Trade Deficits in the Baltic States: How Long Will the Party Last?*

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Abstract

Since their opening up to international capital markets, the economies of Estonia, Latvia and Lithuania have experienced large and persistent capital inflows and trade deficits. This paper investigates whether a calibrated two-sector neoclassical growth model can explain the magnitudes and the timing of the trade flows in the Baltic countries. The model is calibrated for each of the three countries, which we simulate as small closed economies that suddenly open up to international trade and capital flows. The results show that the model can account for the observed magnitudes of the trade deficits in the 1995-2001 period. Introducing a real interest rate risk premium in the model increases its explanatory power. The model indicates that trade balances will turn positive in the Baltic states around 2010.

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1 Introduction

As the transition in Estonia, Latvia and Lithuania enters its second decade with trade deficits and capital inflows that show no signs of reversal, the general public and the Baltic politicians in particular are increasingly concerned about the consequences of the large deficits. Most economists approach the issue using the neoclassical framework and make the point that external deficits in poor countries are not a problem, but rather a sign of healthy development, as long as the foreign capital is wisely invested in the local economy. However, an elementary ingredient in the neoclassical message is that the developing country will, sooner or later, have to start repaying its foreign creditors.

Is there really no reason to worry about the size of the trade deficits in the Baltic states, as long as ten years after liberalization? The aim of this paper is to give a quantitative answer to that question. Calibrating and simulating a two-sector neoclassical growth model for each of the Baltic states, we investigate whether the trade deficits implied by the theory are in line with the magnitudes observed in the data. In simulations of the Baltic countries as initially closed economies that suddenly open up to trade, we pinpoint the predicted timing of capital flow reversals in the model.

The type of model we employ is sometimes referred to as 'the dependent economy model' (Turnovsky, 1997). It is a standard two-sector model of a small open economy with a traded good, a non-traded good, labor, capital and an investment good that augments the capital stock. Traded and non-traded goods are either consumed or used as inputs into the investment sector, in which case we can consider them as equipment and structures. Previous literature includes many applications of the model: Fernandez de Cordoba and Kehoe (2000) apply the model to study the Spanish economy after its entry into the European Community in 1986. Slightly different versions of the same model have been used to study the consequences of exchange-rate based stabilization programs in countries such as Portugal (Rebelo, 1993) and Argentina (Burstein, Neves and Rebelo, 2003).

In this paper, we use the same basic model as in Fernandez de Cordoba and Kehoe (2000), where the authors point to the importance of incorporating frictions in factor mobility for the two-sector growth model to explain data on capital flows and real exchange rates. Our paper builds on this finding and contributes to the development of the dependent economy model in two ways. Firstly, we specify adjustment costs in a way that enables us to calibrate the factor frictions used in the analysis. Relating the magnitude of frictions in the model to what we observe in the data is a prerequisite for taking the quantitative implications of the model simulations seriously. In contrast, Fernandez de Cordoba and Kehoe (2000) chose ad hoc parameter values for the factor frictions to match the model in the dimensions they wanted to study. Secondly, we do modelling and data work to study the effects of incorporating a calibrated interest rate premium in our simulations for the Baltic countries.

The sudden change of the economic system in the Baltic states after their independence in 1991 and an almost immediate economic liberalization make the countries well-suited as test cases for the model. Estonia, Latvia and Lithuania were completely closed off from the west before 1991 and upon opening, they were much poorer than their western neighbors. The three countries are small and have become very open; the population ranges from 1.4 million in Estonia to 3.7 million in Lithuania, while exports plus imports amount to more than 110 percent of GDP in all three countries.

In Section 2, we identify the years when trade and capital flows were liberalized in each of the Baltic countries. These years will be used as the first open periods in our simulations. Section 3 looks at data for the Baltic countries and identifies important macroeconomic developments that have been associated with the trade deficits in the decade after liberalization. Data is presented for the trade balances, real GDP growth rates, the sectoral composition of GDP and the real exchange rates.

Sections 4, 5 and 6 present the model, its calibration, and the results of our basic simulations. The model is found to capture the main dynamics of trade balances and output, but the initial responses to the shock of liberalization are larger in the model than what we observe in the Baltics. Furthermore, the real exchange rate dynamics of the model do not show any of the persistence found in the data. Both of these problems are in the next section addressed with an extension of the model.

In Section 7, we augment the model to account for financial frictions by introducing and calibrating an interest rate risk premium on foreign loans to each of the Baltic states. The model dynamics for the trade balances, the real exchange rates and the sectoral composition of GDP now more closely capture the variation in the data. The trade deficits in the model are in line with what we observe in the data, and the predicted year of capital flow reversal is around 2010 for all three countries. The date of reversal is robust to varying the initial capital stocks used in the simulations. If the neoclassical model is an appropriate framework for analyzing the Baltic countries, our results indicate that the current sustained trade deficits should not be a reason to worry and that the reversal of capital flows will come in about seven years.

Section 8 concludes and gives suggestions for future research.

2 Dating the Economic Liberalization in the Baltic Countries

In this paper, the Baltic states will be modeled as initially closed economies that suddenly open up to trade with the rest of the world. A time period in the model will represent one year. Although extraordinarily rapid, the economic liberalization was a gradual process that took more than a year. It is therefore not possible to identify exactly one year in which it all happened. To make our computational experiment valid, we identify the first year for which it can be said that the Baltic economies where sufficiently integrated in the world economy, sufficiently driven by market forces, and had sufficiently well working currency arrangements for our model of the small open economy to make sense.

In their quest to achieve social stability and economic growth, the Baltic states rather closely followed the recommendations of the 'Washington consensus', which advocated a rapid shift from a planned economy to an open market system. With some minor exceptions, Estonia opted for a complete liberalization of import and export flows by 1993, thereby becoming one of the most open countries in the world. Latvia and Lithuania also liberalized their trade flows in 1993, but retained import duties of 15 percent or less on most products, as well as export duties on some products. Capital flows were liberalized by 1993 in Latvia and Lithuania and by 1994 in Estonia.

To appropriately choose the first open years in our simulations, the degree to which economic outcomes were market determined in the years following the independence from the Soviet Union should also be considered. A relatively large private sector with competing firms is important for a successful application of the model, since our model assumes perfect competition. Most prices were liberalized and a process of rapid privatization was begun in the Baltics already in 1992. Privatization was less rapid in Latvia, which is seen in Table 1, where the share of the private sector in GDP is taken as a proxy for the progress of privatization. Table 1 also reveals that the private sector did not produce half of GDP or more in any of the three countries until 1994.

The existence of a credible national currency is of importance because a liberalization of capital flows is incomplete without a reasonably functioning foreign-exchange market. All three countries substituted away from the Russian rouble in 1992, with Estonia implementing a currency board in mid-1992. In the same year, Latvia and Lithuania introduced transitional currencies that were allowed to float. In 1993, Latvia adopted a permanent currency, which was pegged to the SDR at the beginning of 1994. The Lithuanian permanent national currency was not issued until the end of 1994, when a currency board was established.

A weighted assessment of these elements of liberalization leads us to treat 1994 as the first open year for Estonia, since most of the liberalization had been completed by that year. For Latvia and Lithuania, we choose 1995 as the year of opening, motivated by the slower pace of reforms in those countries. Privatization was less rapid in Latvia, and Lithuania was slower in implementing an exchange-rate based stabilization program and introducing a credible national currency. Current account data lends support to these choices of opening years. According to the World Development Indicators database, the current account turned negative in Estonia in 1994 and in Latvia in 1995. For Lithuania, the current account, as a percentage of GDP, was close to zero in 1993 and 1994, to become significantly negative in 1995.

3 Effects of the Economic Liberalization

All three Baltic countries have been running substantial trade deficits since the economic liberalization.[1] Net trade in goods and services as a percentage of nominal GDP is presented in Figure 1, which shows steady trade deficits of around 10 percent of GDP since the liberalization. The contraction of the deficits during the 1999-2000 period was a result of the Russian crisis in 1998-1999. Data for 2002 shows that in Estonia and Latvia, trade deficits are now back at around 10 percent of GDP.

The completion of liberalization coincided with the time when economic growth returned to the Baltic states, following a period of contraction immediately after the independence. During the 1995-2001 period, real economic activity expanded with yearly average growth rates of 4.9 percent in Estonia, 4.8 percent in Latvia and 3.8 percent in Lithuania. Figure 2 shows annual real GDP growth rates in the three countries after the opening.

In the model which we subsequently develop, the GDP share of traded output and the real exchange rate will be closely associated with trade flows. Next, we therefore examine the development of these variables in data for the Baltic states.

A shift in economic activity from the traded to the non-traded sectors is associated with the large trade deficits in the Baltic countries. Defining manufacturing (except electricity, gas and water), agriculture, mining and transportation as the traded sector and other industries as non-traded, Figure 3 shows the reduction of the traded sector as a share of GDP to vary from 7 percentage points in Estonia to 14 percentage points in Latvia. The shift mainly consists of a contraction in manufacturing and agriculture and an expansion of the wholesale/retail trade, the real estate and the construction industries. In Estonia and Lithuania, after contracting to around 40 percent of GDP, economic activity shifted back towards the traded sector in the period 2000-2001.

Along with sustained trade deficits, the Baltic states have also experienced marked real exchange rate appreciations. Figure 4 presents the development of the log of the bilateral real exchange rate with Germany for each of the Baltic countries after the liberalization. We choose to present the real exchange rate with Germany, since it is the largest trading partner for Latvia and Lithuania and the third largest for Estonia. Germany is also the largest economy in the EU, which accounts for more than half of the total trade in all three Baltic states. Nominal exchange rates and Consumer Price Indices from the IFS are used to construct the series labeled rer in Figure 4.

In the model that we develop in section 4, there is only one traded good and no nominal

[1] Before the collapse of the USSR, the Baltic republics were net exporters.

variables. Therefore, we can only hope to account for the part of the real exchange rate fluctuations which is due to changes in the relative price of non-tradable to tradable goods in each country. Assuming that Purchasing Power Parity holds for goods in the traded sector, we use the same decomposition as in Betts and Kehoe (2001) to express the real exchange rate in terms of its traded and non-traded components:

$$RER_t = RER_{Tt} * RER_{Nt}, \tag{1}$$

where

$$RER_{Tt} = S_t \frac{P^G_{Tt}}{P^C_{Tt}}, \qquad RER_{Nt} = \frac{P^G_t}{P^C_t}\frac{P^C_{Tt}}{P^G_{Tt}}.$$

Here S_t stands for the nominal exchange rate expressed in units of Baltic currencies per DM, P^G_t is a price index for Germany, P^C_t, $C \in \{Est, Lat, Lit\}$ is a price index for each of the Baltic states and P_{Tt} is a price index for tradable goods.

In (1), RER_{Tt} captures price changes of traded goods whereas RER_{Nt} captures relative price changes of non-traded goods. Expressing (1) in log form we have:

$$rer_t = rer_{Tt} + rer_{Nt}. \tag{2}$$

The assumption of Purchasing Power Parity in our model implies that $rer_{Tt} = 0, \forall t$ and that fluctuations in the real exchange rate can only be caused by movements in the relative price of non-tradables across countries. Since we cannot account for more than rer_N with our model in section 4, we plot rer_N together with the log of the real exchange rate in Figure 4. When constructing price indices for traded goods (P^C_{Tt} and P^G_{Tt}), we use Producer Price Indices for the manufacturing sector in each country.[2]

In line with the existing empirical evidence for other countries, we find most of the real exchange rate movements in the Baltic states to be explained by changes in the relative prices of traded goods.[3] Relative movements of non-traded prices are, however, also important and account for 43 percent of the movement in the real exchange rate between 1994 and 2001 in Latvia. The same figures for Estonia and Lithuania are 30 percent and 17 percent, respectively. Figure 4 reveals a co-movement between rer and rer_N, with a clear trend of sustained appreciation present in both the real exchange rate and its non-traded component for all three countries. Therefore, we can hope for the model to account for a significant part of the observed real exchange rate fluctuations, although the Purchasing Power Parity assumption considerably limits its explanatory power.

[2]For a more detailed discussion of the suitability of PPI as a measure of price changes for traded goods; see Engel (1999) and Betts and Kehoe (2001).

[3]For evidence on other countries, see Engel (1999), Chari, Kehoe and McGrattan (2001), Betts and Kehoe (2001), and Burstein, Neves and Rebelo (2003).

4 The Model

Each Baltic country is modeled as a small open economy with a representative consumer. There are five goods in any period: a traded good, a non-traded good, capital, labor and an investment good augmenting the capital stock in the subsequent period.

The representative consumer maximizes the sum of discounted utility from the consumption of traded and non-traded goods. Taking prices as given, the consumer solves the following problem:

$$\max_{\{c_{Tt},c_{Nt},k_{t+1},b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{\sigma}-1}{\sigma}\right] \tag{3}$$

where

$$c_t = \left[\varepsilon c_{Tt}^{\eta} + (1-\varepsilon)\, c_{Nt}^{\eta}\right]^{\frac{1}{\eta}} \tag{4}$$

subject to

$$\begin{aligned} c_{Tt} + p_{Nt}c_{Nt} + q_{t+1}k_{t+1} + b_{t+1} \leq w_t L + (1+r_t)b_t + v_t k_t, \forall t \\ c_{Tt} \geq 0, \forall t \\ c_{Nt} \geq 0, \forall t \\ b_{t+1} + q_{t+1}k_{t+1} \geq -A, \forall t \\ k_0, b_0 \quad \text{given.} \end{aligned} \tag{5}$$

Here, c_{Tt} is consumption of the traded good, which is numeraire in the model; c_{Nt} is consumption of the non-traded good; p_{Nt} is the relative price of the non-traded good; k_{t+1} is investment in the domestic capital stock, purchased at the relative price of capital q_{t+1}; b_{t+1} is investment in a bond denominated in units of traded goods and earning the interest r_{t+1}; L is the endowment of labor, inelastically supplied at wage w_t; and $v_t k_t$ is income from selling capital at the relative price v_t to firms producing traded or non-traded goods.

Note that q_t is the price at which the consumer acquires capital for period t (the transaction takes place at the end of period $t-1$), whereas v_t is the price at which the consumer sells capital in period t to firms producing traded or non-traded goods.

The specified utility function exhibits a constant intertemporal elasticity of substitution, $1/(1-\sigma)$, and a constant intratemporal elasticity of substitution between traded and nontraded goods in consumption, $1/(1-\eta)$. ε is a preference parameter and β is a subjective discount rate.

If b_{t+1} is negative, the economy is borrowing from the rest of the world. Ponzi schemes are ruled out by assuming that consumer's assets, $b_{t+1} + q_{t+1}k_{t+1}$, in any period cannot be smaller than $-A$, for A sufficiently large.

The first-order conditions for the consumer maximization problem are:

$$
\begin{aligned}
u_{c_T}(c_t) - \theta_t &= 0, && (6)\\
u_{c_N}(c_t) - \theta_t p_{Nt} &= 0, && (7)\\
\theta_{t+1}\beta(1 + r_{t+1}) - \theta_t &= 0, && (8)\\
\theta_{t+1}\beta v_{t+1} - \theta_t q_{t+1} &= 0, && (9)
\end{aligned}
$$

where θ_t is a Lagrange multiplier for the consumer budget constraint, $u(c_t) = (c_t^\sigma - 1)/\sigma$, and where $u_{c_T}(c_t)$ denotes the marginal utility from consumption of traded goods in period t.

The model allows for different specifications of interest rate determination. If the economy is closed in period t, there can be no foreign borrowing or lending, $b_{t+1} = 0$, and the return on investment is endogenously determined in the model. If the economy is open, the interest rate is equal to an exogenously given international rate, $r_{t+1} = r_{t+1}^*$ and b_{t+1} is endogenously determined.

A condition of no arbitrage between investments in domestic capital and foreign assets requires the relationship between the prices of capital before and after production to be

$$v_{t+1} = q_{t+1}(1 + r_{t+1}). \qquad (10)$$

In addition to being consumed, the traded and non-traded goods can be used as inputs into the investment sector. The economy's resource constraint for non-traded goods is:

$$c_{Nt} + x_{Nt} \leq F_N(k_{Nt}, k_{Nt-1}, l_{Nt}, l_{Nt-1}), \ \forall t \qquad (11)$$

where x_{Nt} is the input of non-traded goods into the investment sector. Note that the production process for non-tradables, $F_N(.)$, is a function of inputs of capital and labor into the non-traded sector in both the current and the previous period. Output depends on lagged production factors due to costs associated with frictions in capital and labor mobility.

The resource constraint for traded goods is more complicated, due to the possibility of trading with the rest of the world:

$$c_{Tt} + x_{Tt} + b_{t+1} - b_t(1 + r_t) \leq F_T(k_{Tt}, k_{Tt-1}, l_{Tt}, l_{Tt-1}), \ \forall t \qquad (12)$$

where $b_{t+1} - b_t(1 + r_t)$ is the trade balance.

Investment goods are produced using a Cobb-Douglas technology taking traded and non-traded goods as inputs. The investment good augments the capital stock in the subsequent period, which gives the following law of motion for capital:

$$k_{t+1} - (1-\delta)\, k_t \leq G x_{Tt}^{\gamma} x_{Nt}^{1-\gamma},\ \forall t. \tag{13}$$

Firms in the investment sector are assumed to operate under perfect competition. They choose how much of the traded and non-traded good to buy as inputs, taking prices p_{Nt} and q_{t+1} as given. In every period, firms in the investment sector maximize:

$$\max_{\{x_{Tt}, x_{Nt}\}} q_{t+1} G x_{Tt}^{\gamma} x_{Nt}^{1-\gamma} - x_{Tt} - p_{Nt} x_{Nt}. \tag{14}$$

The problem in (14) has the following first-order conditions:

$$q_{t+1}\gamma G x_{Tt}^{\gamma-1} x_{Nt}^{1-\gamma} - 1 \leq 0, \tag{15}$$

$$q_{t+1}(1-\gamma) G x_{Tt}^{\gamma} x_{Nt}^{-\gamma} - p_{Nt} \leq 0. \tag{16}$$

Firms producing traded or non-traded goods maximize infinite horizon profits under perfect competition. Taking prices as given (with p_{Tt} normalized to 1, since the traded good is numeraire), the firms choose how much capital and labor to buy in each period. The firms in the traded and non-traded sectors solve the following problem:

$$\max_{\{k_{jt}, l_{jt}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \left[\prod_{i=0}^{t} \frac{u_{c_T}(c_{i+1})}{u_{c_T}(c_i)} \right] \pi_t, \tag{17}$$

where

$$\pi_t = p_{jt} F_j(k_{jt}, k_{jt-1}, l_{jt}, l_{jt-1}) + q_{t+1}(1-\delta) k_{jt} - w_t l_{jt} - v_t k_{jt}, \tag{18}$$

$j \in \{T, N\}$ and δ is a constant per-period capital depreciation rate. The production functions are assumed to have the following form:

$$F_j(k_{jt}, k_{jt-1}, l_{jt}, l_{jt-1}) = A_j k_{jt}^{\alpha_j} l_{jt}^{1-\alpha_j} - \Phi(k_{jt}, k_{jt-1}) - \Psi(l_{jt}, l_{jt-1}), \tag{19}$$

$$\text{where} \quad \Phi(k_{jt}, k_{jt-1}) = \frac{\phi\zeta}{1+\zeta} \left(\frac{|k_{jt} - (1-\delta) k_{jt-1}|}{k_{jt-1}} \right)^{\frac{1+\zeta}{\zeta}} k_{jt-1}, \quad \zeta > 0, \phi \geq 0, \tag{20}$$

$$\Psi(l_{jt}, l_{jt-1}) = \psi \left(\frac{l_{jt} - l_{jt-1}}{l_{jt-1}} \right)^2 l_{jt-1}, \quad \psi \geq 0. \tag{21}$$

Here, $\Phi(.)$ is a convex cost associated with investment, which we model in line with Abel and Eberly (1994) and Eberly (1997). Note that the specification in (20) implies capital frictions to be present in steady state, because the cost is associated with the transformation of investment goods rather than the adjustment of the capital stock. $\Psi(.)$ is a quadratic cost associated with the adjustment of the labor force in a sector, in line with Sargent (1978) and Cooper and Willis (2003). The specification implies that there are costs of both hiring and firing, whenever labor movements between sectors take place. It is in the specification of the factor frictions that our model differs from the model in Fernandez de Cordoba and Kehoe (2000). The functional forms in equations (20) and (21) can readily be calibrated to the data, which is not the case for the frictions used by Fernandez de Cordoba and Kehoe.

The first-order conditions for the profit maximization problem in (17) are:

$$p_{jt}\frac{\partial F_j(k_{jt},k_{jt-1},l_{jt},l_{jt-1})}{\partial l_{jt}}+\beta p_{jt+1}\frac{u_{c_T}(c_{t+1})}{u_{c_T}(c_t)}\frac{\partial F_j(k_{jt+1},k_{jt},l_{jt+1},l_{jt})}{\partial l_{jt}}-w_t\leq 0, \quad (22)$$

$$p_{jt}\frac{\partial F_j(k_{jt},k_{jt-1},l_{jt},l_{jt-1})}{\partial k_{jt}}+q_{t+1}(1-\delta)-v_t+\beta p_{jt+1}\frac{u_{c_T}(c_{t+1})}{u_{c_T}(c_t)}\frac{\partial F_j(k_{jt+1},k_{jt},l_{jt+1},l_{jt})}{\partial k_{jt}}\leq 0.$$

Definition of equilibrium An equilibrium in this model is characterized by sequences of prices $\{\widehat{p}_{Nt},\widehat{w}_t,\widehat{q}_{t+1},\widehat{v}_t,\widehat{r}_{t+1}\}_{t=0}^{\infty}$, consumption and assets $\left\{\widehat{c}_{Tt},\widehat{c}_{Nt},\widehat{k}_{t+1,}\widehat{b}_{t+1}\right\}_{t=0}^{\infty}$, sectoral production plans $\left\{\widehat{k}_{Tt},\widehat{l}_{Tt}\right\}_{t=0}^{\infty}$ and $\left\{\widehat{k}_{Nt},\widehat{l}_{Nt}\right\}_{t=0}^{\infty}$, and inputs into the investment sector $\{\widehat{x}_{Tt},\widehat{x}_{Nt}\}_{t=0}^{\infty}$, such that:

(i) given prices $\widehat{p}_{Nt},\widehat{r}_{t+1},\widehat{q}_{t+1}$ and $\widehat{v}_{t+1}$, the representative consumer's first-order conditions in (6)-(9) are satisfied in every period.

(ii) given prices $\{\widehat{p}_{Nt},\widehat{w}_t,\widehat{q}_{t+1},\widehat{v}_t\}_{t=0}^{\infty}$, producers in sector $j\in\{T,N\}$ choose factor inputs $\left\{\widehat{k}_{jt},\widehat{l}_{jt}\right\}_{t=0}^{\infty}$ so that the first-order conditions in (22) are satisfied in every period.

(iii) given prices $\widehat{p}_{Nt}$ and $\widehat{q}_{t+1}$, the investment sector's first-order conditions in (15) and (16) are satisfied in every period.

(iv) The market clearing conditions in (11), (12) and (13) are satisfied in every period. If the economy is closed in period t, $\widehat{b}_{t+1}=0$. If the economy is open in period t, $\widehat{r}_{t+1}=r^*_{t+1}$.

(v) Factor markets clear in every period:

$$\begin{aligned}\widehat{k}_{Tt}+\widehat{k}_{Nt} &= \widehat{k}_t,\quad \forall t \\ \widehat{l}_{Tt}+\widehat{l}_{Nt} &= L,\quad \forall t.\end{aligned} \quad (23)$$

5 Calibration

In this section, we first discuss the data used in the calibration and then present the way we calibrate the model to the Baltic countries.

5.1 Data issues

Most of the macroeconomic data we need for this paper was readily available at the statistical offices in the Baltic states. The only exceptions, which we now discuss in more detail, were data on capital stocks and input-output tables.

Capital stock estimates Unfortunately, there are no official estimates on capital stocks available for the Baltic countries. Furthermore, since the time series of National Accounts data for the Baltic states are very short, we cannot estimate the capital stock using the perpetual inventory method. Instead, we estimate the capital stock by assuming the total capital stock to be the sum of fixed tangible assets of all enterprises in the economy, and the total stock of residential housing. A detailed explanation of this method is presented in Appendix A. Dividing these estimates with the output for the same year, we obtain capital-output ratios of 1.41 for Estonia, 1.40 for Latvia and 1.33 for Lithuania.

We have confidence in our estimates for two reasons. First, using a different methodology, Hazans (1999) arrives at a similar estimate for the part of the capital stock excluding residential housing for Latvia. Second, the size of our estimates for residential housing stocks relative to real GDP per capita is broadly in line with the averages for countries with similar income levels in PWT 5.6.[4]

Input-output tables Our calibration of the model to the Baltic economies relies on input-output tables. Given the amount of detailed data required, it should not be surprising that input-output matrices were not constructed for the early years of transition in the Baltic states. We base our calibration on the first official input-output tables for 1997 for Latvia and Estonia and the 1998 experimental input-output table for Lithuania.

We aggregate the input-output tables into two-sector input-output tables, which requires that we classify each sector of the economy as traded or non-traded. In deciding whether an industry is traded, we use a classification that has empirical foundations in De Gregorio et al. (1994), and that is commonly used in the literature (see for instance Stockman and Tesar (1995)). The classification is summarized in Table 2.

In the context of the model, the classification in Table 2 has an intuitive appeal. We can think of the traded sector as producing *equipment* and the non-traded sector as producing *structures*. The traded sector should include services and goods that can be immediately traded and used when the borders open up. Furthermore, the sector should consist of products that are fairly homogenous across countries. Defined this way, the traded sector can be expected to satisfy the assumption of Purchasing Power Parity.

Based on Table 2, we aggregate the 57 sector input-output matrices compiled by

[4]See Summers et al. (1995).

the central statistical offices in the Baltic countries to obtain the two-sector matrices presented in Tables 3 and 4.[5]

5.2 Initial factors and parameter values

When calibrating the model, we use the equilibrium conditions of the model while normalizing all prices to 1 for the initial year, except the rental price of capital. Results of the calibration for each of the Baltic states are summarized in Table 5.

As explained above, we cannot use input-output tables for the last closed year (1993 for Estonia and 1994 for Latvia and Lithuania) in our calibration. In general, parameters derived from input-output tables for 1997 or 1998 might be more representative for the simulated time span, but caution is called for since relative price changes occur between the beginning of the simulation and the year for which parameter values are calibrated. We deal with this by constructing appropriate price indices for traded and non-traded goods. Price changes for traded goods are captured with the PPI for manufacturing, and for non-traded goods we use GDP deflators for the non-traded sector. These indices connect the normalized prices of the last closed year with prices of the year for which input-output tables are available.[6]

In our baseline simulations, we set the value of $\sigma = -1$, which is a standard value in the literature (see, for example, Mankiw, Rotemberg and Summers (1985)) and implies an intertemporal elasticity of substitution in consumption equal to 0.5. Following empirical estimates in Kravis et al. (1982) and Stockman and Tesar (1995), the intratemporal elasticity of substitution between traded and nontraded goods in consumption is also set equal to 0.5, so that $\eta = -1$. In Section 7, we perform sensitivity analysis by investigating the model dynamics under different assumptions about the consumption elasticities.

In simulating the model, we will take Germany as representing the world outside the Baltic states. The rate of depreciation, δ, is calibrated for Germany, using the law of motion for capital and the Summers et al. (1995) data on capital stocks and expenditures on gross fixed capital formation. To obtain our parameter value, we calculate a fifteen-year average for the years 1975-1989, which yields $\delta = 0.081$.

An assumption on which we will base our simulations is that the German economy has reached its steady state. The discount factor, β, is therefore calibrated for Germany, using the average real return on German government bonds over the 1981-2001 period. The measured annual real interest rate is $r^* = 0.0419$, which implies that $\beta = 1/(1+r^*) = 0.9597$.

To calibrate ε, the consumption entries by sector in the input-output tables need to be

[5] We have not received permission to publish the 1998 unofficial input-output table for Lithuania.

[6] In theory, this should not be a problem, since we use price indices as deflators to uncover the allocations expressed in base year prices. In practice, it of course introduces an additional source of measurement errors.

adjusted with price indices. Using the first-order conditions for the consumer's problem in (6) and (7), we obtain:

$$\varepsilon = \frac{\left(\frac{c_{N97}}{c_{T97}}\right)^{\sigma-1}}{\left(\frac{p_{N97}}{p_{T97}}\right)^{\sigma} + \left(\frac{c_{N97}}{c_{T97}}\right)^{\sigma-1}}, \tag{24}$$

where c_{T97} and c_{N97} are consumption of traded and non-traded goods in current prices, which can be obtained directly from the input-output table.[7]

In order to calibrate the parameters of the production function for the investment sector, γ and G, we use estimates from the literature. Burstein et al. (2004) report that in OECD countries, 41 percent of aggregate investment expenditures are spent on the output of the traded sector. Empirical work by Bems (2004), on a larger sample of countries, reports a very similar expenditure share on traded goods and shows that this share does not vary systematically with the level of income. Based on this evidence, we set $\gamma = 0.41$ for each of the Baltic states. Using the first order conditions in (15) and (16), the value of G is then obtained as

$$G = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}. \tag{25}$$

Eberly (1997) has estimated the convex component of capital frictions of the same form that we specified in (20). Looking at annual data for the OECD countries between 1981-1994, she finds that ζ ranges from 0.65 in Sweden to 1.95 in France. For the Baltic states, we have adopted the convexity parameter that she estimated for the US, $\zeta = 1.22$. Our choice is motivated by the observation that the Baltic states in the 1990's were closer to the US, with very liberal capital regulations, more bankruptcies and higher volatility of the capital stock at the firm level than in Western Europe. Unfortunately, Eberly cannot simultaneously identify the level parameter, ϕ, and the convexity parameter. In our baseline simulations we set $\phi = 1$, resulting in steady state investment costs of 1.4 percent of GDP in Estonia, 1.6 percent in Latvia and 1.9 percent in Lithuania. In Section 7, as a robustness check, we also report the model dynamics for the case of larger investment costs ($\phi = 2$), and for the case with no investment costs ($\phi = 0$).

Next, we calibrate the production functions for traded and non-traded goods. Output figures for each sector in the last year before liberalization, y_{T0} and y_{N0}, were obtained from National Accounts data. Normalizing the total output in each country to 100, the values of sectoral outputs are presented in the second and third rows of Table 5.

To obtain values for $k_{T0}, k_{N0}, l_{T0}, l_{N0}, \alpha_T, \alpha_N, A_T$ and A_N, we solve a system of eight equations provided by the equilibrium conditions of the model for the autarky steady state. The equations are presented in detail in Appendix B and the resulting values for initial factor endowments, income shares and productivity levels are reported in Table 5.

[7] In the case of Lithuania, the time subscript in equation (24) is 1998.

The calibrated income shares are broadly in line with the empirical findings in Gollin (2002), where it is argued that capital income shares in most countries around the world are in the 0.20-0.35 range. In all three Baltic states, there are no notable differences in the income shares across the traded and nontraded sectors. This finding is in line with Parente and Prescott (2000), who note that highly aggregated sectors of economic activity exhibit similar income shares.

Finally, we calibrate ψ so that sectoral job creation in the model never exceeds the highest rates of sectoral net job creation observed in the data. For the period from the first open year until 2001, data on employment by economic activity is available at the national statistical offices. After aggregating this data into sectors, we find that the largest observed annual net job creation rates were 6.4 percent in Estonia, 5.1 percent in Latvia and 2.9 percent in Lithuania. In all three countries, the maximum increase took place in the non-traded sector. The high sectoral adjustment capacities we find in the data are in line with Haltiwanger and Vodopivec (2002), who study job flows in Estonia and reveal a very high degree of flexibility in the labor market of that economy.

6 Simulation of the Model

In this section, we simulate the model introduced and calibrated in the previous sections. Each Baltic country is modeled as an initially closed economy that opens up in the first year after the economic liberalization (1994 for Estonia and 1995 for Latvia as well as Lithuania). Figure 5 presents the simulated time paths of the trade balance, the annual growth rate of real GDP, the GDP share of traded output and the logarithm of the real exchange rate for the three model economies. To contrast the model results with the data, we have included the corresponding Baltic data in the graphs. Note that the relevant data series for the real exchange rate is rer_N and not rer.

After the economic liberalization, the capital-poor model economies borrow heavily from abroad, as revealed by the large trade deficits in Figures 5a-5c. Naturally, this implies that in steady state, the economies will have to run permanent trade surpluses. In essence, the large net inflows of traded goods are a result of consumption smoothing by consumers. After the shock of liberalization, borrowing allows consumers to transfer the higher levels of future consumption into the early stage of transition. Trade deficits in the model exceed those observed in the data for all three countries, although the model does capture the main dynamics.

The model growth rates of real GDP capture the trends observed in the data, as shown in Figures 5d-5f. The initial contraction of real GDP in the model is a result of costly factor reallocation, as a response to liberalization. For Latvia and Lithuania, we do not observe such effects in the data. After the initial adjustment, however, GDP in the model expands at a rate similar to the data for all three countries.

In line with the data, traded output as a fraction of GDP decreases after liberalization. However, this process exhibits more persistence in the data than in the model, which is seen in Figures 5g-5i. Since consumers in the model can only borrow traded goods, the shock of liberalization makes the non-traded goods relatively scarce. As specified in (13), the investment sector requires both traded and non-traded goods as inputs for augmenting the capital stock. While traded goods can be borrowed, non-traded goods must be produced at home. Thus, non-traded goods become a bottleneck for development in the model. The optimal response of the Baltic model economies is to initially import traded goods and specialize in the production of non-traded goods at home.[8]

In terms of the real exchange rate, Figures 5j-5l show that the model dynamics imply a sharp appreciation in the first open year. The intuition for the marked appreciation in the model follows from our discussion of traded output: the scarcity of the non-traded good results in a sudden substantial increase in its relative price. Similar to the sectoral dynamics of output, the model predicts too strong an appreciation of the real exchange rate in the first year after liberalization and fails to capture the persistence in the data.

7 Interest Rate Risk Premium

After the opening of their economies, the Baltic states faced considerably higher real interest rates than Germany, which is something that has so far not been accounted for in our model. Interest rate differentials can slow down capital flows in the model and cause persistence in the movements of the real exchange rate and the sectoral composition of output. We pursue a simple way of investigating such dynamic effects by introducing real interest rate risk premia on foreign loans in the model, which we calibrate to the risk premia that can be observed in data for the Baltic countries.

It is common in the literature on business cycles in small open economies to model the risk premium as a function of aggregate debt, in line with Benigno (2001) and Schmitt-Grohé and Uribe (2003). A look at the risk premia and the debt levels in the Baltic countries however reveals that the interest risk premia in the Baltic countries mainly have been determined by factors other than the debt level. Table 6 reveals that the ratio of total external debt to GNI has increased dramatically in all three countries, while a first glance at Table 7 tells us that the risk premia at the same time fell substantially.[9] Subsequently, we will define the risk premia and explain the calculations behind Table 7.

We believe that institutional factors explain the falling risk premia in the Baltics. The Institutional Investor ratings (IIR), which Reinhart et al. (2003) use as a component in

[8] If the model had no frictions in factor markets, the optimal solution would be for all three countries to completely specialize in producing non-traded goods in the first open period.

[9] Our definition of total debt is the same as in Reinhart et al. (2003), and includes both private and public external debt. The data in Table 6 is taken from the Global Development Finance database.

evaluating debt intolerance, have been constantly improving for the Baltic countries since 1994 (*Institutional Investor*, March 2004). A theoretical foundation for the effects of institutions on the risk premium has been provided by Eaton, Gersowitz and Stiglitz (1986), who point to the importance of the possibility of enforcing contracts when extending international credit to developing countries. Hutchison (2002) has provided empirical evidence that countries with better institutions and regulatory environments run lower risks of banking crises. Using the World Bank Governance Indicators provided by Kaufmann et al. (2003), one finds that the Baltic countries, between 1996 and 2002, gradually approached the institutional quality of Germany when it comes to political stability, control of corruption, democracy, rule of law and regulatory quality.

Given that the standard growth framework does not lend itself readily to the modelling of changing institutional factors, we chose to introduce the empirically observed interest rate premium exogenously in the model.

The real interest rate risk premium ρ_t^C for country $C \in \{Est, Lat, Lit\}$ in period t is defined as:

$$1 + r_t^C = (1 + \rho_t^C)(1 + r_t^*), \tag{26}$$

where $1 + r_t^C$ is the gross interest rate faced by consumers in country C on foreign loans to be repaid in period t, and where r_t^* is the international real interest rate.

Taking Germany and the U.S. as representing the rest of the world, the risk premium is calibrated as:

$$\rho_t^C = \frac{r_t^C - r_t^W}{1 + r_t^W}. \tag{27}$$

Here, r_t^C is the annualized average real interest rate charged on 6-12 month DM denominated loans to the private sector in Estonia or on 6-12 month US dollar denominated loans to the private sector in Latvia and Lithuania; and r_t^W is the real interest rate on loans to enterprises for up to twelve months in Germany (for Estonia) or the real prime loan rate in the U.S. (for Latvia and Lithuania). Yearly CPI inflation rates in Germany (for Estonia) or the U.S. (for Latvia and Lithuania) were used to calculate real interest rates.

There are several reasons for considering DM denominated loans in Estonia and US dollar denominated loans in Latvia and Lithuania. Lending rates are appropriate, since it is the private sector that has incurred most of the debt in the Baltic countries: In the period 1997-2001, private debt as a percentage of total debt averaged 86 percent in Estonia, 61 percent in Latvia and 40 percent in Lithuania. We want to avoid any local currency risk considerations to be reflected in the measured risk premium, which is why foreign currency loans must be considered. It is also the case that most of the lending to the private sector in the Baltic states during the 1990's was denominated in foreign currencies. In Estonia, the majority of the foreign currency loans were DM denominated, while in Latvia and Lithuania almost all such loans were denominated in US dollars.[10] Although theoretically, it would be better to calculate the risk premium in DM (or Euro) denominated loans for all three countries, the market for such loans was very thin in Latvia and Lithuania in the 1990's. By calculating the risk premium using US dollar interest rates, we implicitly assume that, for the sake of our simulations, differences in the U.S. and German real interest rates can be ignored.

The interest rate data for the Baltic countries was taken from the web sites of the national central banks.[11] Interest rate data for the U.S. is from the IMF International Financial Statistics, whereas the interest rate data for Germany is from the Economist Intelligence Unit database. The risk premia we arrived at through these calculations are shown in Table 7 and the resulting interest rate differentials in the model are depicted in Figure 6.

Since a non-negligible real interest rate risk premium is still present in 2001, we must take a stand in our simulations about the future size of the premium. In our baseline simulations, we assume that after 2001, the risk premium in the three Baltic states will decrease linearly, reaching zero in 2005. This is based on the assumption that a financial crisis does not occur in the Baltic countries or that the country risk does not increase relative to Germany in the years to come. We believe that this is the most likely scenario. With the accession to the EU, the IIR ratings of the three Baltic countries increased substantially in September 2004 (*Institutional Investor*, September 2004), which according to Reinhart et al. (2003) would imply that the countries can sustain higher debt levels without increasing the risk of a crisis. With the participation in the ERM and the likely adoption of the Euro in 2007/2008, Estonia, Latvia and Lithuania will have to comply with the requirements of the Stability and Growth Pact, which will strengthen fiscal discipline and help to avoid surging public debt. When simulating the model, we perform sensitivity analysis with respect to our assumption about the future interest rates, and in the next section, we further discuss the possibility of a financial crisis in the Baltic countries.

With a country-specific interest rate risk premium, the problem of the representative

[10] These differences in denomination is a result of the exchange-rate arrangements. The Estonian Kroon was fixed to DM, the Lithuanian Lita was fixed to the US dollar and the Latvian Lat was pegged to the SDR, which in the 1990's was dominated by the US dollar.

[11] The websites are www.bank.lv/eng/main/pubrun/monaps, www.eestipank.info/pub/en/dokumendid/statistika/tabelid and www.lb.lt/eng/statistic/index.html.

consumer in country C now reads:

$$\max_{\{c_{Tt},c_{Nt},k_{t+1},b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \frac{1}{\rho} (\varepsilon c_{Tt}^{\rho} + (1-\varepsilon)\, c_{Nt}^{\rho} - 1) \tag{28}$$

$$\text{subject to: } c_{Tt} + p_{Nt} c_{Nt} + b_{t+1} + q_{t+1} k_{t+1} \leq w_t L + (1 + r_t^C) b_t + v_t k_t, \forall t \tag{29}$$

$$c_{Tt} \geq 0, \forall t$$

$$c_{Nt} \geq 0, \forall t$$

$$b_{t+1} + q_{t+1} k_{t+1} \geq -A, \forall t$$

$$b_{t+1} \begin{cases} \leq 0 & \text{if } \rho_{t+1}^C > 0 \\ \in \mathbb{R} & \text{else} \end{cases} \tag{30}$$

$$k_0, b_0 \quad \text{given.}$$

Here, $r_t^C = (1 + r^*)\left(1 + \rho_t^C\right) - 1$ is the real interest rate at which consumers can borrow in period $t-1$, and ρ_t^C is the risk premium for country C in period $t-1$. Once more, in our simulations, we will assume the rest of the world to be in steady state, so that $r^* = \beta^{-1} - 1$.

Note that the constraint (30) implies that the consumer cannot lend abroad, if there is a positive risk premium. Naturally, a more accurate specification of the investment opportunities would be to allow consumers to lend at the world interest rate in any period. From our simulations of the model in section 6, we know, however, that the representative consumer does not optimally lend until after 2006 at the world interest rate in any of the three countries. The constraint on foreign lending reflects the exogenous nature of the introduced risk premium. Although it would be more satisfactory to obtain the risk premium as an endogenous outcome of the model, the current setup provides a simple way of evaluating the effects of such a premium. The rest of the model is the same as in Section 4.

The model with a risk premium is solved by first finding a solution without imposing the constraint in (30). If the optimal solution in any period t is to lend at an interest rate above the international rate, we set $b_{t+1} = 0$ and resolve the model. It turns out that for Estonia and Lithuania, the optimal solution with the calibrated risk premia never violates (30). In the Latvian model economy, the constraint on b_{t+1} is violated in the first open period. The opening is therefore postponed for a period, since the calibrated interest rate in the period after liberalization is so high that consumers do not find it optimal to borrow.

The dynamics of the model with the interest rate risk premium are presented in Figure 7.[12] The higher interest rates slow down the capital inflows and thus, the initial adjustments in all of the graphs are more gradual. Since the cost of borrowing from

[12]In the simulations shown in Figure 7, ψ has been recalibrated to match the observed maximum net job creation rates: $\psi^{Est} = 1.39$, $\psi^{Lat} = 16.65$, $\psi^{Lit} = 30.07$.

abroad now varies between periods in a realistic manner, the model accounts for more of the variations in the data.

For Lithuania, the model captures the overall trade balance dynamics, although the size of the deficits in the model is still larger than in the data. Part of the discrepancy between the model and the data in Figures 7a-7c is likely to be a consequence of the Russian crisis of 1998-99, which we have not modelled. As shown in Figure 2, Latvia was the country least affected by the crisis while Lithuania was most severely hit.

Figures 7d-7f show the initial contraction of GDP in the model to be smaller and more in line with the data when an interest rate risk premium is introduced. The simulated GDP growth rates still capture the trends of the data, but the rates of expansion are slightly lower than in the model without the risk premium.

An interesting result is that the model with a risk premium can generate a more gradual decrease in the relative size of the traded sector, and some sustained appreciation in the real exchange rate. In terms of sectoral adjustment, the model dynamics in Figures 7g-7i are now more similar to the gradual shift towards the non-traded sector that we observe in the Baltics. The overall magnitude of the shift is, however, still larger in the model economies than in the data.

The real exchange rate appreciation in the model now lasts for three periods in Lithuania and for two periods in Estonia and Latvia (see Figures 7j-7l). Furthermore, the overall size of the appreciation for Latvia and Lithuania is very close to what we observe in the data. For Estonia, the introduction of the risk premium results in the model real exchange rate not moving enough, however.

Sensitivity analysis Tables 8-10 summarize the dynamics of the model with interest rate premia, under different initial capital stocks and parameter values that deviate from the baseline calibration. In producing each line of the tables, the other parameters of the model were recalibrated when required.

The estimates of the initial capital-output ratios in the Baltic countries are crucial for the outcome of our simulations, since in the model trade deficits are a consequence of the Baltic economies being capital poor when liberalization occurs. In Tables 8-10, we see that changes in the initial capital stocks have a considerable effect on the size of the trade deficits that the model economies experience during the first decade after liberalization. For instance, a twenty-percent decrease in the initial capital stock decreases the Estonian minimum trade balance by about three percentage points of GDP in the peak year, while a twenty-percent increase in the capital stock increases the minimum trade balance by three percentage points. At the same time, the year in which capital flows are reversed is rather insensitive to varying the initial capital stocks. The first year of trade surplus only changes by a year up or down when varying the initial capital stocks for the three countries.

Tables 8-10 further reveal that the consumption elasticities do not matter very much for the years of trade flow reversals predicted by the model. The magnitudes of the trade deficits are, however, sensitive to the elasticity of intertemporal substitution. For a lower value of the intertemporal elasticity, the model economies display larger trade deficits than in the baseline simulations.

The sensitivity analysis shows that the parameters governing the factor frictions are important for the dynamics in the model. Switching off the investment friction, or dramatically changing its convexity properties, affects the years of trade flow reversals in the model. Similarly, switching off the labor friction produces much larger trade deficits and earlier reversals than in the baseline simulations. This should not be surprising, given that Fernandez de Cordoba and Kehoe (2000) demonstrated the importance of including factor frictions in the two-sector model, in order for it to match the data at all.

Given the variation in the capital share parameters that we calibrate for the Baltic countries, it is of interest to note that the dates of trade flow reversals, for all three countries, are completely insensitive to setting both α_T and α_N to 1/3.

In each table, the last line shows that the model dynamics do not change much if we assume that the interest rate differential with Germany disappears by 2008, instead of 2005.

8 Concluding Remarks

The results of the simulations in this paper show that a calibrated two-sector growth model can account for much of the trade deficits in the Baltic states during the last decade. The model predicts that the current deficits will be reversed into trade surpluses in 2008 for Estonia, in 2011 for Lithuania and in 2013 for Latvia. The predicted years of trade flow reversals have in the simulations proven robust to considerable changes in the initial capital inherited from the Soviet Union. There is reason to have confidence in the results of the neoclassical model, since the implications of the model for real GDP growth, the sectoral composition of GDP and the real exchange rate are in line with the data for the Baltic countries.

The analysis has shown that the reversal of trade flows will have far reaching effects on the Baltic economies. The current boom in the service and real estate sectors will, according to the model, come to an end as capital and labor will have to be shifted into the traded sector to produce export goods. A high degree of flexibility in the labor market therefore seems imperative for the economies to successfully accommodate the pressures for sectoral readjustment in the future. Politicians and the general public in the Baltics should bear in mind that a serious transfer problem, with drastically reduced imports as a result, might arise if the factors of production cannot easily be moved into the export sector.

One important aspect which we have not modelled in this paper is the possibility of a financial crisis in the Baltic countries. Although we believe that the most likely future scenario is one without sudden stops in the Baltic countries, there is still a risk of future crises. As many emerging markets have experienced in the last decade, financial crises tend to be associated with sudden interruptions of capital flows and sharp increases in the trade balance. Although our model cannot account for reversals of trade flows due to financial crises, we believe that the model says something about the long run dynamics of capital flows in the Baltic countries. In the event of a crisis in the next years, we would likely see trade surpluses before the reversal dates predicted by the model. However, we believe that a sudden stop would only cause a temporary reversal of capital flows in the Baltic countries. These small countries are still much poorer than their fellow members in the EU, and they will offer attractive investment opportunities to foreigners for a long time. We conjecture that the forces of economic transition would be sufficiently strong to produce trade deficits again in the Baltic countries, soon after the crisis. In the event of a sudden stop, we could therefore expect trade surpluses for a sustained period of time to arise later than predicted by our analysis.

The prospects of productivity growth in the Baltic states have also been omitted in our quantitative exercise. Productivity is likely to increase as the Baltic states catch up with the EU economies. In the model, this would increase the steady-state levels of capital and consumption, thereby inducing larger trade deficits. The Balassa-Samuelson effect of higher relative productivity growth in the traded sector, would in our model increase the relative price of non-traded goods and lead to a more sustained appreciation of the real exchange rate.

Our analysis has furthermore not taken into account that economic trends in countries that open up to trade can depend on changes in government policies and on tax changes in particular. As indicated in Conesa and Kehoe (2003), taking capital taxation into account would slow down capital flows in the model, reduce the investment demand for non-traded goods, and thereby reduce the initial appreciation of the real exchange rate.

The introduction of an interest rate risk premium is found to improve the model's explanatory power. An interesting extension of the present work would therefore be to endogenize financial market frictions, which could be done by incorporating explicit financial contracts in the model. The introduction of uncertainty and volatility of interest rates in the model would have the effect to slow down capital flows due to precautionary savings. We think that extensions in this direction could be very fruitful. Solving for stochastic transition paths lies beyond the scope of this paper, but it is an extension that we hope to pursue in future research. Another improvement would be to explore ways of relaxing the assumption of purchasing power parity for traded goods, since that would allow the model to account for a larger part of the observed real exchange rate movements.

A Estimates of the capital stocks

In this appendix, we describe the methodology used for estimating the capital stocks in the Baltic states. The final estimates are obtained as a sum of the value of fixed tangible assets and the value of residential housing in each of the countries.

Data on fixed tangible assets is provided by the national statistical offices in each of the countries. It is obtained from the balance sheets of all larger companies (more than 100 employees) and a representative sample from small enterprises. For Lithuania, the earliest measurement of fixed tangible assets that we have obtained was for the end of 1995. To obtain the same figure for 1994, we subtract gross fixed capital formation for 1995 ($GFCF_{95}$) and add consumption of fixed capital for 1995 (CFC_{95}) to the fixed tangible assets in 1995 and then deflate the resulting figure with the GDP deflator for 1995. The nominal value of the stocks of fixed tangible assets that we obtain are 1772.6 million lats for Latvia in 1994, 21115.4 million krooni for Estonia in 1993 and 13506.9 million litas for Lithuania in 1994.

To our knowledge, there is no reliable data available for the stock of residential housing in the Baltic states. To obtain an estimate of the residential capital, we therefore look at comparable data for other countries. The country which is closest to the Baltic states in its economic conditions and for which residential housing stock data is available in the PWT 5.6 data set is Poland. To estimate the residential housing stock for the Baltic states using Polish data, we assume that in each of the Baltic countries, the real value of residential capital per capita in the last closed year was the same as the real value of residential capital per capita in Poland in 1990. More formally,

$$\frac{real\ rescap_i^C}{n_i^C} = \frac{real\ rescap_{90}^{Pol}}{n_{90}^{Pol}}, \tag{A.1}$$

where $C \in \{Est, Lat, Lit\}$, i is the last closed year (1993 for Estonia and 1994 for Latvia and Lithuania), *real rescap* is the real value of the residential capital stock and n is population. Such an assumption is quite reasonable, since before the collapse of socialism, the level of economic development in Poland and the Baltic states was similar and, by 1994, the progress of transition in the Baltics was at a level comparable to Poland's progress by 1990.

According to the data in PWT 5.6, the Polish stock of residential housing in 1990 was at a level of 47 per cent of real GDP. Next, we use PWT 6.1 (see Heston, Summers and Aten (2002)), which is the first version of the Penn World Tables to include real GDP data for the Baltic states, but it does not yet include data on residential capital stocks for any country. Using PWT 6.1, we translate the value of Polish residential housing into comparable figures for the Baltic states. This is done by first noting that in PWT 6.1, the Polish ratio of residential housing stock to real GDP in 1990 should be the same as in

PWT 5.6, since the different 'international dollars' in which values are measured in PWT 5.6 and PWT 6.1 cancel out in a ratio. Thus, we get that the real residential capital per capita for Poland in 1990 was 3121.8 '1996 international dollars'. Using our assumption in equation (A.1), the Polish per capita value of the residential housing is applied to each of the Baltic states through the following formula:

$$nominal\ rescap_i^C = \frac{nominal\ GDP_i^C}{real\ GDP_i^C} \frac{real\ rescap_{90}^{Pol}}{n_{90}^{Pol}} n_i^C, \tag{A.2}$$

where the notation is the same as in equation (A.1). $real\ GDP_i^C$ is measured in 1996 international dollars and $nominal\ GDP_i^C$ is measured in year i local currency of country C. The resulting value for the $nominal\ rescap_i^C$ is measured in the same (nominal) units as tangible fixed assets. Using this procedure, we get that the residential capital stock was 1087.0 million lats for Latvia in 1994, 9666.8 million krooni for Estonia in 1993 and 7836.5 million litas for Lithuania in 1994.

Adding up fixed tangible assets and residential housing stock and dividing the sum by nominal GDP, we obtain the following capital to output ratios:

$$\frac{k_{93}^{Est}}{y_{93}^{Est}} = 1.410, \qquad \frac{k_{94}^{Lat}}{y_{94}^{Lat}} = 1.399, \qquad \frac{k_{94}^{Lit}}{y_{94}^{Lit}} = 1.334. \tag{A.3}$$

B Calibration of production functions

First, note that output in sector j, where $j = \{T, N\}$, in the last year before liberalization is:

$$y_{j0} = A_j k_{j0}^{\alpha_j} l_{j0}^{1-\alpha_j} - \frac{\phi\zeta}{1+\zeta} \delta^{\frac{1+\zeta}{\zeta}} k_{j0}, \tag{B.1}$$

where the last term is the cost associated with the transformation of investment goods into capital. Next, we use the fact that capital in each sector in equilibrium must earn its marginal product, which implies that

$$y_{j0} X_j = \left(\alpha_j A_j k_{j0}^{\alpha_j - 1} l_{j0}^{1-\alpha_j} + Z \right) k_{j0}, \tag{B.2}$$

where $Z = \beta\phi\delta^{\frac{1}{\zeta}} \left(1 - \frac{1}{\beta} - \frac{\zeta}{1+\zeta}\delta\right)$ is once more a term stemming from investment transformation costs and where X_j denotes the income share of capital and is obtained from the aggregated input-output tables using the following formula:[13]

$$X_j = \frac{os_{j,97}}{os_{j,97} + wl_{j,97} + mix_{j,97}}. \tag{B.3}$$

[13]Note that since capital frictions are present in the steady state in the model, the capital income share in a sector differs from α_j.

Here, os is the operating surplus (i.e. the operating surplus of incorporated enterprises), wl is remuneration of employees and mix stands for mixed income (i.e. the operating surplus of private unincorporated enterprises). We include all mixed income in labor income, which has been proposed by Gollin (2002) as one way of getting the income shares right. This is a sensible adjustment for self-employment, since household enterprises in the Baltic countries are labor intensive. Unfortunately, we only have data on the division between mixed income and operating surplus for Latvia. Since the three Baltic economies are very similar in structure, we assume the relative size of these subcategories of business profit to be the same for all three countries. In the case of Lithuania, the time subscript in (B.3) refers to 1998.

Equilibrium conditions also require that the returns to capital and labor are the same in both sectors, which implies that:

$$\alpha_T A_T k_{T0}^{\alpha_T - 1} l_{T0}^{1-\alpha_T} = \alpha_N A_N k_{N0}^{\alpha_N - 1} l_{N0}^{1-\alpha_N}, \tag{B.4}$$

$$(1-\alpha_j) A_j k_{j0}^{\alpha_j} l_{j0}^{-\alpha_j} = 1, \quad j = \{T, N\}, \tag{B.5}$$

where in the last equality, we used the fact that initial wages have been normalized to 1. Finally, we can use the market clearing condition for capital:

$$k_0 = k_{T0} + k_{N0}. \tag{B.6}$$

The eight equations in (B.1)-(B.2) and (B.4)-(B.6) are used together to obtain values for $k_{T0}, k_{N0}, l_{T0}, l_{N0}, \alpha_T, \alpha_N, A_T$ and A_N.

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Table 1: The size of the private sector in the Baltic states, percent of GDP

	1991	1992	1993	1994	1995	1996
Estonia	10	25	40	55	65	70
Latvia	10	25	30	40	55	60
Lithuania	10	20	35	60	65	65

Source: EBRD Transition report 1995-2000

Table 2: The division of industries into traded and non-traded sectors

Traded industries	**Non-traded industries**
Agriculture	Energy
Fish	Construction
Mining	Wholesale/retail
Manufacturing	Hotel services
Transport/	Finance
Communications	Real estate/renting
	Public administration
	Education
	Health
	Other community services

Table 3: Aggregated input-output matrix for Latvia, 1997

(Million Lats)

EXPENDITURES

		1	2	3	1+2+3	*C+G*	*I*	*X*	*C+G+I +X*	*TOTAL*
	1	1630.2	664.0	69.6	2363.8	1179.7	459.7	1438.9	3078.3	5442.1
R	2	404.5	570.9	76.4	1051.8	1212.8	286.6	207.6	1707.0	2758.9
E	3	14.3	22.1	37.8	74.1	419.8	0.0	17.5	437.4	511.5
C	1+2+3	2049.0	1257.0	183.7	3489.7	2812.3	746.3	1664.1	5222.7	8712.5
E	*wl*	660.5	745.0	197.2	1602.7					1602.7
I	*rk*	614.6	554.3	75.3	1244.1					1244.1
P	*os*	448.9	479.2	55.6	983.7					983.7
T	*mix*	165.7	75.1	19.7	260.5					260.5
S	*T*	324.0	78.9	25.8	428.6					428.6
	wl+rk+T	1599.2	1378.1	298.2	**3275.5**					**3275.5**
	M	1794.0	123.7	29.6	1947.3					1947.3
	TOTAL	5442.1	2758.9	511.5	8712.5	2812.3	746.3	1664.1	5222.7	

Source: derived from Central Statistical Bureau of Latvia (2001)

1. Traded sectors (agriculture, fishing, mining, manufacturing, transport).

2. Non-traded sectors (except services not for sale).

3. Services not for sale (public adm., defense, other community services).

wl. Remuneration of employees.

rk. Net business income, of which

os. Operating surplus (incorporated enterprises).

mix. Mixed income (unincorporated enterprises).

T. Net indirect taxes and transfers including value added tax.

M. Imports.

C+G. Private consumption plus government consumption.

I. Investment

X. Exports

Table 4: Aggregated input-output matrix for Estonia, 1997

(Billion Kroons)

EXPENDITURES

		1	2	3	1+2+3	*C+G*	*I*	*X*	*C+G+I +X*	*TOTAL*
	1	43.1	18.1	1.5	62.7	21.5	10.6	41.9	74.0	136.7
R	2	10.9	15.2	2.2	28.2	21.5	8.9	7.6	38.0	66.2
E	3	0.3	0.5	0.5	1.3	9.5	0.0	0.7	10.2	11.5
C	1+2+3	54.2	33.7	4.2	92.2	52.4	19.6	50.2	122.2	214.4
E	*wl*	13.7	15.7	4.2	33.6					33.6
I	*rk*	10.2	9.9	1.0	21.1					21.1
P	*os*	7.0	8.7	0.8	16.5					16.5
T	*mix*	3.2	1.2	0.2	4.6					4.6
S	*T*	5.5	3.6	0.9	9.9					9.9
	wl+rk+T	29.4	29.2	6.1	**64.6**					**64.6**
	M	53.1	3.3	1.2	57.7					57.7
	TOTAL	136.7	66.2	11.5	214.4	52.4	19.6	50.2	122.2	

Source: derived from Statistical Office of Estonia (1997)

1. Traded sectors (agriculture, fishing, mining, manufacturing, transport).

2. Non-traded sectors (except services not for sale).

3. Services not for sale (public adm., defense, other community services).

wl. Remuneration of employees.

rk. Net business income, of which

os. Operating surplus (incorporated enterprises).

mix. Mixed income (unincorporated enterprises).

U. Net indirect taxes and transfers including value added tax.

M. Imports.

C+G. Private consumption plus government consumption.

I. Investment

X. Exports

Table 5: Calibration of the model for the Baltic countries

	Latvia	**Estonia**	**Lithuania**
	Initial factors		
y_0	100.00	100.00	100.00
y_{T0}	54.72	47.21	49.09
y_{N0}	45.28	52.79	50.91
k_0	140.00	141.03	133.45
k_{T0}	74.99	61.72	64.34
k_{N0}	65.01	79.31	69.11
L	63.35	67.52	57.65
l_{T0}	35.09	33.00	28.68
l_{N0}	28.26	34.52	28.97
	Parameters		
A_T	1.1923	1.1899	1.2282
A_N	1.1760	1.1511	1.2128
α_T	0.3637	0.3062	0.4202
α_N	0.3809	0.3515	0.4352
γ	0.41	0.41	0.41
G	1.9677	1.9677	1.9677
σ	-1	-1	-1
η	-1	-1	-1
ε	0.3789	0.4043	0.4159
δ	0.0809	0.0809	0.0809
β	0.9597	0.9597	0.9597
ζ	1.22	1.22	1.22
ϕ	1	1	1
ψ	22.15	4.79	39.83

Table 6: Total external debt in the Baltic countries, percent of GNI

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Estonia	4	5	6	35	51	50	49	52	54
Latvia		7	9	24	49	51	62	67	74
Lithuania		8	12	16	35	35	44	44	45

Table 7: Real interest rate risk premia in the Baltic countries

	1994	1995	1996	1997	1998	1999	2000	2001
ρ^{Est}	0.150	0.049	0.017	0.009	0.046	0.010	0.006	0.018
ρ^{Lat}		0.189	0.136	0.051	0.032	0.039	0.018	0.021
ρ^{Lit}		0.168	0.140	0.046	0.023	0.037	0.013	0.012

Table 8: Sensitivity analysis of the model with interest rate risk premia, Estonia

Deviation from baseline calibration	Min. trade balance % of GDP	Min. trade balance year	Year of reversal
None	-10.8	1997	2008
$0.8k_0$	-13.5	1997	2008
$1.2k_0$	-7.5	1999	2009
$1/(1-\eta)=0.8$	-10.3	1999	2009
$1/(1-\eta)=0.2$	-11.8	1997	2008
$1/(1-\sigma)=0.8$	-9.1	1999	2009
$1/(1-\sigma)=0.2$	-12.6	1997	2008
$\phi=0$	-14.5	1996	2006
$\phi=2$	-10.0	1999	2010
$\zeta=0.65$	-11.9	1996	2007
$\zeta=1.95$	-10.9	1999	2009
$\psi=0$	-14.5	1996	2007
$\alpha_T=\alpha_N=1/3$	-11.4	1997	2008
$1+r_t=1/\beta, t\geq 2008$	-10.0	1997	2009

Table 9: Sensitivity analysis of the model with interest rate risk premia, Latvia

Deviation from baseline calibration	Min. trade balance % of GDP	Min. trade balance year	Year of reversal
None	-10.4	2001	2013
$0.8k_0$	-13.1	2000	2012
$1.2k_0$	-8.2	2003	2014
$1/(1-\eta)=0.8$	-11.0	2000	2012
$1/(1-\eta)=0.2$	-9.9	2002	2014
$1/(1-\sigma)=0.8$	-8.2	2003	2014
$1/(1-\sigma)=0.2$	-14.0	2000	2012
$\phi=0$	-12.4	1998	2010
$\phi=2$	-9.6	2003	2015
$\zeta=0.65$	-11.3	2000	2011
$\zeta=1.95$	-10.2	2002	2014
$\psi=0$	-19.4	1998	2009
$\alpha_T=\alpha_N=1/3$	-7.3	2003	2013
$1+r_t=1/\beta, t\geq 2008$	-9.5	2001	2013

Table 10: Sensitivity analysis of the model with interest rate risk premia, Lithuania

Deviation from baseline calibration	Min. trade balance % of GDP	Min. trade balance year	Year of reversal
None	-18.5	1998	2011
$0.8k_0$	-22.0	1998	2011
$1.2k_0$	-15.6	2000	2012
$1/(1-\eta) = 0.8$	-18.9	1998	2011
$1/(1-\eta) = 0.2$	-18.6	1999	2011
$1/(1-\sigma) = 0.8$	-15.8	1998	2012
$1/(1-\sigma) = 0.2$	-21.9	1998	2011
$\phi = 0$	-24.7	1997	2008
$\phi = 2$	-16.6	2000	2013
$\zeta = 0.65$	-20.4	1997	2010
$\zeta = 1.95$	-17.7	2000	2012
$\psi = 0$	-33.9	1997	2008
$\alpha_T = \alpha_N = 1/3$	-10.0	2000	2011
$1 + r_t = 1/\beta, t \geq 2008$	-18.1	1998	2011

Figure 1: Trade balance

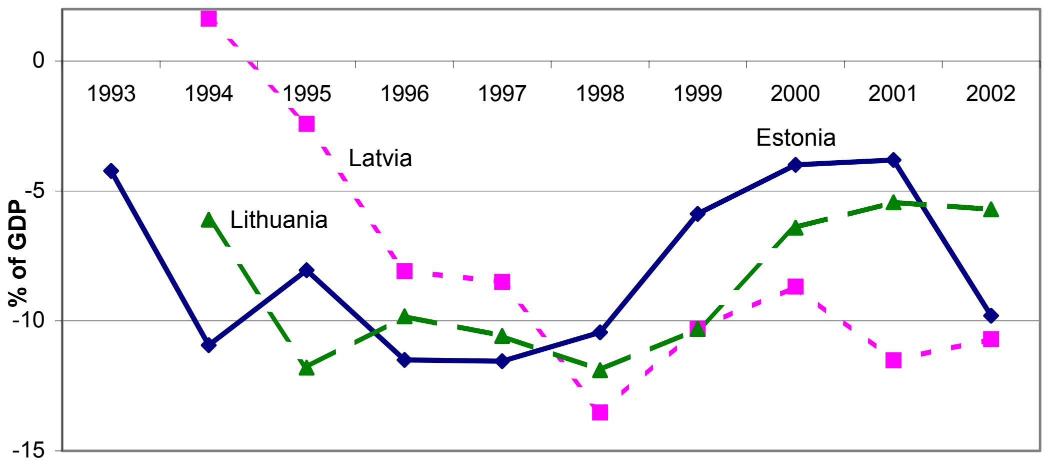

Figure 2: Real GDP growth

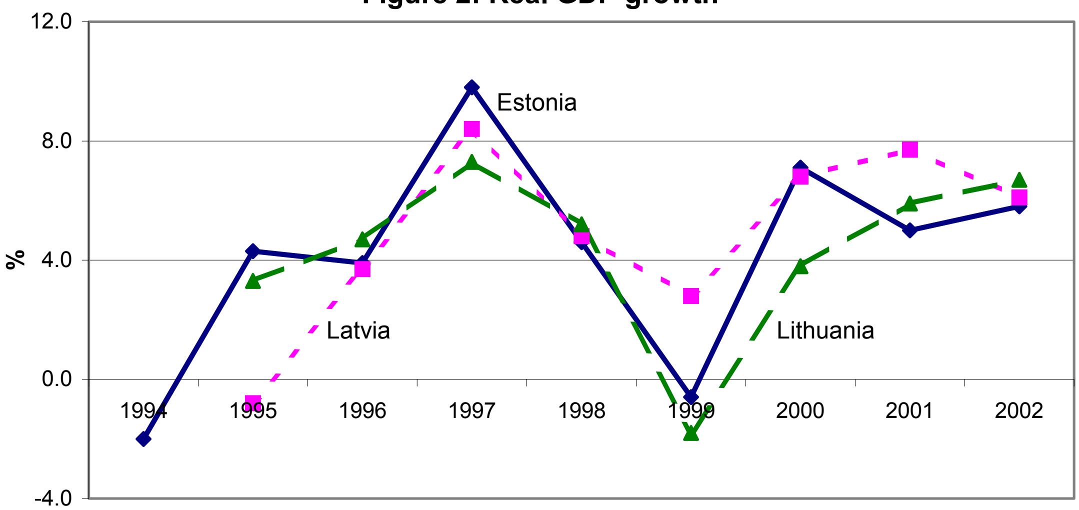

Figure 3: Traded sector

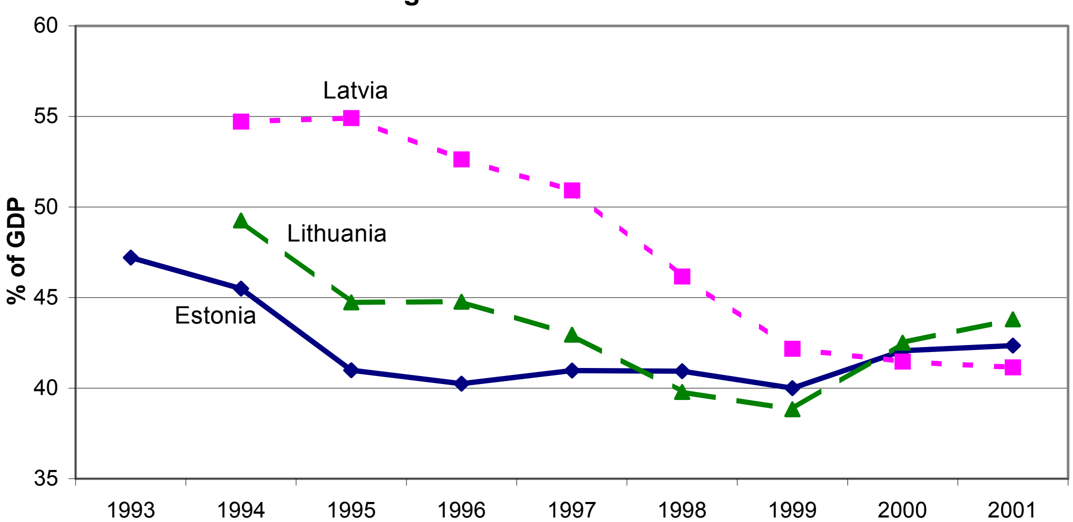

Figure 4: Real exchange rates in the Baltic states

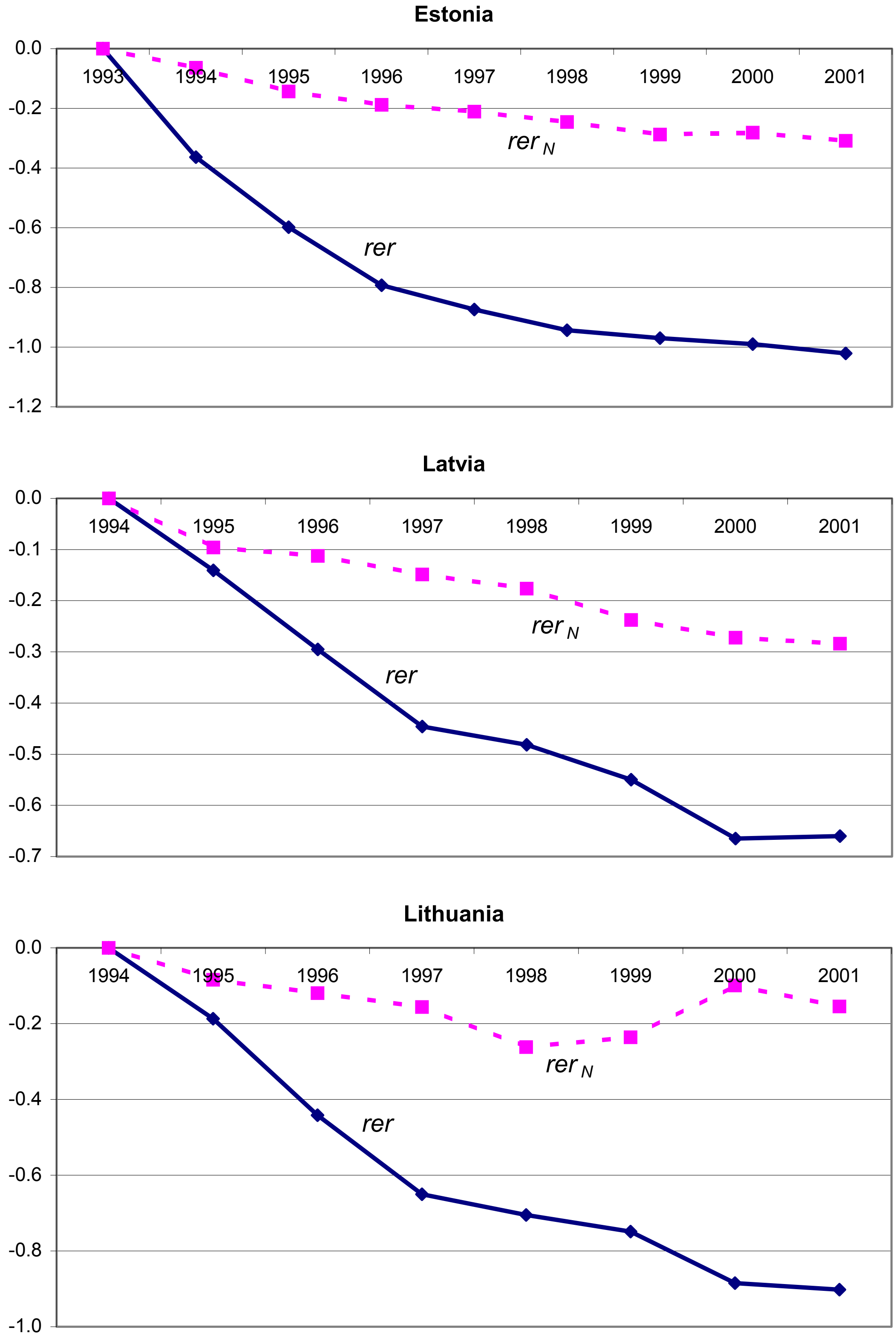

Figure 5: The basic model

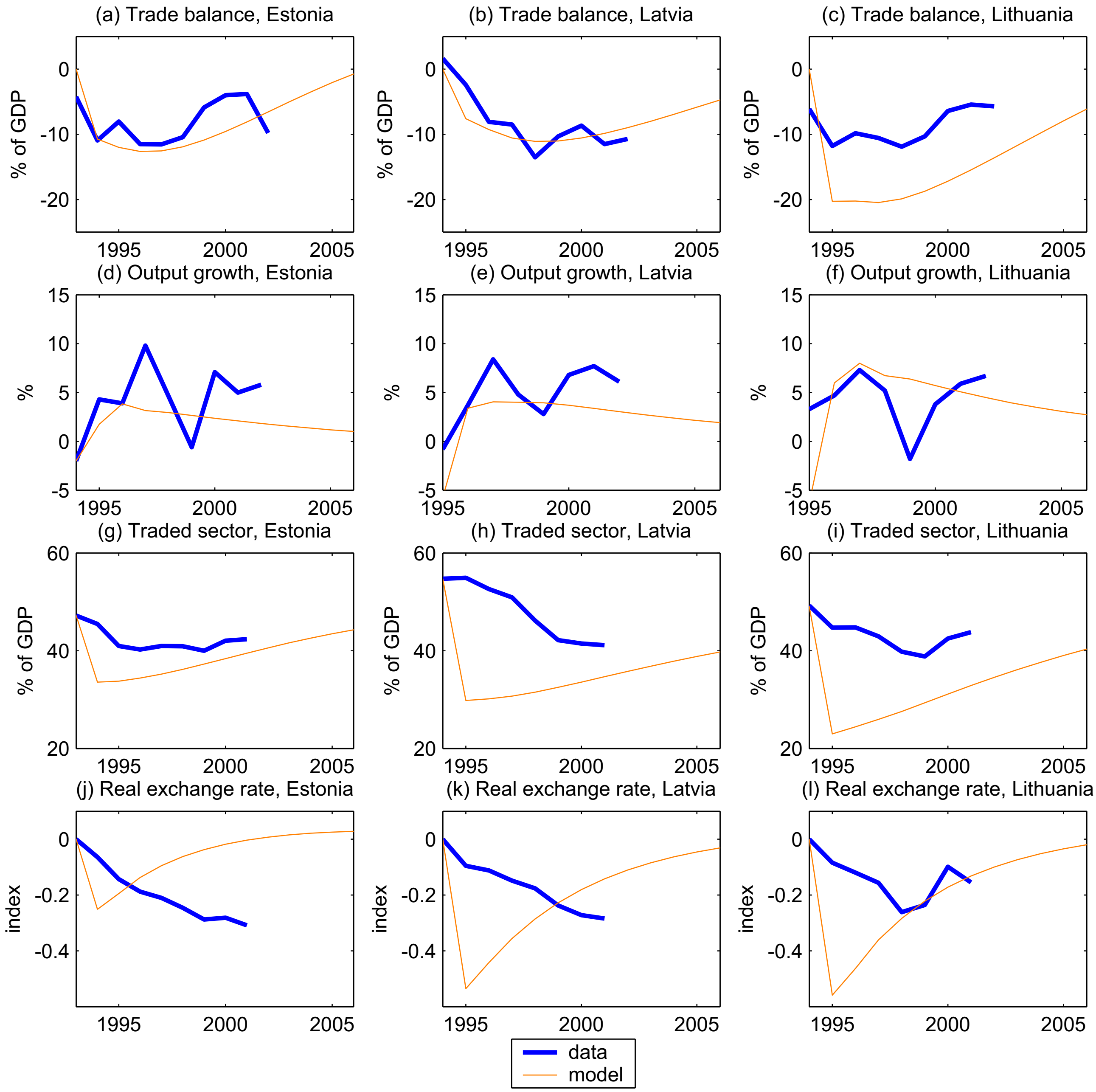

Figure 6: Real interest rates in the model

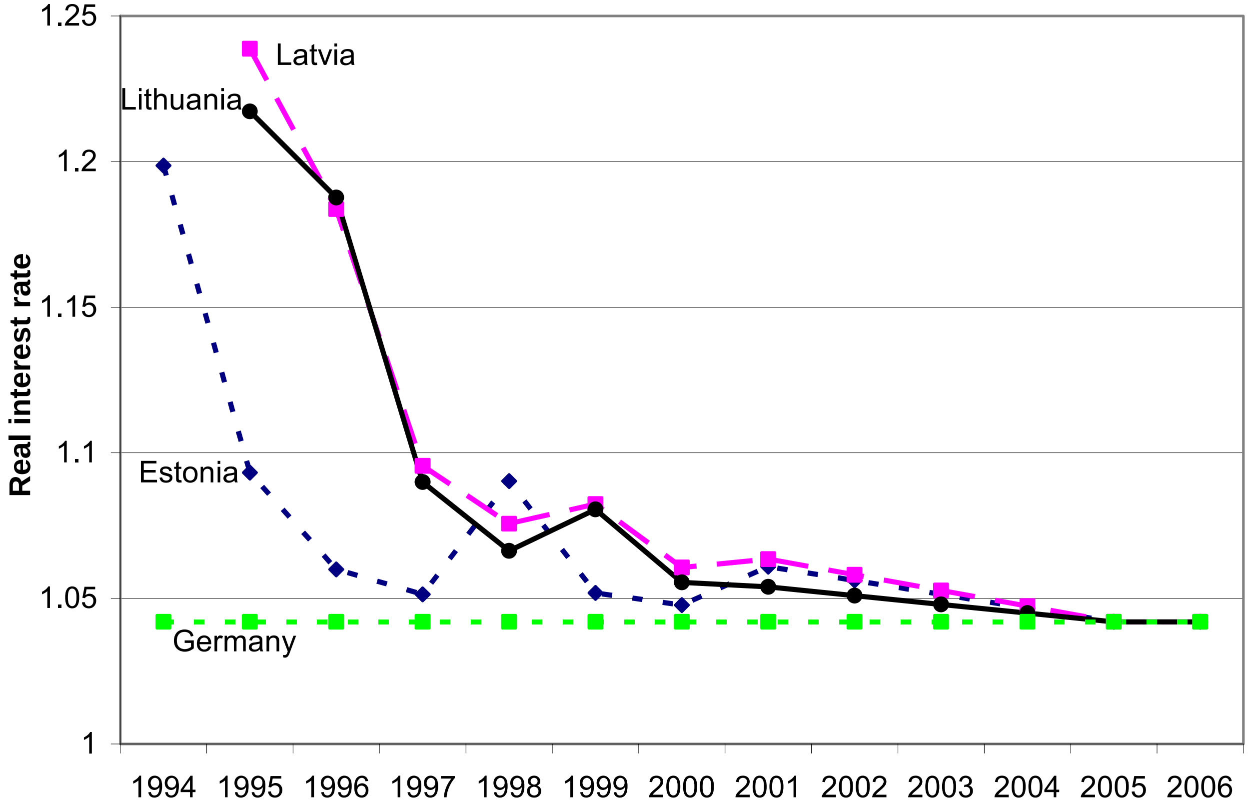

Figure 7: The model with interest rate risk premia