ECONOMETRIC MODEL SPECIFICATION AND DATA DESCRIPTION

Econometric models of structural determinants of assets and liabilities were estimated using a balanced panel of the G-7 countries (see Tables 1 and 2 for estimation results). The estimation period was 1992-2000 for the assets model and 1992-2001 for the liabilities model. The choice of the sample was driven by data availability. The estimation technique used is the generalized least squares (GLS) random effects procedure. The equations have the following forms:

$$ASS_{it} = \alpha_0 + \alpha_1 * GDPPC_{it} + \alpha_2 * MC_{it} + \alpha_3 * INFL_{it} + \alpha_4 * GOVOLDAGE_{it} + \alpha_5 * OLDAGE_{it} + \varepsilon_{it}$$

$$LIAB_{it} = \alpha_0 + \alpha_1 * GDPPC_{it} + \alpha_2 * INFL_{it} + \alpha_3 * INT_{it} + \alpha_4 * FLA_{it} + \alpha_5 * UN_{it} + \varepsilon_{it},$$

where the variables are defined as follows:

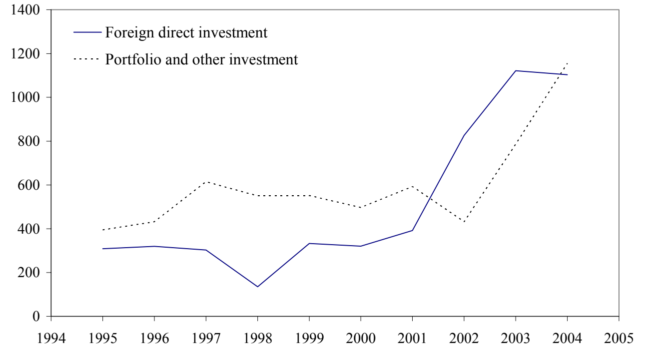
- *ASS* is the ratio of household financial assets to disposable income, available from OECD.
- *LIAB* is the ratio of household liabilities to disposable income, available from OECD.
- *GDPPC* is per capita GDP from the IMF's World Economic Outlook (WEO) database.
- *MC*, the ratio of market capitalization of listed companies to GDP, is used as an index of financial market development, available from the World Bank's World Development Indicators database.
- *INFL* is the consumer price index (CPI)—annual inflation calculated on the basis of CPI data from the WEO database.
- *GOVOLDAGE* is the ratio of old age-related public expenditure to GDP, available from the OECD Social Expenditure Database.
- *OLDAGE* is the old-age dependency ratio, calculated using OECD data on labor force Statistics.
- *INT* are short-term interest rates from IMF, *International Financial Statistics* (*IFS*).
- *FLA*, total liabilities of firms as a percentage of assets, available from the IMF's Corporate Vulnerability Utility database, is used as a proxy for corporate indebtedness.
- *UN* is the OECD standardized rate of unemployment.

V. Monetary Policy Implications of Capital Account Volatility under an Inflation Targeting Regime[32]

A. Introduction and Summary

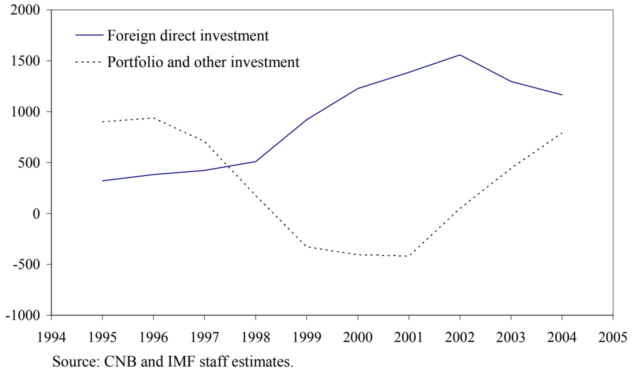
74. **Two trends are evident in the Czech data on financial flows**: (i) an increase in the volatility of direct and portfolio and other investment flows; and (ii) a decline in the magnitude of direct investment flows and an increase in the magnitude of portfolio and other investment flows (Text Figures). While it is difficult to predict whether the volatility of capital flows will continue to increase in the future, there are some reasons to believe that the relative importance of portfolio and other flows might increase over time. Large privatization-related FDI inflows are expected to diminish in importance over the medium term as the country moves up the technology ladder and the marginal product of capital declines. The composition of FDI is likely to shift toward intermediate products and services with lower capital intensity than past FDI.[33] On the other hand, portfolio flows are likely to increase in importance. Increasing trends in investment from funds tracking EU fixed-income securities have already been observed following the Czech Republic's entry in the EU. Moreover, the Czech Republic was also recently included in the Lehman Aggregate Index, which is widely tracked by investors, with expected increases in the liquidity, depth and turnover of asset markets.

Standard Deviation of Quarterly Capital Flows, 1993-2004
(In millions of dollars, three-year rolling averages)



Source: CNB and IMF staff estimates.

Mean of Quarterly Capital Flows, 1993-2004
(In millions of dollars, three-year rolling averages)



Source: CNB and IMF staff estimates.

[32] Prepared by Philippe Karam (INS), Douglas Laxton (RES) and Natalia Tamirisa (EUR). The authors are grateful to Meral Karasulu (WHD) and participants in a EUR seminar for very useful comments.

[33] This change in the composition of FDI is consistent with the authorities' medium-term growth strategy: *Economic Strategy for the Czech Republic*, prepared by the Prime Minister's Office, Prague, Czech Republic, June 2005.

75. **This chapter focuses on the implications of capital account volatility for monetary policy**. To the extent that volatility of key macroeconomic variables increases as capital flows become more volatile, monetary policy will need to become more responsive to capital account shocks to keep inflation on target. The chapter first considers macroeconomic and policy implications of two different types of capital account shocks, namely FDI and portfolio and other investment, with varying degree of persistence. The chapter then examines the implications of a change in the composition of shocks that the Czech economy is exposed to (namely, an increase in the volatility of FDI and portfolio flows, and an increase in the magnitude of portfolio flows and a decline in FDI flows) on the optimally-calibrated monetary policy rules.

76. **The analysis of capital account shocks is based on a two-region version of the IMF's new Global Economic Model (GEM)**. GEM is a dynamic stochastic general equilibrium model developed at the Fund. It has been developed to provide an optimizing intertemporal framework capable of addressing basic policy questions involving international transmission of policy and structural shocks. The model has choice-theoretic foundations building on the new open-economy literature[34] and assumes there is a fundamental role for monetary policy to anchor inflation and inflation expectations by being committed to adjusting the policy rate in response to new information about developments in the economy. Two regions are included in the version of the model used in this chapter—the Czech Republic and the European Union—and it has been calibrated to model the trade linkages between these two economies.

B. A Brief Description of the Model[35]

77. **Each region in GEM includes households, firms, and a government**. Consumption and production are characterized by constant elasticity of substitution utility and production functions. There are two factors of production, labor and capital, which can be moved across sectors to produce a continuum of tradable and nontradable intermediate goods as well as raw and semi-finished materials. Land is a factor of production in fixed supply. A distribution sector drives a wedge between wholesale (producer) prices and retail (consumer) prices that downstream firms producing the final nontradable good must pay. Investment is driven by a Tobin's q-relationship, in which firms respond sluggishly to differences between the discounted value of their marginal products of capital and the replacement value of their capital stock. To simulate realistic investment flows, capital accumulation is subject to adjustment costs of a quadratic functional form. The model assumes imperfect international capital markets where only short-term bonds denominated in foreign currency are traded. Wage contracts and prices of intermediate goods are subject to adjustment costs, i.e., there

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[34] See Obstfeld and Rogoff (1995 and 2000) and Lane (2001).

[35] For a detailed description of the structure and properties of the GEM and its calibration to Czech and EU data, see Laxton and Pesenti (2003).

are nominal wage and price rigidities, designed to guarantee that the model exhibits meaningful dynamics and a realistic representation of lags in the monetary transmission mechanism. Government spending falls exclusively on nontradable goods, both final and intermediate, and is financed through tax and seigniorage revenues. The monetary authority in both countries is assumed to set short-term interest rates based on information about inflation and output.

78. **The model has been calibrated to reflect key macroeconomic features of the Czech Republic and the Euro area**. The shares in GDP of consumption, investment, government spending, exports and imports are calibrated to correspond to historical averages in the two economies. The baseline parameters are based on available estimates from the literature, adjusted to reflect specific characteristics of the Czech and the EU economies. The model adequately replicates the lags in the monetary transmission mechanism that are used in both the Czech National Bank's forecasting model and the ECB's area-wide model. Variability in Czech interest rates and inflation corresponds to the recent, post-disinflation period (see Laxton and Pesenti, 2003).

79. **Monetary policy is specified in terms of a (Generalized) Taylor rule**.[36] A simple interest rate reaction function relates interest rates to the deviation of the inflation rate from the targeted level, the deviation of the interest rate from the neutral level, and the lagged level of the output gap:

$$(1+i_{t+1})^4 - 1 = \omega_i\left[(1+i_t)^4 - 1\right] + (1-\omega_i)\left[\left(1/\beta^4\right)\left(P_t/P_{t-4}\right) - 1\right] + \omega_1\left[P_t/P_{t-4} - \Pi_t\right] + \omega_2\left[ygap\right],$$

(1)

where the left-hand side is the annualized interest rate i_{t+1}, i_t is the lagged interest rate with $0 < \omega_i < 1$, P_t/P_{t-4} is the year-on-year CPI inflation rate, Π_t is the year-on-year inflation target, and *ygap* is the output gap (defined as the deviation of real GDP from the steady-state level implied by the model.) The term with the weight $(1-\omega_i)$ refers to the neutral interest rate. The parameter β is the discount rate and a reciprocal of the steady state real interest rate. In the steady state, the nominal interest rate equals the equilibrium real interest rate plus the rate of inflation.

[36] Taylor (1993). The term "Generalized Taylor (GT) rule" is used here to refer to a Taylor rule with interest rate inertia (ω_i>0). The interest rate rule in the model is similar to the one used in the Czech National Bank's *Quarterly Projection Model* (see CNB, 2003). The main difference is that the CNB rule depends on a model-consistent forecast of year-on-year inflation one year in the future, while the Taylor rule depends on a contemporaneous measure of inflation.

80. **Weights in the interest rate rule function are optimally calibrated to minimize a standard loss function**. In line with a conventional approach in the literature on the evaluation of the monetary policy rules in empirically-based models,[37] we assume a linear loss function, which depends on the unconditional variances of inflation, the output gap, and the first difference of interest rates. Underlying the standard loss function, there is an implicit assumption that minimizing variability in inflation and detrended measures of output is broadly equivalent to maximizing welfare.[38] The loss function is given by:

$$L = \sigma^2\left(P_t / P_{t-4}\right) + L_{ygap}\sigma^2\left(ygap\right) + L_i\sigma^2\left(i_{t+1} - i_t\right), \quad (2)$$

In the baseline loss function L, the weight on inflation variability is 1 and the weights on interest rate variability L_i and the output gap L_{ygap} are ½ each. Alternative weights are considered as part of the robustness analysis. The optimally-calibrated rules imply inertia in the policy rate and a higher weight on inflation vis-à-vis the output gap.

81. **The model encompasses a variety of stochastic shocks.** These include shocks to productivity in all sectors, shocks to aggregate investment (the depreciation rate), consumption (the marginal utility of consumption), government spending, labor effort (the marginal disutility of labor), and a preference shifter that reflects the weight of tradable goods in final good production. Each shock is assumed to follow a stochastic process of the following form:

$$y_t = (1 - \Psi)\bar{y}_t + \Psi y_{t-1} + \varepsilon_t^y, \quad (3)$$

where y_t is the variable, $\bar{y}_t$ is its steady-state value, Ψ is the persistence parameter, and ε_t^y is a Gaussian disturbance term. The distributions of these shocks are calibrated to reflect the historical variability of key macroeconomic variables in the Czech Republic and the EU: real GDP, consumption, investment, government expenditure, exports, imports, CPI inflation, short-term interest rate, and real effective exchange rate. In addition to the above shocks, a risk premium shock is introduced in the GEM model as an additive component in a financial intermediation (friction) function. In the model, domestic agents face a financial transaction cost when they trade the international foreign-denominated bond. Adjustment cost parameters affect the extent of the intermediation friction, and have an impact on the dynamics of net foreign assets and the current account. The source of uncertainty relating to financial intermediation friction in the model is synonymous with what is known as an

[37] See Williams (2003) for a survey.

[38] This assumption holds true as long as the monetary policy does not have significant first-order effects on welfare through its impact on the average level of real variables, such as investment, labor effort, and real income (Svensson, 2003a and 2003b).

uncovered-interest rate-parity shock or a risk premium shock in other models. In the absence of shocks to the risk premium, arbitrage implies that the interest rate differential will be equal to the expected change in the value of the Czech koruna.

C. Capital Account Shocks

82. **We assume that positive FDI shocks lead to productivity improvements**. High-quality foreign technology embodied in Czech production leads to persistent productivity improvements with tested and reliable markets of final products. An example of such FDI is large-scale investment in assembly lines for automobiles, TV sets, and computers, which has been attracted to the Czech Republic over the past decade by the high marginal product of capital and educated labor force. Less persistent FDI shocks reflect investment in medium-size production facilities for intermediate components. Markets for such components are characterized by lower entry costs and greater competition and hence greater uncertainty about market demand and productivity improvements.

83. **Portfolio investment shocks are modelled as a decline in the country risk premium**. The decline in the risk premium can reflect a variety of factors: improved country fundamentals, increases in global liquidity or structural shocks such as a regional reallocation of portfolios. We assume that portfolio investment shocks differ by their persistence as in the case of FDI shocks.

84. **The impact of capital account shocks and their implications for monetary policy depend on the response of aggregate demand and supply**. The supply-side effects reflect changes in incentives, such as an increase in the desired capital stock (when productivity and external demand for domestic tradable goods rises), an increased desire to work (when the demand for labor increases leading to higher real wages), or a reallocation of factors between sectors (when productivity in the tradables sector increases). On the demand side, the increase in consumption depends on the extent to which individuals view an increase in real wages and real appreciation as a permanent increase in their future income. This effect in turn depends on the planning horizon of individuals (their level of impatience) and the persistence of the shock. Investment responds to the real interest rate increase reflecting the increased demand for tradable goods resulting from the FDI shock, while net exports respond to the increase in the demand for domestic tradable goods as well as changes in the real exchange rate.

85. **To assess more general implications of capital account volatility for monetary policy, we recalibrate the weights in the interest rate rule to a new combination of shocks compared to the baseline**. In the interest rate equation (1), the weights minimize the variability of inflation, interest rates, and output in line with the loss function (equation (2), given the historical combination of standard demand and supply shocks. In the simulation experiments, weights are re-estimated assuming a new composition of shocks: (i) smaller and less persistent FDI shocks, and (ii) larger and less persistent risk-premium shocks.

D. Simulation Results

86. **FDI inflows lead to supply-side improvements, which tend to offset the inflationary effect of demand expansion**. In the case of a persistent FDI shock, the real exchange rate appreciates by ⅓ of a percent (in percent deviation from a baseline of zero in the figures), reflecting Balassa-Samuelson effects and improved foreign market penetration (after a slow transition start with low real exchange rate appreciation) . Consumers view this real exchange rate appreciation as a positive wealth effect, which will lead to a permanent increase in their future income. Investment and exports surge in response to higher external demand. The current account deficit widens by about ½ of a percent, as savings fall to accommodate increased investment and consumption. With persistent improvements in productive capacity, the supply-side effects dominate demand-side effects, limiting inflationary pressures and the interest rate response (Figure 1). In fact, in our simulations, the inflation rate remains broadly stable in the long run in the case of persistent FDI. With less persistent FDI, the macroeconomic effects are qualitatively similar (Figure 2). However, since FDI productivity improvements are less certain, the demand pressures are more likely to call for raising interest rates. In our simulations, the monetary authorities would need to tighten interest rates slightly, by less than 25 basis points, to keep the inflation rate on target.

87. **Portfolio inflows lead to real exchange rate appreciation and pressures for inflation to fall, requiring an interest rate cut**. A persistent decline in the risk premium in the uncovered interest parity condition leads to significant real appreciation on impact, about 4 percent in our simulations (Figure 3). This appreciation represents a temporary misalignment of the exchange rate, since it is not associated with an improvement in the productive capacity of the economy and raises concerns about the sustainability of the ensuing current account deficit. Real appreciation creates disinflationary pressures, to which the monetary authorities respond by lowering interest rates by over 40 basis points. The less persistent is the decline in the risk premium and the associated portfolio inflows, the smaller is the real appreciation (2½ percent in our simulations), and the smaller is the interest rate cut needed to bring inflation to the targeted level (25 basis points) (Figure 4).

88. **Higher volatility of capital flows reduces the weight on interest-rate smoothing component of the monetary policy rule**. We assume that the composition of shocks hitting the Czech Republic changes, with FDI shocks becoming smaller and less persistent and portfolio shocks becoming larger and less persistent. Smaller and less persistent FDI shocks do not lead to any significant changes in the variability of macroeconomic variables, because such shocks are broadly consistent with the historical composition of shocks and historical macro-variability in the Czech Republic (Table 1). In contrast, larger and less persistent risk-premium shocks increase variability of aggregate demand components, the output gap, and inflation. To minimize macroeconomic variability, it becomes appropriate to assign a somewhat lower weight to the interest rate smoothing component of the monetary policy rule ($\omega_i = 0.91$ compared to $\omega_i = 0.96$ in Table 1). Monetary policy needs to be less constrained by past interest rates to address increasing macroeconomic volatility. This result is robust to

alternative weights on the output gap and interest rate variability in the loss function given by equation (2).

Table 1. Optimal Weights in the Monetary Policy Rule and Measures of Macroeconomic Variability 1/

	Optimal weights			Measures of macro-variability (σ)		
	Interest rates (ω_i)	Inflation rate (ω_1)	Output gap (ω_2)	Inflation rate	Output gap	Interest rates
Baseline	0.96	0.29	0.13	1.73	1.79	0.57
Smaller and less persistent FDI shocks	0.96	0.29	0.13	1.73	1.78	0.57
Larger and less persistent portfolio shocks	0.91	0.28	0.12	1.76	1.95	0.67

Source: IMF staff estimates.
1/ The table reports weights in the Generalized Taylor rule given by equation (1). The weights have been optimally calibrated to minimize the standard loss function given by equation (2). Also reported are measures of macro-variability in the loss function.

E. Conclusion

89. **The main conclusion of this chapter is that an increase in capital account volatility calls for a more responsive monetary policy**. The capital account shocks considered in this chapter were classified as FDI and portfolio investment shocks. Yet conclusions can be generalized beyond this dichotomy:

- Capital account shocks might be associated with supply-side improvements, which would help offset the demand-side effects and dampen inflationary impact of demand expansion. If such supply-side effects are smaller in the case of more volatile capital flows, demand-side effects are more likely to dominate, calling for a greater monetary policy response to keep inflation close to target.

- To the extent that capital account volatility increases the volatility of key macroeconomic variables, monetary policy may need to become more responsive and be somewhat less constrained by past interest rates. However, unless the volatility of capital flows increases significantly, the impact on the optimal monetary policy rule is likely to be relatively small. The difficulty of forecasting the persistence of capital flows in real time also calls for caution in responding actively to capital account shocks.

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Figure 1. The Czech Republic: Simulated Effects of a Persistent FDI Shock

(Deviation from the baseline; in percent, unless otherwise specified)

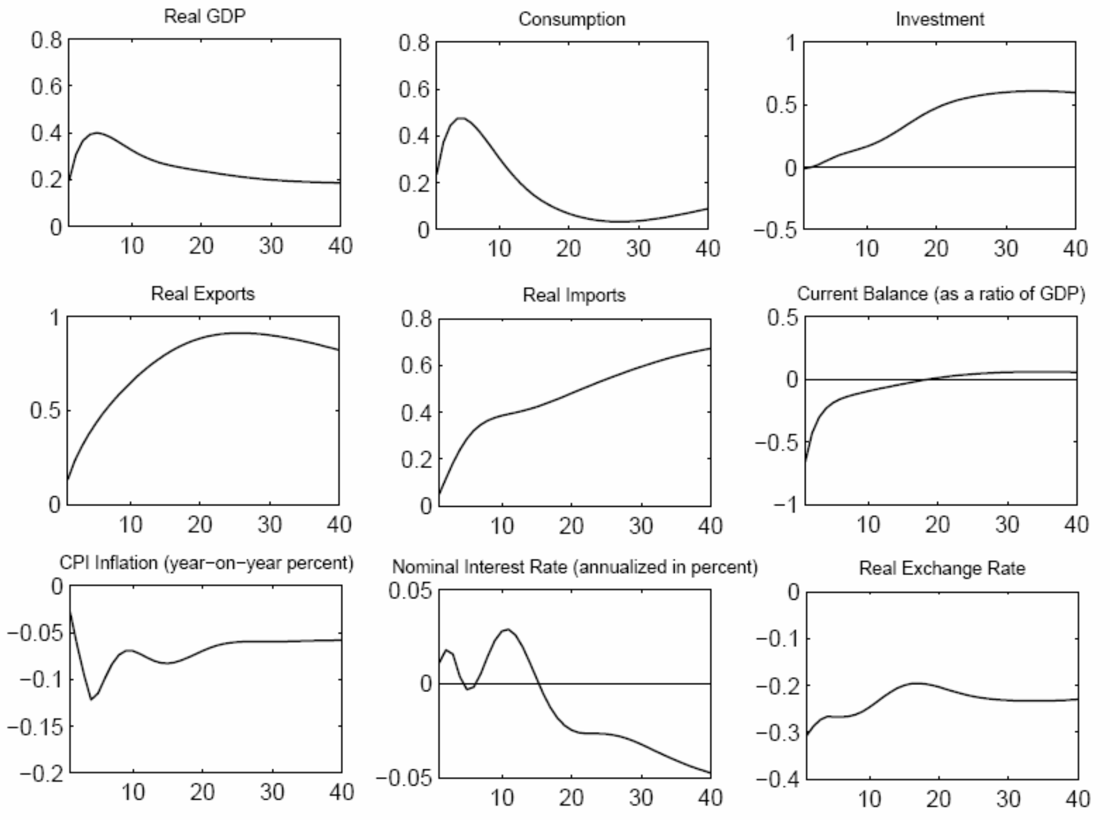

Figure 2. The Czech Republic: Simulated Effects of a Less Persistent FDI Shock

(Deviation from the baseline; in percent, unless otherwise specified)

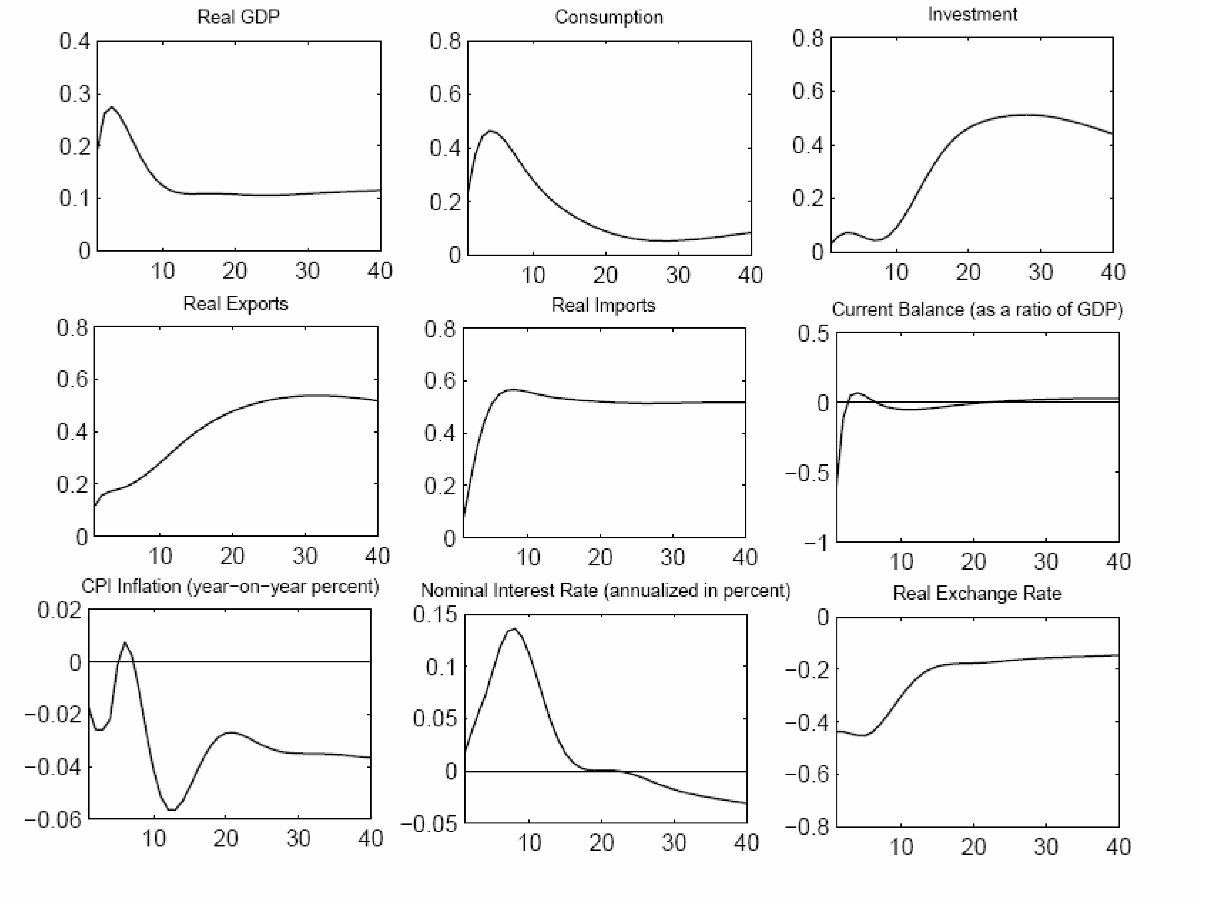

Figure 3. The Czech Republic: Simulated Effects of a Persistent Portfolio Investment Shock

(Deviation from the baseline; in percent, unless otherwise specified)