit labor costs vis-à-vis the main trading partners (average of almost 10 percent per year over 1993–95). After a rapid deceleration in inflation from 21 to 10 percent from 1993–94, inflation was 9 percent in 1995.

While fiscal policy remained relatively prudent during this period, it did not adequately support monetary policy and added to upward pressure on domestic interest rates. The government's attempt at reducing the share of the budget in the economy slowed during the years 1993–95. Overall, revenues fell by approximately 0.5 to 1 percent of GDP per year,

and the fiscal balance deteriorated from a surplus of 0.4 percent in 1993 to a deficit of 2.0 percent of GDP in 1995. In particular, the 1995 budget saw a reduction in the value-added tax (VAT) rate as well as in corporate and personal income tax rates. On the expenditure side, wages increased following higher minimum wages and general wage increases for public sector employees.

Given the mixture of accelerating capital inflows and expansionary fiscal and wage policies, it was apparent that the current situation was unsustainable. In order to gain more control over monetary policy, the authorities decided to adopt a wider exchange rate band at end-January 1996 to discourage speculative inflows.

C. Exchange Rate Flexibility and Currency Crisis, 1996–97

The decision to widen the exchange rate band in January 1996 marked the beginning of the end of the boom period of the Czech economy. Initially, the central bank gained greater monetary control as short-term capital inflows ceased with the greater exchange rate uncertainty and the continuing widening of the current account deficit. However, the initial tightening of monetary policy and deceleration in money expansion led to a rise in real interest rates. In view of slowing GDP growth, political pressures emerged to loosen monetary policy and, in April 1997, the CNB reduced the required reserve ratio by 2 percent and relied on sterilization operations to keep the monetary stance unchanged. The lack of fiscal support and other macroeconomic policies caused a further increase in the current account deficit to 7.4 percent of GDP in 1996. In the end, the combination of weak fundamentals, uncertainty about the future stance of monetary policy, and contagion effects from the emerging Asian crisis resulted in a foreign exchange crisis in May 1997 during which speculative attacks caused a 10 percent depreciation of the koruna.

As this period revealed, the large-scale capital inflows, exacerbated by expansionary fiscal policy, made it progressively more difficult for the monetary authorities to sustain the peg. In this regard, the empirical analysis below will mainly focus on this particular period in order to assess the relationship between capital inflows, monetary policy and broader economic outcomes.

III. Capital Inflows, Sterilization, and the Monetary Approach to the Balance of Payments

In order to understand and interpret the relationship between inflows and sterilization, a theoretical framework is developed in this section. First, the so-called *offset coefficient* is calculated, which measures the degree by which a change in domestic credit is offset by flows on the financial account in the balance of payments. Then, a short discussion follows on what impact sterilization will have on domestic interest rates when this inflow originates either from internal factors, such as rising domestic money demand, or from external factors, most notably, a fall in foreign interest rates. The derived equations form the basis for the econometric model, which is estimated in the empirical section.

Box 1. Macroeconomic Framework

Assumptions:
Fixed exchange rate.
Small country assumption: Domestic policy actions do not affect foreign wealth and interest rates.
Fixed prices: Wages and prices are given.
Exogenous Current Account (CA): The balance on the current account is predetermined and set to zero.
Infinite supply of foreign assets: The small country assumption implies a relatively small size of domestic demand compared to world supply. Any change in domestic demand for foreign bond does not affect the price of these bonds.
Foreign acquisition of domestic assets: Foreigners can only hold domestic bonds (i.e. not domestic money)

Relations:

Demand for the monetary base:	$M_{0D}=L(Y^{+},W^{+},i^{-},i^{*-})$	(1)
Domestic demand for domestic bonds:	$B_D=H(Y^{-},W^{+},i^{+},i^{*-})$	(2)
Domestic demand for foreign bond:	$B_F=J(Y^{-},W^{+},I^{-},I^{*+})$	(3)
Foreigners demand for domestic bonds:	$B_D^{*}=F(Y^{-*},W^{+*},i^{+},i^{-*})$	(4)
Bond supply:	$B^{S} = B^{G} + B^{CB}$	(5)
Domestic money supply:	$M^{s} = R + Cr$	(6)
Balance of payments (BOP):	$BOP = CA + K = F\text{-}J=R$	(7)
Portfolio constraint	$L_x+H_x+J_x=0 \quad for\ x=y,i,i^{*}$	(8)
Wealth constraints	$L_w+H_w+J_w=1$	(9)

Note: The notation used is read in following way; $L(y^{+}, ...)$ means that the partial derivative of money demand with respect to income is positive.

Variables:
y = domestic output, W = domestic wealth, I = domestic interest rates, I^{*} = foreign interest rates, R = stock of central bank reserves, Cr = domestic credit, CA = current account, K= capital account, F = non-residents' holding of domestic bonds, J = residents' holding of foreign bonds.

The theoretical model is basically a monetary approach to the balance of payments model (MABOP) developed by Kouri and Porter (1974), which distinguishes domestic and foreign bonds in a fixed exchange rate regime. The general arrangement of the model is presented in Box 1. The external current account is set to zero, which implies a surplus in the balance of payments whenever foreigners increase their net financial claims on domestic residents. In addition, it is assumed that both wages and prices are fixed and the supply of foreign assets on international markets is unlimited. The dynamic determinants are found by first inserting equations (3) and (4) into equation (7) and then totally differentiating equation (7):

$$\Delta R = F_{y*}\Delta y^{*} + F_{w*}\Delta w^{*} - J_{y}\Delta y - J_{w}\Delta w + (F_{i*} - J_{i*})\Delta i^{*} + (F_{i} - J_{i})\Delta i \,. \qquad (7')$$

According to equation (7'), a fall or an increase in foreign and domestic interest rate, respectively, prompts net capital inflows as domestic assets become relatively more attractive compared to foreign assets. The equilibrium condition on the money market is obtained by equalizing the demand equation (1) with the money supply equation (6):

$$Cr + R = L(y, w, i, i^*), \tag{10}$$

Differentiating this relation, inserting it into the expression for changes in reserves (7'), and solving for Δi gives the reduced form for changes in the domestic interest rate:

$$\Delta i = -\frac{1}{L_i + F_i}\left[(F_{i^*} + L_{i^*})\Delta i^* + L_y \Delta y + L_w \Delta w + \Delta Cr + F_{y^*}\Delta y^* + F_{w^*}\Delta w^*\right]. \tag{11}$$

The reduced form for foreign reserves is obtained by total differentiating equation (10) and inserting equation (11). Using the portfolio constraint, $-J_i = H_i + L_i$ yields the following expression:

$$\Delta R = -\frac{1}{H_i + F_i}[(F_i - J_i)\Delta Cr + \{(J_{i^*} - F_{i^*})L_{i^*} + (F_{i^*} - J_{i^*})L_i\}\Delta i^*$$

$$+ \{(J_i - F_i)L_y - J_y L_i\}\Delta y + \{(J_i - F_i)L_w - J_w L_i\}\Delta w + F_{y^*}L_i \Delta y^* + L_i F_{w^*}\Delta w^*] \tag{12}$$

The offset coefficient is defined as the partial derivative of the change in reserves (ΔR) with respect to the change in domestic credit (ΔCr):

$$R_{\Delta Cr} = \frac{\Delta R}{\Delta Cr} = \frac{\overset{-}{J_i} - \overset{+}{F_i}}{\underset{+}{H_i} + \underset{+}{F_i}}, \qquad -1 \leq R_{\Delta Cr} \leq 0 \tag{13}$$

The change in foreign reserves following changes in the domestic credit is often used as a measure of monetary independence.[5] There is a large degree of monetary independence, when $R_{\Delta Cr}$ is close to zero given that only a small proportion of a change in reserve money will be offset by balance of payment capital flows. On the other hand, monetary independence is small when $R_{\Delta Cr}$ is close to -1, given that a change in domestic credit will be perfectly offset by a corresponding change in the opposite direction in international reserves, leaving the domestic money stock unchanged. Furthermore, equation (13) reveals that an increase in the elasticity of foreigners' demand for domestic bonds with respect to the domestic interest rate (a higher value of F_i) increases the offset to monetary policy, other things being equal. Imposing capital controls by, for example, preventing foreigners from holding domestic bonds erases the F_i term and reduces the absolute size of the offset coefficient, implying more independence to the monetary authorities.

[5] In a sense, this is also a measure of capital mobility. If capital mobility is high, the offset coefficient will be high and monetary independence will be small.

The model can be made more realistic by incorporating a reaction function for the monetary authorities (De Grauwe, 1983):

$$\Delta Cr = - b\, \Delta R + \Delta Z, \qquad (14)$$

where $0 \leq b \leq 1$ and b is the sterilization parameter that measures to what extent monetary policy insulates the economy from balance of payment movements and Z comprises an array of exogenous variables relevant to monetary y policy such as the output gap, expected inflation rates, and similar variables. Full sterilization (b=1) implies that domestic money supply is independent of net flows into the economy. Under these circumstances, the domestic money supply is insulated from balance of payment movements and the money supply will only change as a result of changes in Z, as shown below:

$$\Delta M = \Delta Cr + \Delta R = - \Delta R + \Delta Z + \Delta R = \Delta Z. \qquad (15)$$

On the other hand, a no-sterilization policy (i.e., b=0) implies that any net capital flow will be reflected in an equivalent change in the domestic money supply. Section II revealed that the Czech authorities aggressively attempted to insulate money growth from capital inflows, and implicitly assumed that b must be positive.

The debate about the appropriateness and effectiveness of sterilization remained intense in the 1990s. Calvo, Leiderman, and Reinhart (1992), on the one hand, criticized sterilization for leading to excessively high domestic interest rates, thereby perpetuating capital inflows and quasi-fiscal costs.[6] Reisen (1993), on the other hand, defended sterilization, by pointing out that many Asian countries retained monetary independence by using sterilization policies in the beginning of the 1990s. Meanwhile, Frankel (1994) attempted to bridge the gap between the two views by pointing out that the nature of the shock is important for the appropriate monetary response. If the shock causing the inflows *pushes* foreign capital to a country, for example after a fall in foreign interest rates, which increases the attractiveness of domestic assets vis-à-vis foreign ones, sterilization will not, in itself, push up but rather exert a downward pressure on domestic interest rates. In this instance, there might be a case for sterilizing these inflows and for supplying the domestic bonds that investors want. On the other hand, when the inflows are *pulled*, for instance, by the success of the stabilization program, which raises domestic residents' demand for money, sterilization will lead to higher domestic interest rates, which would elevate the quasi-fiscal costs of the central bank. In such cases, the authorities should refrain from sterilizing inflows and should rather supply the domestic money that residents want.[7]

---

[6] Quasi-fiscal cost amounts to the interest differential vis-à-vis international levels multiplied by the size of the sterilization operation. See Calvo, Leiderman, and Reinhart (1993b) for further explanation.

[7] This analysis considers a transitory shock. However, if the shock proves to be permanent, sterilization may not be feasible because of large quasi-fiscal costs. In this case, the best policy response would be to change financial policies to both maintain macroeconomic stability and attract more modest levels of inflows.

IV. Empirical Questions, Econometric Methodology, and Data Issues

A. Empirical Questions

The preceding section examined the theoretical relationship between capital flows, domestic interest rates, and sterilization policies.[8] Using the equations (11), (12), and (14) as the basis framework, the following questions about the experience and monetary policy management of capital inflows in the case of Czech Republic can be raised. A first question is to what extent the monetary authorities maintained monetary independence during the high-capital-inflows period in their attempt to insulate the money supply from the surge in capital inflows. This question can be examined by estimating the offset coefficient derived in the previous section in a regression with foreign reserves and changes in the domestic credit as the dependent and independent variable, respectively. As mentioned above, a high degree of monetary independence means that a limited amount of the capital flows will recorded in the wake of monetary policy changes.

A second, and related question, is to what extent foreign or internal factors pushed or pulled foreign capital to the Czech Republic, respectively. This question relates to Frankel's conclusion (Frankel, 1994) that an unnecessarily high domestic interest rate will prevail when sterilization is undertaken in the case of an internal shock from higher domestic money demand (*pull* factor). On the other hand, sterilization will be more appropriate when capital is *pushed* by falling international interest rates.[9] The empirical model should therefore contain a relation for foreign reserves to answer these two questions.

A third question is whether monetary policy became endogenous to keep money supply constant. In other words, given the significant capital inflows, the Czech monetary authorities may have responded by tightening domestic credit. If this was indeed the case, the domestic credit will be endogenous in the relation for foreign reserves, which will give rise to a sterilization bias.[10] In order to avoid this problem, the econometric model should allow for domestic credit to be endogenous, which would imply a simultaneous econometric system (this issue will be discussed in greater length in Section IV.B).

---

[8] One problem with the MABOP model presented in the previous section is its static nature. More recent currency crisis models have dynamic characteristics and a survey can be found in Flood and Marion (2001). However, the MABOP model was used in this paper as it closely resembles the main features of the Czech experience with capital inflows and sterilization policies in a fixed exchange rate setting.

[9] To let changes in reserve stocks reflect flows on the capital account, a current account close to balance is required in every period. Table 1 showed that the Czech current account deficit indeed was negligible compared to surpluses on the financial account, even though there was a significant increase in the current account deficit in 1995.

[10] In the context of the theoretical model, the sterilization bias arises if the sterilization parameter, b, in equation 14 is significant, implying that the authorities systematically varied domestic credit in response to capital inflows. The failure to account for such policy in a single equation regression, where the endogenous domestic credit component is treated as exogenous, would give rise to biased estimates.

A fourth question is whether the extensive use of sterilization bonds raised Czech interest rates as pointed out by Calvo, Leiderman, and Reinhart (1993a), who highlight the fact that increasing the supply of bonds as part of the sterilization policies will ultimately drive up domestic interest rates. This will result in even larger inflows, which would thereby magnify, rather than solve, the problem of monetary pressures in the economy as a result of these inflows. One way of examining this question would be to include a measure of sterilization policies in the macro-econometric model. Unfortunately, it would not be possible to include both foreign reserves and this measure at the same time because of the significant correlation between the two variables (found in Section II.B), which would give rise to multicollinearity. However, at least for the year 1995, where the correlation coefficient between the two variables became close to one, international reserves would proxy sterilization measures more closely.

B. Econometric Methodology and Data Issues

In order to analyze the questions raised in the previous section, a VAR was estimated, containing domestic credit, domestic interest rates, and foreign reserves as endogenous variables. In order to examine whether the foreign interest rate "pushed" capital inflows to the Czech Republic, it was included as an exogenous component of the system. This system took the following form (including a constant term):

$$\Delta Cr_t = \sum_{i=1}^{k} \alpha_{1i} \Delta Cr_{t-i} + \sum_{i=1}^{k} \beta_{1i} \Delta R_{t-i} + \sum_{i=1}^{k} \chi_{1i} \Delta i_{t-i} + \sum_{i=1}^{k} \delta_{1i} \Delta i^*_{t-i} + \varepsilon_{1t}$$

$$\Delta R_t = \sum_{i=1}^{k} \alpha_{2i} \Delta Cr_{t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta R_{t-i} + \sum_{i=1}^{k} \chi_{2i} \Delta i_{t-i} + \sum_{i=1}^{k} \delta_{2i} \Delta i^*_{t-i} + \varepsilon_{2t}$$

$$\Delta i_t = \sum_{i=1}^{k} \alpha_{3i} \Delta Cr_{t-i} + \sum_{i=1}^{k} \beta_{3i} \Delta R_{t-i} + \sum_{i=1}^{k} \chi_{3i} \Delta i_{t-i} + \sum_{i=1}^{k} \delta_{3i} \Delta i^*_{t-i} + \varepsilon_{3t,}$$

where Δi is the change in domestic interest rate defined as the three-month Pribor rate in the Czech Republic, Δi^* is the change in a weighted average of the three-month money market rate in Germany and the three-month U.S. bond rate derived by using the weights in the currency basket mentioned above, ΔR is the change in the stock of reserves denoted in millions of U.S. dollars converted into koruny using the end of period official koruna/dollar rate, ΔCr is the change in domestic credit as a proportion of the monetary base (M1). Domestic credit was found by deducting foreign reserves from M1 according to the method by Leiderman (1984). All data are on a monthly basis and obtained from IMF's *International Financial Statistics*.[11]

[11] Since it was not possible to obtain monthly data for GDP, one could instead have used monthly industrial production as a measure of real activity. However, in the case of the Czech Republic, which has a significant service sector, this approach would underestimate the true GDP. As a result, it was not included in the regression. Nor did the regressions include a measure for current account, because only export and import figures were available on monthly basis. By ignoring the service balance of the current account, this measure

(continued)

The variables were included in first differences (i.e. monthly changes) for the following reasons.[12] First, the Dickey-Fuller test found that all variables but domestic interest rates contained a unit root, and they had to be specified in first differences to avoid spurious regressions.[13] Second, the MABOP model stated that financial account flows arise because of *changes* in the foreign and domestic interest rates. Two caveats of using first differencing relate to the loss of information compared to specification in levels and the absence of long-run implications of the results.

Given a relatively short time-span available (three years), monthly instead of quarterly observations were used. The resulting number of observations was 36. This small number of observations required a limited adjustment period of only one month. This adjustment time, however, may be justified, because the model only contains monetary variables that adjust relatively quickly.[14] The resulting degrees of freedom are 21, which were still relatively small.

However, the information contained in monthly data may be limited, owing to strong seasonal variation. The presence of seasonal variation in the data can severely restrict firm conclusions about the interaction of the variables. The degree of seasonality in the data was examined by carrying out a simple *F*-test by regressing each variable on monthly seasonal dummies. The null hypothesis implied no seasonality (all coefficients of the seasonal dummies are simultaneously tested zero), while rejection of the null hypothesis meant that seasonality was present in the data. The *p*-value (measuring the likelihood that *F*-statistic exceeds the critical value) was 32 percent, 49 percent, 91 percent, and 75 percent in the case of foreign reserves, domestic credit, domestic and foreign interest rates, respectively. Hence, the tests strongly support the null hypothesis of no seasonality in the data, and subsequent estimation procedures will not contain seasonal dummies.

By simultaneously including interest rates and domestic credit, it is basically assumed that both variables have an impact on the economy. Often, interest rates are used as a measure of

---

would overestimate the true deficit given the significant tourist earnings in the country. Furthermore, it may be problematic to exclude prices given that monetary authorities had a target in mind. However, the empirical analysis includes changes in *M*, which have been found to be relatively closely correlated with price developments.

[12] The first difference measure for reserve variables and domestic credit were computed by taking first difference and then dividing them by M1 to obtain consistent growth rates.

[13] The *t*-statistics of the augmented Dickey-Fuller test were -1.2, -1.7, -1.5 and -3.5 for i^*, *Cr*, *R* and *i*, respectively.

[14] Reserves are also affected by non-monetary net flows such as FDI and part of the investment portfolio. However, these inflows represented a minor part of total inflows. Furthermore, the model is a short-term model, which may imply that real variables would exhibit relative little variation over the period of interest. In addition, the reaction function (the *Cr* equation) should include the output gap, but satisfactory data for this variable could not be obtained on a monthly basis.

the tightness of monetary policy. But in a credit-constrained economy, like the Czech one at that time, with imperfect competition in the financial sector, companies might tend to finance their investments with available credit. In this case, credit measures impact the economy along with interest rates. Of course, these two policy variables are certainly interdependent, which is also confirmed by the empirical analysis below.

V. EMPIRICAL EVIDENCE

This section first presents the results from the VAR regressions specified in the previous section and then analyzes the impact on each of the model's endogenous variables using impulse response functions. Thereafter, the results of a test for a structural break in 1995, when short-term inflows accelerated, are reported. The final subsection analyzes the influence of the sterilization strategy on the foreign asset-liability portfolio of the banking sector.

A. Estimation Results

The VAR (1) model was estimated by a standard ordinary least squares (OLS) procedure, and the results are shown in Table 3. The estimation yielded intuitively appealing results: The reserve relation revealed three interesting findings; first, foreign interest rates appeared to exert a negative and significant impact on foreign reserves, indicating that capital was *pushed* to the Czech Republic between January 1993 and January 1996. In other words, the estimated model captures the idea that the general decline in foreign interest rates during that period significantly caused capital inflows within the same month. This effect remains (albeit only being significant at a 10 percent level) in the subsequent month. The resulting long-run effect (two months) of foreign interest rate on foreign reserve of the CNB was -0.06, being almost significant at a 5 percent significance level. Second, domestic interest rates were found to significantly pull capital to the Czech Republic. The coefficient on domestic interest rates is positive and significant, which implies that a positive change in interest rates caused more inflows. This supports the hypothesis that foreign and domestic investors saw existing levels of Czech short-term returns to be attractively high. Third, the *offset coefficient* seems to be relatively small implying that changes in credit only resulted in 20 percent offsetting reserve flows. Hence, the monetary authorities in the Czech Republic were partially successful in influencing the domestic money stock, but as the scale of the operations grew rapidly, it was becoming increasingly apparent that the policy was not sustainable.

The domestic interest rate equation shows that changes in foreign interest rates significantly affected domestic rates by more than a factor of one in the first period. However, the subsequent period corrects this overshooting, implying a one-to-one relation between changes in foreign and Czech interest rates over two months. Furthermore, an increase in the supply of credit led to a fall in domestic interest rates to restore equilibrium in the credit market, although this effect was only significant at a 10 percent level.

Table 3. A VAR(1) Model of Domestic Credit, Foreign Reserves, and Domestic and Foreign Interest Rates
(Sample period: January 1993–December 1995)

	Equation		
	ΔCr	ΔR	Δi
Explanatory variables:			
ΔCr_{t-1}	0.28*	-0.15*	-7.40*
	(-1.71)	(-1.87)	(-1.75)
ΔR_{t-1}	-0.11	-0.07	-7.10
	(-0.29)	(-0.34)	(-0.72)
Δi_{t-1}	-0.01	0.01*	0.27
	(-1.51)	(-1.88)	(-1.49)
Constant	-0.00	0.03**	0.12
	(-0.26)	(-4.48)	(-0.37)
Δi^*_{t-1}	0.06	-0.06**	2.51*
	(-1.14)	(-2.25)	(-1.77)
Δi^*_{t-1}	-0.08	-0.03	-1.53
	(-1.40)	(-1.01)	(-1.04)
Single equation diagnosis: 1/			
Portmanteau 4 lags	1.01	0.67	5.77
AR F (3, 25)	0.16	0.14	1.97
Normality Chi^2	5.32*	9.51**	9.07**
ARCH 3 F(3, 22)	0.18	0.43	1.56
$X_i^2 F(10, 17)$	0.27	0.56	1.93
$X_i X_j F(20, 7)$	0.29	0.47	3.47
Vector diagnosis: 1/			
Vector AR F(27, 50)		0.76	
Vector normality Chi^2 (6)		19.9**	
Vector $X_i^2 F(60, 67)$		0.86	
Vector $X_i X_j$ F(120, 19)		0.43	
R^2	0.28	0.36	0.25

Source: Author's own calculations.

Notes: Regression *T*-statistics in parentheses. Asterisks indicate significance: (*) = significant at 10 percent level and (**) = significant at 5 percent level. Estimations were carried out in EVIEWS and PCFIML.

1/ White noise diagnostic test. The given numbers are *F*-statistics; large values lead to rejection of the white noise residual characteristics. Portmanteau is the Box-Pierce test for an autoregressive structure of the error terms. AR is an autocorrelation.

Finally, domestic credit was not found to be significantly affected by any of the variables in the models, except for its own lagged value. A one percent increase in domestic credit implied a third of a percentage point increase in the same variable in the next period. Interestingly, foreign reserves were not found to significantly have affected domestic credit, implying that the concerns about sterilization bias were not warranted (although the coefficient was negative as expected). This might have been a result of the aggressive sterilization policies, which attempted to insulate the domestic credit from the capital inflows.

All assumptions regarding the error terms were met except the one concerning normality. Nonnormality of the individual equations' error terms led to a rejection of normality of the full system's error term. The limited adjustment period did not cause autocorrelation problems as the regressions included relatively fast-adjusting monetary variables.

The estimated model seems to reasonably consistent with the MABOP model. Most of the coefficients had the right sign. The monetary authorities were able to retain some degree of monetary independence and refrained from making domestic credit policy dependent on balance of payments flow in a systematic manner. Capital flows were both pushed by foreign interest rates and pulled by returns on domestic bonds.

B. Reasons for Low Offset Coefficient

The regression revealed that some degree of monetary independence was preserved despite considerable integration of the Czech banking sector in foreign markets and falling country risk ratings. The low offset coefficient might be a result of the limited substitutability between Czech and foreign assets. This can be a result of either effective capital controls (low F_i) or limited access to foreign assets (high J_i) of domestic agents. The Czech Republic did indeed impose some restrictions on capital inflows following continuous increases in capital inflows during the second half of 1994 and onward. However, domestic banks easily circumvented these measures and the capital control may therefore not have had the desired result of reducing capital mobility during this period (Begg, 1996, p. 70).[15] Limited access to foreign assets may be a more valid explanation of the little balance of payment offset. In January 1993, financial depth, measured by the ratio of M2 relative to GDP, was relatively limited, although greater than in other transition countries (Begg, 1996). In addition, the credit markets remained highly segmented with limited competition (OECD, 1996). Finally, the comprehensive sterilization operations may also have added to monetary independence.

C. Dynamic Responses of System Using Impulse Response Analysis

A notable feature of a VAR system is the ability to analyze the impact of a shock to its endogenous variables on the other variables in the system using impulse response analysis.[16] This section analyzes the dynamic impact of shocks to foreign reserves, domestic reserves, and domestic credit.

Figure 3 shows the responses of each variable to a positive one standard deviation (OSD) shock to each of the three endogenous variables assuming the following ordering of the endogenous variables: domestic credit, domestic interest rates, and foreign reserves.[17] The

[15] For a discussion of the implemented capital control measures, see OECD (1996), p. 40.

[16] Technically, the impulse response function traces the effect of a one standard deviation (OSD) innovation in the endogenous variables to current and future values of all endogenous variables.

[17] The ordering is determined in such a way that the first variable (domestic credit) in the ordering is assumed to cause the other two (domestic interest rates and foreign reserves) but not vice versa. The second variable causes

(continued)

two dashed lines around the impulse curves show the standard deviations of each response multiplied by two. If the interval between the two dashed lines contains zero (the first axis), then the response of variable *Y* to a shock in variable *X* is not significant for that period. Since the VAR model is of first order, it suffices to examine 6 months ahead from the time when the shock happened, since the system, by then, will to a large extent have fully adjusted.

A shock in Czech credit levels leads to an immediate increase in domestic interest rates, followed by a sharp drop before converging toward zero in the remaining four months (the first column of graphs). In terms of reserves, a tighter credit policy is followed by a surge in capital inflows, but of smaller magnitude than if Czech and foreign assets were perfect substitutes.

The impact of a shock to foreign reserves on domestic interest rates and credit levels are fairly small (graphs in first and third row of the second column). As previously found, the empirical analysis finds little support for the *sterilization bias* hypothesis. There is also little indication that reserve changes exerted upward pressure on domestic interest rates. This may be explained by the fact that reserves were an imperfect measure of sterilization efforts in the full period seen by a correlation coefficient of only 0.5.

The impact of a shock to domestic interest rates on foreign reserves and domestic credit is relatively significant. More importantly, there is a significant and positive impact of domestic interest rates on foreign reserves of the central bank. As expected, the graph in the first row reveals that domestic credit contracts as a result of an increase in domestic interest rates.[18]

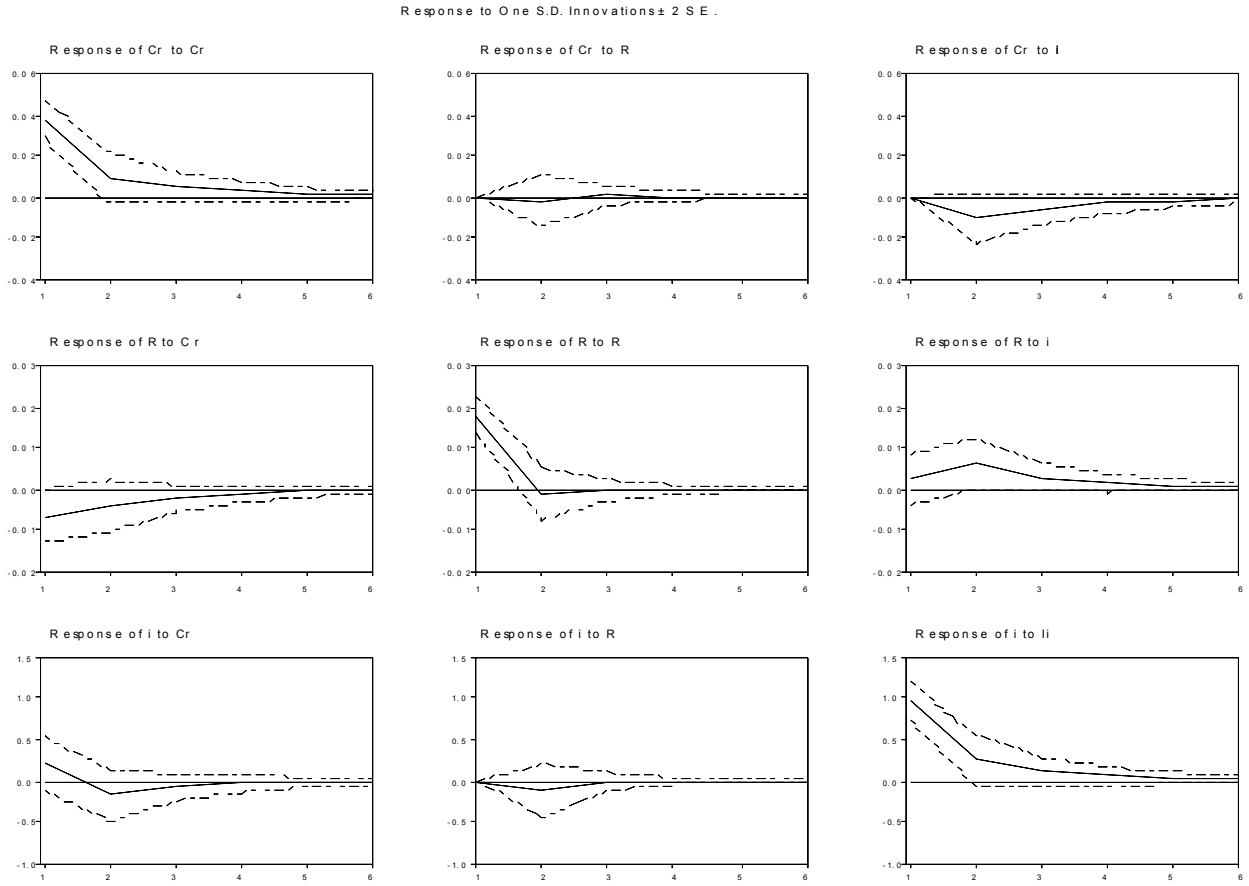
These reasons are consistent with previous empirical findings. Most significantly, the analysis here finds that that domestic interest rate significantly pulled foreign capital to the Czech Republic. Since the authorities struggled to absorb the large amount of liquidity created by the significant surge in short-term capital inflows during 1995, it might be relevant to examine more closely what caused this surge. The next section performs a structural break test for 1995 and singles out the specific changes that took place in that year.

---

the third but not vice versa. Then one gets a recursive system, which is a necessary condition for this analysis to be properly carried out (Lütkepohl, 1993, pp.43–56).

[18] The direction of causality between domestic credit and interest rates is difficult to ascertain as the monetary rules changed over the period. In July 1994, the CNB switched to total bank reserve targeting, which however, did not prevent a sharp increase in domestic interest rates. At the beginning of 1995, the excess bank reserves were adopted as the operational target subject to an overriding upper limit on interbank interest rates. During this period, the authorities attempted to restrain interest rate increases to discourage capital inflows.

Figure 3. Impulse Response Functions



Source: Author's own calculations.

Note: The following order was used: *Cr*, *i*, *R*.

D. Impact of Intensive Sterilization Operation in 1995

Monetary policy came under increasing pressure during 1995 when short-term capital inflows escalated. Section II explained how the Czech authorities increasingly implemented extensive sterilization measures to cope with these inflows that year (evident with a correlation coefficient equal to 0.8 between changes in foreign reserves and sterilization measures). However, as these operations were overwhelmed by the large-scale capital inflows, the Czech authorities decided to widen the bands around the parity in the beginning of 1996 in order to increase exchange rate uncertainty and discourage especially short-term capital inflows.

Given the acceleration in short-term capital inflows to Czech Republic and the grand scale monetary operations in 1995, a test for structural break might detect a significant change in the VAR system. This is tested using a simple *F*-test, which consists of two steps; first, the VAR model was estimated for two subperiods ranging from 1993:1 to 1994:12 and 1995:1 to

1995:12, respectively; second, based on the test regression, a standard *F*-test statistic was calculated using a sum of squares method.[19] The null hypothesis asserts that the VAR model was stable over the three years, while the alternative hypothesis says that a structural change in the basic relationships of the model took place in 1995.

H_0: $\beta_{1993.3\text{-}1994.12} = \beta_{1995.1\text{-}1995.12} \rightarrow$ No structural break.

H_A: A structural break.

A large value of the test statistics increases the probability of rejection of the null hypothesis. The results indicate a structural break in the relation for foreign reserves (significant at a 5 percent level) and domestic credit in 1995 (although at less significant). The domestic interest rate equation appears to be stable, evident from a very small *F*-statistic. Thus, the model does indeed capture the observed changes in capital inflows during 1995, seemingly being caused by the impact of the large differential between domestic and foreign short-term interest rates.

Having established that a structural break took place in 1995, it might be interesting to examine in more details what specific factors caused this change.[20] In that context, each explanatory variable was multiplied by a step dummy taking the value one in 1995, thereby allowing the slopes to vary in that year. The VAR model was then estimated by the usual OLS technique.[21] The results are shown in Table 4. The three columns in the table represent a full period effect (A), a specific 1995 effect (B), and the sum of these measuring the total impact in 1995 (A + B), respectively.

The specific changes to the international reserve relation reveal that the pull-effect of the Czech interest rate became significantly stronger in 1995. The *pull* effect increases five times compared to the estimate for the full period and became more significant. Surprisingly, foreign interest rates, which fell slightly during 1995, still *pushed* capital to the country, evident from the breakdown of the inverse relationship between foreign returns and capital flows in 1995. However, the negative coefficient remains significant for the full sample period. In addition, the inclusion of slope dummies for 1995 increased the absolute value and significance of the offset coefficient in front of domestic credit for the full period, though this effect was not significant.

---

[19]The results from these two regressions can be obtained on request from the author.

[20] This finding also suggests that the result in the previous sections should be treated with some caution. However, the model taking into account the structural break, which is provided below, yielded similar results as the one used in the previous section.

[21] One obstacle with this dummy method relates to the increased number of coefficients, especially, when the sample is small, as in our case. The degrees of freedom fall from 35 - 6 = 29 to 35 -11 = 24, when the model includes dummy variables on all explanatory variables except the constant term.

Table 4. Effects of the Surge in Short-Term Capital Inflows in 1995

Equation	Variable	Full period (A)	1995-specific (B)	Total effect in 1995. (A+B) 1/
ΔR	Δi_{t-1}	0.01*	0.03**	0.03
	Δi^*_t	-0.07**	0.30**	0.22
	ΔR_{t-1}	-0.20	0.65**	0.45
ΔCr	ΔR_{t-1}	0.50	-1.27**	-0.77
	ΔCr_{t-1}	0.47**	-0.80*	-0.32
Δi	Stable	…	…	…

Sources: Author's calculations.
Notes: Significance is indicated by the number of asterisks: (**) = significant at 5 percent level and (*) = significant at 10 percent level.
A full list of regression results is available from the author.
1/ The individual numbers might not add up to the totals, owing to rounding.

The equation for domestic credit indicates that a sterilization bias arose and monetary policy became more erratic in 1995. The first observation concerns the negative and significant 1995-specific coefficient of foreign reserves, ΔR_{t-1}, implying a systemic *inverse* response in domestic credit policy to the large balance of payments surpluses. In other words, the CNB directly attempted to circumvent the expansionary effect of the large inflows by restricting credit measures in 1995. The second observation relates to the *negative* correlation that now appears between changes in credit measures in two adjacent periods, ΔCr_{t-1}, indicating that conducting monetary policy might have been more difficult as inflows accelerated. Attempts to tighten credit policy were subverted by reserve flows expanding liquidity in the Czech economy. This is consistent with the widely accepted view that economies experiencing large speculative capital inflows may find it difficult to maintain a stable monetary policy as they attempt to sterilize these inflows.

Finally, again consistent with the structural break analysis, the interest rate relationship was found to be stable during the full sample period with none of the 1995-specific dummies being significant. Interestingly, however, foreign reserves, which became highly correlated with outstanding sterilization measures in 1995, were found to have a positive (although insignificant) impact on Czech interest rates that year, yielding some support to Calvo's critique that prolonged sterilization can lead to higher domestic interest rates causing even more inflows.

The structural break analysis in this section pointed to some critical effects of the extensive use of sterilization policies in the wake of large capital inflows in 1995. One important finding was the strong pull effect of domestic interest rates on capital inflows. In addition, the analysis found that heavy sterilization operations actually raised domestic interest rates

(yet insignificantly). Another interesting finding was that the large-scale capital inflows, in fact, caused a more erratic credit policy in 1995. The next section discusses the reasons for the aggressive borrowing by domestic banks during the intensive sterilization period.

E. Role of Commercial Banks During High-Capital-Inflows Period

This section examines the role of the commercial banks. The analysis shows that the High-yielding Sterilization Bonds and a credible fixed exchange rate system (at least in the short run) induced banks to borrow extensively abroad and invest in domestic bonds in what can be viewed as a *sterilization game* between the commercial bank and the monetary authorities. As seen in Figure 1, Czech interest rates remained high, despite a fall in foreign interest rates during 1995.

The substantial foreign borrowing by Czech banks in 1995 could indeed have been part of a *sterilization game* that arose with the continuation of sterilization policies and a credible fixed exchange rate system. This allowed banks to borrow cheaply abroad and invest these funds domestically in high-yielding sterilization bonds. In this way, given a sizeable interest differential and few restrictions on capital flows, sterilization policies actually induced additional inflows of a short-term nature (evident from the strong pull effect of domestic interest rates on capital inflows in 1995).

The beneficiaries in this sterilization game were of course capital importers, private banks of both foreign and domestic origin, which profited at the expense of the central bank and ultimately the government, which incurred a quasi-fiscal cost. Hence, the motive for foreign borrowing by domestic private banks during sterilization periods was at least twofold; the first motive was as usual to meet credit demand of the private sector. The second was of a more speculative nature; namely, to exploit the profitable investment opportunity offered by high yielding sterilization bonds (relative to foreign bonds).

The evidence from the Czech sterilization and capital inflow experience from mid-1994 until end-1995 does indeed seem to conform to this sterilization game story. Figure 4 shows how private banks exploited this profit opportunity as they increased their foreign liabilities heavily from mid-1994 to end-1995. For example, in the first and second half of 1995, Czech banks increased their foreign liabilities by US$1,378 million and US$2,089 million, respectively (BIS, 1997).[22] This amounts to an increase of 35 percent and 37 percent, respectively. In the same period, short-term foreign borrowing accounted for 50 percent of total liabilities of the Czech economy. Secondly, Czech private banks channeled a large part of these funds into CNB bills (mainly issued for sterilization purposes), as holdings of these bonds amounted to US$4,548 million at the end of 1995, or equivalent to 40 percent of total foreign reserve holdings in the CNB. Given the nominal interest rate differential of six percentage points, participants in this sterilization game implicitly received a profit equal

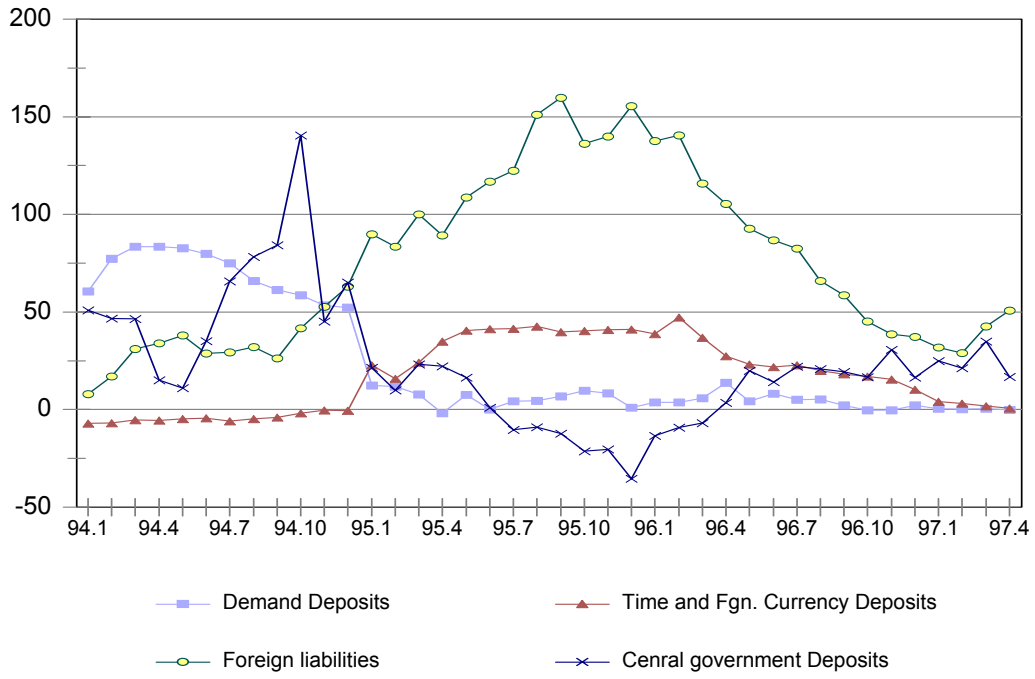
[22] This also amounted to an reduction in their net foreign assets position as their holdings of foreign assets remained roughly constant during the period.

to US$272 million. A large number of the CNB bills were also bought by nonresidents, such as foreign banks (Begg, 1996, page 70, footnote 70).

The high domestic interest rates were perceived to be attractive under the credible fixed exchange rate system. In addition, the combination of a tight monetary policy (achieved by the extensive sterilization operations) and increasing budget deficits exerted further upward pressure on the interest rate and thereby helped to attract further inflows entailing significant quasi-fiscal costs to the CNB.[23]

Figure 4. Main Assets and Liabilities of Commercial Banks, 1994–97

(In percentage change from previous year)



Source: IMF, *International Financial Statistics*.

VI. Conclusions and Some Policy Implications

The Czech economy experienced a deep recession following the currency crisis in 1997. Although the crisis was partly a result of contagion effects from the emerging Asian crisis, the Czech economy appeared to become a victim of its own success. Like the Asian crisis countries, the Czech economy enjoyed high economic growth and strong balance of

[23] Based on data from OECD (1996, p. 39), the quasi-fiscal cost of sterilization in 1995 in GDP terms was about 1 percent.

payments surpluses in most years preceding the crisis. Huge capital inflows masked a significant deterioration in the current account, however. Although these inflows initially rewarded strong fundamentals, they increasingly became more short-term.

Under the circumstances, the Czech authorities were initially successful in maintaining monetary independence, but the sterilization policy created a vicious circle of high interest rates, more capital inflows, and the need for additional sterilization interventions. In the end, the policy proved unsustainable and too costly, and the authorities therefore widened the exchange rate band. Concerning the effect of foreign interest rates on capital inflows, the VAR model showed that, first, foreign interest rates appeared to exert a negative and significant impact on foreign reserves, indicating that capital was *pushed* to the Czech Republic between January 1993 and January 1996 while domestic interest rates *pulled* significant amounts of foreign capital to the Czech Republic. Meanwhile, further analysis showed how high-yielding sterilization bonds and a credible fixed exchange rate system induced banks to borrow extensively abroad and invest in domestic bonds, in what can be viewed as a sterilization game between the commercial banks and the monetary authorities.

One could argue that the authorities held on too long to the combination of a fixed exchange rate and sterilization policies. No doubt an earlier increase in the width of the allowed exchange rate band would have been useful in deterring destabilizing short-term inflows. This solution may not have been politically feasible in the Czech case, since allowing more exchange rate variability would most likely have caused a nominal appreciation, which could have had further adverse effects on the already deteriorating trade balance.

Another option would have been a correction of the policy mix toward tighter fiscal policy and looser monetary policy resulting from less intensive sterilization of the capital inflows. This would have relieved some of the upward pressure on domestic interest rates, which could have helped decrease the amount of "hot" money inflows, thereby increasing monetary stability in the economy. The loosening of fiscal policy throughout the period in a system of fixed exchange rates increased, rather than relieved, the upward pressure on domestic interest rates. The implementation of tighter fiscal policy appeared feasible (even though the government budget was in surplus at the beginning of the period), given that the economy was operating at close to full employment (Begg, 1998).

The main lesson of the paper may, indeed, be that a strategy of relying solely on monetary and sterilization measures without support from fiscal (or other macroeconomic) policies to cushion the economy from the expansionary impact of capital inflows under fixed exchange rate systems may not succeed. In this case, domestic interest rates are likely to remain high, which will attract further capital inflows. In other words, the authorities need to support the fixed exchange rate stabilization policy with appropriately tight fiscal policies in order to relieve the upward pressure on domestic interest rates and thereby discourage short-term capital inflows.

References

Bank for International Settlements (BIS), 1997, *The Maturity, Sectoral and Nationality Distribution of International Bank Lending* (Basel).

Begg, D., 1996, "Monetary Policy in Central and Eastern Europe: Lessons after Half a Decade of Transition," IMF Working Paper 96/109 (Washington: International Monetary Fund).

———, 1998, "Pegging Out: Lessons from the Czech Exchange Rate Crisis," Centre for Economic Policy Research No. 1956 (London: Centre for Economic Policy Research) pp. 1–29.

Boorman, Jack, Timothy Lane, Marianne Schulze-Ghattas, Ales Bulir, Aish R. Ghosh, Javier Hamann, Alex Mourmouras, and Steven Phillips, 2000, "Managing Financial Crises: The Experience in East Asia," *Carnegie-Rochester Conference Series on Public Policy*, Vol. 53, pp. 1–67.

Calvo, G. A., L. Leiderman, and C. M. Reinhart, 1992, "Capital inflow and Real Exchange Rate Appreciation in Latin America: The Role of External Factors," IMF Working Paper 92/62 (Washington: International Monetary Fund).

———, 1993a, "The Capital Inflows Problem: Concepts and Issues," IMF Paper on Policy Analysis and Assessment 93/10 (Washington: International Monetary Fund).

———, 1993b, "Capital Inflows to Latin America: The Role of External Factors," *Staff Papers,* International Monetary Fund, Vol. 40, pp. 108–51.

Davidson, R., and J. McKinnon, 1993, *Estimation and Inference in Econometrics* (Oxford: Oxford University Press).

Dêdek, O., 1997, "Currency Convertibility and Exchange-Rate Policies in the Czech Republic" *Russian and East European Finance and Trade*, Vol. 33, No.3, pp. 46–80.

De Grauwe, P., 1983, *Macroeconomic Theory For the Open Economy* (Aldershot: Gower Publishing Company Limited).

Flood and Marion, 2001, " --- "

Frankel, J. A., 1994, "Sterilization of Money Inflows: Difficult (Calvo) or Easy (Reisen)?," IMF Working Paper 94/159 (Washington: International Monetary Fund).

Greene, W., 1993, *Econometric Analysis*, 2nd edition (New York: Macmillan).

Gros, D. and A. Steinherr, 1995, *Winds of Change: Economic transition in Central and Eastern Europe* (London: Longman).

International Monetary Fund, various issues, *International Financial Statistics* (Washington: International Monetary Fund).

———, 1998, *World Economic Outlook*, October (Washington: International Monetary Fund).

Johnston, B. S. M. Darbar, and C. Echeverria, 1997, "Sequencing Capital Account Liberalisation: Lessons from Experiences in Chile, Indonesia, Korea, and Thailand," IMF Working Paper 97/157 (Washington: International Monetary Fund).

Kornai, J., 1995, *Highways and Byways*, (Cambridge, Mass.: MIT Press).

Kouri, P., and R. Porter, 1974, "International Capital Flows and Portfolio Equilibrium," *Journal of Political Economy*, Vol. 82 (May/June), p 443-467.

Leiderman, L., 1984, "On the Monetary-Macro Dynamics of Colombia and Mexico," *Journal of Development Economics,* Vol. 14 (January/February) pp.183–201.

Lipschitz, Lane, and Mourmouras, 2002; "Capital Flows to Transition Countries: Master or Servant," IMF Working Paper 02/11 (Washington: International Monetary Fund).

Lütkepohl, H, 1993, *Introduction to Multiple Time Series Analysis* (Heidelberg: Springer-Verlag Berlin).

Organization for Economic Cooperation and Development (OECD), 1996, *OECD Economic Surveys: The Czech Republic*, (Paris: OECD).

Reisen, H., 1993, "Macroeconomic Policies toward Capital Account Convertibility," in *Financial Opening: Policy Issues and Experiences in Developing Countries,* ed. by Helmut Reisen and Bernhard Fischer, (Paris: OECD), pp. 43–55.