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Productivity differentials and external balance in ERM II

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The views expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.

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Abstract

Differences in growth, productivity and inflation levels are going to be a prominent feature of the future of EMU, as the convergence process is still on-going in the new Member States. This convergence process can be described by the Balassa-Samuelson proposition, which states that faster growth in the traded goods sector than in the non-traded goods sector results in a rise in the price of non-traded goods and an appreciation of the trend real exchange rate. In this study, the aim is to construct a small open economy model that enables examination of the effects of Balassa-Samuelson-type growth in an intertemporal fixed exchange rate framework with a focus on the external balance. To address the well-known problems with small open economy models, an endogenous discount rate is used. The results imply that faster productivity growth in the traded than in the non-traded goods sector may induce external imbalances, leading to increased vulnerability of the economy. However, trade account deficits would appear to be a temporary phenomenon, as this line of development can be reversed by the natural shift in the composition of consumption towards non-traded goods that is characteristic of catch-up economies. In the meantime, fiscal policy plays a key role.

Key words: small open economy, Balassa-Samuelson effect, ERM II, external balance

JEL classification numbers: F41, F33, F32

Tuottavuuserot ja ulkoinen tasapaino ERM II -maissa

Suomen Pankin tutkimus
Keskustelualoitteita 7/2005

Marketta Henriksson
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Maiden väliset erot kasvussa, tuottavuudessa ja inflaatiossa tulevat olemaan olennainen osa rahaliittoa tulevaisuudessa, sillä uusien jäsenmaiden lähentyminen nykyiseen euroalueeseen nähden on edelleen kesken. Tätä lähentymisprosessia voidaan kuvata Balassan – Samuelsonin hypoteesin avulla. Hypoteesin mukaan avoimen sektorin suljettua sektoria nopeampi tuottavuuden kasvu johtaa hyödykkeiden hintojen nousuun suljetulla sektorilla ja reaalisen valuuttakurssin trendin vahvistumiseen. Tässä tutkimuksessa tavoitteena on tutkia Balassa – Samuelson -tyyppisen kasvun vaikutuksia intertemporaalisessa pienen avotalouden mallissa, jossa maalla on kiinteä valuuttakurssi. Erityistä huomiota kiinnitetään ulkoisen tasapainon kehitykseen. Mallissa käytetään endogeenista diskonttotekijää pienten avotalouksien malleihin liittyvien tunnettujen ongelmien välttämiseksi. Tulokset osoittavat, että nopeampi tuottavuuskasvu vaihdettavia hyödykkeitä valmistavalla sektorilla saattaa johtaa ulkoisiin epätasapainottomuuksiin, mikä johtaa talouden haavoittuvuuden kasvuun. Kauppataseen alijäämät näyttäisivät kuitenkin olevan väliaikainen ilmiö, sillä tämä kehityssuunta kääntyy, kun kulutuksen rakenne muuttuu ei-vaihdettavien hyödykkeiden suuntaan, mitä voidaan pitää tyypillisenä lähentyville maille. Finanssipolitiikalla on tärkeä rooli epätasapainottomuuksien hallinnassa.

Avainsanat: pieni avotalous, Balassan – Samuelsonin vaikutus, ERM II, ulkoinen tasapaino

JEL-luokittelu: F41, F33, F32

Contents

1 Introduction

External imbalances are an often voiced concern, when the economic developments in the new EU Member States are discussed. Eg in connection with the ERM II entry of Estonia and Lithuania in June 2004, the EU pointed out the reduction of the current account deficits as a major policy challenge (European Union, 2004). Even though there are no convergence criteria relating to the external balance, it still is an essential part of the convergence process. Thus, the topic is likely to surface in the discussions preceding the adoption of the euro by the new Member States.

Convergence has always been a much discussed aspect of European unification, particularly in the monetary union context. There are both fast and slow growth countries already in the current EMU and in the future enlarged monetary union, growth differentials are likely to be even more pronounced, as the convergence process is still on-going in the new Member States. Moreover, price levels rise with GDP per capita, as stated by the Balassa-Samuelson proposition, which implies that inflation differentials are going to be a prominent feature of the future EMU.[1]

Indeed, the Balassa-Samuelson framework forms a good basis for examining convergence related questions. Begg et al (2003) have confirmed the presence of the Balassa-Samuelson premises among the five CEECs – the Czech Republic, Hungary, Poland, Slovenia and Estonia – namely that labor productivity is indeed growing faster in the traded (industry) than in the non-traded (services) sector, wages tend to be equalized between sectors and that prices of services have been rising faster than the producer price index. Nevertheless, they limit the research on the real exchange rate appreciation and the consequences for ERM II participation.

As a matter of fact, much research on the euro area enlargement has focused on the Balassa-Samuelson effect, with the effects on the equilibrium real exchange rate gaining special attention. Another popular line of research has focused on convergence related questions, where two approaches can be recognized: On the one hand, there has been discussion on the appropriate exchange rate regime for convergence and on the other hand, the focus has been on the optimum currency area criteria, where the similarity of shocks between the euro area and the future EMU members has been examined.[2] The Balassa-Samuelson framework appears suitable for examining the effects of continued fast growth on a country's external and fiscal balance. In general, the implications of the Balassa-Samuelson effect in an intertemporal framework appear to have gained less attention.

In the current study, the aim is to construct a framework that is suited

[1] The Balassa-Samuelson hypothesis – which originates from Balassa (1964) and Samuelson (1964) – states that faster productivity growth in the traded than in the non-traded goods sector results in a rise of the price of the non-traded good and a trend appreciation of the real exchange rate, which in fixed exchange rate regimes is visible as higher inflation. The size of the Balassa-Samuelson effect has been estimated in different studies to be 0-2 percent per year. (See eg European Commission (2004) and Mihaljek and Klau (2003)).

[2] Égert (2004) provides a survey on the studies on equilibrium exchange rates, while Järvinen (2003) provides a survey on the latter two topics.

for analyzing convergence/growth related questions in small open economies that have a fixed exchange rate regime with a monetary union. Both the home economy as well as the monetary union produce a traded and a non-traded good using labour as the only input. It will be assumed that growth differentials stem from differences in productivity growth, ie the home economy will experience faster productivity growth in its traded than its non-traded goods sector, consistent with the Balassa-Samuelson tradition.

In contrast to the traditional small open economy models, the study employs an endogenous discount rate, in line with Schmitt-Grohé and Uribe (2003) to deal with the well-known problems of representative agent models of small open economies.[3] The model is set in a fixed exchange rate framework but the results can be extended to the monetary union case.

The numerical analysis in this study focuses on the Baltic states that firstly, have a tradition with fixed exchange rates and secondly, can be considered as front-runners in euro adoption. Questions of the sustainability of the external balance have been raised particularly with regard to the Baltic states. Recently concerns over sufficient fiscal discipline in Latvia and Lithuania have also been brought up.[4] For the Central European Countries, sound public finances pose the major challenge on the way to euro adoption. The focus of this paper will be on external sustainability leaving fiscal sustainability questions for future work.

The remainder of the paper is divided into three Chapters. Chapter 2 presents the theoretical model and its solution. Then in Chapter 3 numerical methods are employed followed by a discussion of the results, possible policy implications and directions for future work. Chapter 4 concludes.

2 The model

The model is a fairly standard small open economy model, where the home economy pegs its currency to the currency of a monetary union and thus takes the interest rate as exogenous. The construction of the production side follows Montiel (1999). There is a two-sector production structure with traded and non-traded sectors, which use labour as the only input.

The formulation of the household's problem follows to some extent, on the one hand, Obstfeld and Rogoff (2000) and on the other hand, Benigno and Thoenissen (2003). The household side of the model is described by a money-in-the-utility function formulation and an endogenous labour supply. Most importantly, the model employs an endogenous discount rate in line

[3] As noted by Obstfeld (1990), constant time preference rates results in either an indeterminate global distribution of wealth or in the economy with the lowest time-preference rate eventually owning all of the world's outside wealth.

[4] Eg the European Central Bank (ECB, 2004) notes that implementation of a sound fiscal consolidation path is essential for achieving a high degree of sustainable convergence in Latvia and Lithuania.

with Scmitt-Grohé and Uribe (2003) to induce stationarity into the small open economy model.[5]

The first section explains the structure of the model starting with the production side, followed by the household's problem and finally the government and central bank formulations. In the second section, the model is solved analytically.

2.1 Structure of the model

2.1.1 Production

The home economy has a two-sector production structure with traded and non-traded sectors. As the home economy is a small open economy, it takes the price of the traded good as given. There is no capital in the model. Output in the two sectors, Y_T and Y_N respectively, is produced using a fixed sector specific factor and labour, which is assumed to be internationally immobile but able to migrate between the two sectors. The Cobb-Douglas type production function has decreasing returns to scale in the variable factor, labour. The production functions for the traded and non-traded sectors are written as

$$Y_T = A_T F(L_T) = A_T L_T^{\alpha} \tag{2.1}$$

and

$$Y_N = A_N G(L_N) = A_N L_N^{\eta}, \tag{2.2}$$

where the subscript T denotes the traded sector and N the non-traded sector. As are the productivity shifters and L denotes labour. α and η are the labour elasticities in the production functions, which can also be defined as the shares of labour income in total production: $\frac{WL_T}{P_T Y_T}$ in the traded sector and $\frac{WL_N}{P_N Y_N}$ in the non-traded sector, where W is the nominal wage common to both sectors and P_T and P_N are the prices of the traded and non-traded goods, respectively.

Profit maximization gives the first-order conditions

$$A_T F'(L_T) = \alpha A_T L_T^{\alpha-1} = \frac{W}{P_T} \tag{2.3}$$

and

$$A_N G'(L_N) = \eta A_N L_N^{\eta-1} = \frac{W}{P_N}, \tag{2.4}$$

[5] The parameterization of the model would also allow the relative size of the country to be varied. The home economy produces a continuum of differentiated traded goods indexed on the interval $[0, n]$, where n is the relative measure of country size. The foreign economy's traded goods are indexed on the interval $(n, 1]$. In addition, each country produces a continuum of differentiated non-traded goods, indexed on the interval $[0, n]$ for home and on $(n, 1]$ for foreign. In each country, there is a continuum of households, with population size normalized to the range of traded goods.

which state that the marginal product of labour must equal the real wage, defined in terms of the respective price, in both sectors. This allows the sectoral labour demands to be written as a function of wage and the sector price:

$$L_T\left(P_T, W\right) = \left(\frac{W}{\alpha P_T A_T}\right)^{\frac{1}{\alpha-1}} = \left(\frac{w}{\alpha A_T}\right)^{\frac{1}{\alpha-1}} \tag{2.5}$$

for the traded sector and

$$L_N\left(P_N, W\right) = \left(\frac{W}{\eta P_N A_N}\right)^{\frac{1}{\eta-1}} = \left(\frac{w}{\eta p A_N}\right)^{\frac{1}{\eta-1}} \tag{2.6}$$

for the non-traded sector, where w is the real wage in terms of the price of the traded good and $p = \frac{P_N}{P_T}$ the relative price of the non-traded good.

Finally, it is assumed that the productivity in the traded sector follows the first-order autoregressive process:

$$A_{Tt} - \overline{A}_T = \rho\left(A_{Tt-1} - \overline{A}_T\right) + \epsilon_{A_T};\ \rho \in (0,1) \tag{2.7}$$

where $\overline{A}_T$ is the steady state level of productivity that A_{Tt} converges to – this could be assumed to be the monetary union level – and ϵ_{A_T} is distributed $NIID\left(0,\sigma^2\right)$. Thus, the rate at which the economy converges to the steady state, ie monetary union, level is $1-\rho$, ie $1-\rho$ of any difference between A_{Tt} and $\overline{A}_T$ tends to disappear each period, absent any shocks.

2.1.2 Household

Households consume both the home and foreign traded goods as well as the domestic non-traded good. The households in the two countries have identical preferences and the representative household i maximizes the following utility function:

$$U_t^i = E_0 \sum_{t=0}^{\infty} \theta_t \left[\log C_t^i + \chi \log \frac{M_t^i}{P_t} - \kappa \frac{\left(L_t^i\right)^{1+\omega}}{1+\omega}\right] \tag{2.8}$$

$$\theta_0 = 1$$

$$\theta_{t+1} = \beta\left(\widehat{C}_t, \widehat{m}_t, \widehat{L}_t\right)\theta_t,$$

where C_t^i denotes the level of consumption at period t for household i and $\frac{M_t^i}{P_t}$ the real money holdings. The household labour supply L_t^i is divided between labour supplied to the traded and non-traded goods sectors, where the household is indifferent between supplying labour to either sector. E_0 is the mathematical expectation operator given information at time 0 and θ_t the discount factor. χ and κ are scale parameters, while ω is the labour supply elasticity.[6]

[6] It is assumed that utility is increasing and concave in C_t, $\frac{M_t}{P_t}$ and L_t.

To induce stationarity into the small open economy model, an endogenous discount factor is used.[7] As pointed out by Obstfeld (1990) the use of an endogenous time preference avoids the 'sometimes troublesome non-convergence and hysteresis implied by constant time preference', while producing otherwise similar behavior, at least in qualitative terms, to the standard model. In line with Schmitt-Grohé and Uribe (2003), the discount factor is assumed to depend on the average per capita levels of consumption $\widehat{C}_t$, real money balances $\widehat{m}_t$ and labour supply $\widehat{L}_t$, which the representative household takes as given.[8]

The real consumption index C takes a Cobb-Douglas form defined as

$$C = \frac{C_T^{\gamma} C_N^{1-\gamma}}{\gamma^{\gamma} \left(1-\gamma\right)^{1-\gamma}}, \tag{2.9}$$

where C_T and C_N are the two consumption indexes that refer to the consumption of traded and non-traded goods, respectively. γ is the preference parameter, which gives the weight that the household puts on traded goods, ie γ is also the share of total expenditure allocated to the consumption of traded goods. Money is deflated by a consumption-based price index that corresponds to the Cobb-Douglas consumption index specified above:

$$P = P_T^{\gamma} P_N^{1-\gamma}. \tag{2.10}$$

Consumption of traded goods is further divided into consumption of home and foreign traded goods with υ denoting the share of home-produced traded goods in traded goods consumption:

$$C_T = \frac{C_H^{\upsilon} C_F^{1-\upsilon}}{\upsilon^{\upsilon} \left(1-\upsilon\right)^{1-\upsilon}}, \tag{2.11}$$

which implies the price sub-index for traded goods

$$P_T = P_H^{\upsilon} P_F^{1-\upsilon}. \tag{2.12}$$

The law of one price is expected to hold for traded goods:

$$P_T = \varepsilon P_T^{*}, \tag{2.13}$$

ie $P_H = \varepsilon P_H^{*}$ and $P_F = \varepsilon P_F^{*}$, where ε is the nominal exchange rate (the home currency price of foreign currency).

[7] The problems related to the standard model could also be avoided by assuming an overlapping-generations structure but as pointed out by Obstfeld (1990) this could complicate the analysis and be economically besides the point.

[8] Schmitt-Grohé and Uribe (2003) examine several techniques for inducing stationarity of the equilibrium dynamics in the small open economy model (two versions of endogenous discount factor, a debt-contingent interest rate premium, portfolio adjustment costs and complete asset markets) and examine the extent to which these stationarity-inducing techniques affect the equilibrium dynamics at business cycle frequencies. They find that once all models are made to share the same calibration, their quantitative predictions regarding the behavior of key macroeconomic variables are virtually identical.

The foreign utility function is analogous to the home one, except that home money is held only by home households and foreign money only by foreign households. The deflator for foreign money balances can be written as

$$P^* = (P_T^*)^{\gamma} (P_N^*)^{1-\gamma} \tag{2.14}$$

and the price sub-index for traded goods

$$P_T^* = (P_H^*)^{\upsilon} (P_F^*)^{1-\upsilon} . \tag{2.15}$$

Finally, the real exchange rate is defined as

$$\frac{P}{P^*} = \left(\frac{P_T}{\varepsilon P_T^*}\right)^{\gamma} \left(\frac{P_N}{\varepsilon P_N^*}\right)^{1-\gamma} = \frac{1}{\varepsilon}\left(\frac{P_N}{P_N^*}\right)^{1-\gamma} . \tag{2.16}$$

Maximizing equation (2.9) given total expenditure measured in traded goods $Z \equiv C_T + pC_N$, where $p = \frac{P_N}{P_T}$ is the relative price of the non-traded good, gives the household's demand for traded goods

$$C_T = \gamma P' C, \tag{2.17}$$

and for non-traded goods

$$C_N = (1-\gamma)\frac{P'}{p}C, \tag{2.18}$$

where P' is defined as the price index in terms of the price of the traded good $P' = \frac{P}{P_T} = p^{1-\gamma}$. The demand for traded goods can be broken into

$$C_H = \upsilon \frac{P_T}{P_H} C_T = \upsilon\gamma \frac{P}{P_H} C \tag{2.19}$$

$$C_F = (1-\upsilon)\frac{P_T}{P_F} C_T = (1-\upsilon)\gamma \frac{P}{P_F} C \tag{2.20}$$

using equation (2.11).

The period budget constraint of the home representative household i in terms of the price of the traded good is

$$\begin{aligned} & C_{Tt}^i + p_t C_{Nt} + \frac{M_t^i}{P_{Tt}} + \frac{B_{Ht}^i}{P_{Tt}} + \varepsilon_t \frac{B_{Ft}^i}{P_{Tt}} + P_t' \tau_t \\ &= \frac{W_t}{P_{Tt}} L_t^i + \frac{M_{t-1}^i}{P_{Tt}} + R_{t-1}\frac{B_{Ht-1}^i}{P_{Tt}} + f_{t-1} R_{t-1}^* \frac{B_{Ft-1}^i}{P_{Tt}} + \frac{\Pi_{Tt}}{P_{Tt}} + \frac{\Pi_{Nt}}{P_{Tt}} \end{aligned} \tag{2.21}$$

where τ_t is the lump-sum taxes paid to the home government. B_t^i is the nominal holdings of the home government bond that pay a nominal gross interest R_t, which is defined by $R_t = 1 + i_t$, where i_t is the nominal interest rate of home currency loans between t and $t+1$. Similarly, B_t^{*i} is the nominal holdings of the foreign government bond that pay a nominal gross interest R_t^*. f_{t-1} is the forward exchange rate determined in period $t-1$. Π_{Tt} and Π_{Nt} are the profits paid to the household by the traded and non-traded sector firms, which are defined as

$$\Pi_T = P_T Y_T - W L_T \text{ and } \Pi_N = P_N Y_N - W L_N , \tag{2.22}$$

respectively.

The budget constraint can also be written in the more familiar form in terms of total consumption:

$$\begin{aligned}&P_tC_t^i + M_t^i + B_{Ht}^i + \varepsilon_t B_{Ft}^i + P_t\tau_t \\ &= W_tL_t^i + M_{t-1}^i + R_{t-1}B_{Ht-1}^i + f_{t-1}R_{t-1}^* B_{Ft-1}^i + \Pi_{Tt} + \Pi_{Nt}\end{aligned} \tag{2.23}$$

given the definition of the price level by equation (2.10). In equilibrium, taking into consideration the definition of firm profits and rearranging, equation (2.21) can be written in intertemporal form as

$$\begin{aligned}\frac{B_{Ht-1}^i + \varepsilon_{t-1}B_{Ft-1}^i + M_{t-1}^i}{P_{Tt-1}} &= \sum_{s=t}^{\infty}\left(\prod_{j=t}^{s}(1+r_j)^{-1}\right)(C_{Ts}^i \\ &+ p_sC_{Ns}^i + P_s'\tau_s + \frac{r_s}{P_{Ts}/P_{Ts-1}}\frac{M_{s-1}^i}{P_{T,s-1}} - Y_{Ts} - p_sY_{Ns}),\end{aligned} \tag{2.24}$$

where $B_{Ht-1}^i + \varepsilon_{t-1}B_{Ft-1}^i + M_{t-1}^i$ is nominal beginning of period household wealth and r_t is the real rate of return on bonds defined in terms of traded goods:

$$(1 + r_{t-1}) = R_{t-1}\frac{P_{Tt-1}}{P_{Tt}}. \tag{2.25}$$

As the households fully use their lifetime wealth, the transversality condition implies that

$$\lim_{T\to\infty}\left(\prod_{j=t}^{T}(1+r_j)^{-1}\right)\left(\frac{B_{HT}^i + \varepsilon_T B_{FT}^i + M_T^i}{P_{TT}}\right) = 0. \tag{2.26}$$

Households maximize equation (2.8) subject to equation (2.23) taking the firm profits, Π_{Tt} and Π_{Nt}, as given, which produces the following first-order conditions for the household's problem with respect to consumption, real money balances and labour supply:

$$\frac{1}{C_t} = R_t\beta\left(\widehat{C}_t, \widehat{m}_t, \widehat{L}_t\right)\frac{P_t}{P_{t+1}}E_t\frac{1}{C_{t+1}} \tag{2.27}$$

$$\frac{1}{C_t} = R_t^*\beta\left(\widehat{C}_t, \widehat{m}_t, \widehat{L}_t\right)\frac{P_t}{P_{t+1}}\frac{f_t}{\varepsilon_t}E_t\frac{1}{C_{t+1}} \tag{2.28}$$

$$\frac{M_t}{P_t} = \chi\frac{R_t}{R_t - 1}C_t = \chi\frac{1+i_t}{i_t}C_t \tag{2.29}$$

$$\kappa L_t^{\omega} = \left(\frac{W_t}{P_t}\right)\left(\frac{1}{C_t}\right). \tag{2.30}$$

Equation (2.27) is the standard first order Euler condition for optimal intertemporal allocation of consumption. It, together with equation (2.28), implies the covered interest rate parity

$$(1 + i_t) = (1 + i_t^*)\frac{f_t}{\varepsilon_t}. \tag{2.31}$$

Equation (2.27) can also be written as follows:

$$\frac{1}{C_t} = \left(1 + r_t^C\right) \beta \left(\widehat{C}_t, \widehat{m}_t, \widehat{L}_t\right) E_t \frac{1}{C_{t+1}}. \tag{2.32}$$

where r_t^C is the consumption-based real interest rate defined as

$$1 + r_{t-1}^C = R_{t-1} \frac{P_{t-1}}{P_t} = \left(1 + r_{t-1}\right) \frac{P'_{t-1}}{P'_t}. \tag{2.33}$$

As can be seen from equation (2.33), the higher the future price level compared to the present one, the lower the consumption based interest rate for any traded goods based interest rate. The importance of the total consumption based interest rate has been underlined by Dornbusch (1983):

> "In a small country with a non-traded goods sector the relevant interest rate is not the given world interest rate but the real interest rate stated in terms of the domestic consumption basket. To the extent that disturbances affect the relative price structure over time, they also affect the home real interest rate and therefore the optimal path of consumption and borrowing." (Dornbusch 1983, 142).

Condition (2.29) states that households must be indifferent between consuming a unit of the consumption good on date t or using the same funds to raise cash balances, enjoying the derived transactions utility in period t and then converting the extra cash balances back to consumption in period $t + 1$. Equation (2.30) is the leisure-consumption trade-off condition.

2.1.3 Government

The government determines taxes, defined either as lump sum or as a fixed share of output, and issues nominal government debt, which together with the real transfers from the central bank finances government consumption. The government real consumption index G takes the same general form as that of the household, given by equation (2.9):

$$G = \frac{G_T^{\delta} G_N^{1-\delta}}{\delta^{\delta} \left(1 - \delta\right)^{1-\delta}}, \tag{2.34}$$

where the share of traded goods in total government consumption is denoted by δ. This implies that the government demand functions for the non-traded and traded goods are also similar to those of the private sector:

$$G_N = \left(1 - \delta\right) \frac{P'}{p} G \tag{2.35}$$

$$G_T = \delta P' G. \tag{2.36}$$

The period budget constraint of the government is

$$G_{Tt} + p_t G_{Nt} + R_{t-1}\frac{D_{t-1}}{P_{Tt}} = P'\tau_t + v_t + \frac{D_t}{P_{Tt}}, \tag{2.37}$$

where D_t is government end-period debt paying a nominal interest rate R_t, τ_t denotes taxes and v_t the real transfers from the central bank. Equation (2.37) can be written in intertemporal form as

$$\frac{D_{t-1}}{P_{Tt-1}} = \sum_{s=t}^{\infty}\left(\prod_{j=t}^{s}(1+r_j)^{-1}\right)(P_s'\tau_s + v_s - G_{Ts} - p_s G_{Ns}). \tag{2.38}$$

with a transversality condition

$$\lim_{T\to\infty}\left(\prod_{j=t}^{T}(1+r_j)^{-1}\right)\frac{D_T}{P_{TT}} = 0. \tag{2.39}$$

2.1.4 Central bank

The monetary policy of the home central bank is defined by a fixed exchange rate regime, which implies that the home economy takes the interest rate as exogenous.

The central bank issues money M_t through open market purchases of bonds B_{mt}. The period budget constraint is

$$\frac{B_{mt}}{P_{Tt}} + v_t = R_{t-1}\frac{B_{mt-1}}{P_{Tt}} + \frac{M_t - M_{t-1}}{P_{Tt}}, \tag{2.40}$$

which in intertemporal form can be written as

$$\frac{M_{t-1} - B_{mt-1}}{P_{Tt-1}} = \sum_{s=t}^{\infty}\left(\prod_{j=t}^{s-1}(1+r_j)^{-1}\right)\left[\frac{r_s}{P_{Ts}/P_{Ts-1}}\left(\frac{M_{s-1}}{P_{Ts-1}}\right) - v_s\right]. \tag{2.41}$$

2.2 Solution of the model

In solving the model, we assume that there exists international capital markets, where the home economy can borrow and lend unlimited amounts. Combining the budget constraints of the household, the government and the central bank gives us the budget constraint for the whole economy:

$$\frac{F_t}{P_t} = (1+r)\frac{F_{t-1}}{P_t} + Y_t - C_t - G_t, \tag{2.42}$$

where $F_t = B_{Ht} + B_{Ft} + B_{mt} - D_t$ is the economy's net foreign assets.[9] In equilibrium, the intertemporal equation for the net foreign assets can be written as follows

$$\frac{F_{t-1}}{P_{Tt-1}} = \sum_{s=t}^{\infty} \left(\prod_{j=t}^{s} (1+r_j)^{-1} \right) (C_{Ts} + G_{Ts} - Y_{Ts}) . \tag{2.43}$$

The money market clearing condition states that the domestic nominal money demand must equal the domestic nominal money supply in each country. The equilibrium in the non-traded goods sector is defined as

$$C_N + G_N = Y_N, \tag{2.44}$$

ie the private and public consumption of the non-traded goods must equal its production.

$$L = L_T + L_N \tag{2.45}$$

is the labour market resource constraint.

In equilibrium, we have that $\widehat{C}_t = C_t$, $\widehat{m}_t = m_t$ and $\widehat{L}_t = L_t$. The following functional form is assumed for the discount factor

$$\beta(C_t, m_t, L_t) = \frac{\left[1 + \lambda\left(C_t - \overline{C}\right) + \mu\left(m_t - \overline{m}\right) + \varphi\left(L_t - \overline{L}\right)\right]^{-\psi}}{1 + r_t^C} \tag{2.46}$$

$$; \psi \geq 0,$$

where $\overline{C}$, $\overline{m}$ and $\overline{L}$ are some positive constants and ψ the elasticity of the discount factor with respect to the aggregate $\left[1 + \lambda\left(C_t - \overline{C}\right) + \mu\left(m_t - \overline{m}\right) + \varphi\left(L_t - \overline{L}\right)\right]$.[10] The Euler equation (2.27) can now be written as

$$\frac{1}{C_t} = \left[1 + \lambda\left(C_t - \overline{C}\right) + \mu\left(m_t - \overline{m}\right) + \varphi\left(L_t - \overline{L}\right)\right]^{-\psi} E_t \frac{1}{C_{t+1}}. \tag{2.47}$$

To solve the model, we linearize it around a steady state, where $\widetilde{X}_t = X_t - \overline{X}$ defines a deviation from the steady state. In the steady state, the discount rate reduces to

$$\beta\left(\widehat{C}_t, \widehat{m}_t, \widehat{L}_t\right) = \frac{1}{1+r}, \tag{2.48}$$

as can be seen from equation (2.46). Thus, the use of the endogenous discount factor does not affect the calculation of the steady state. The steady state model is presented in the first section of the Appendix.

[9] Therefore, the current account equation is

$$\frac{CA_t}{P_t} = r\frac{F_{t-1}}{P_t} + Y_t - C_t - G_t.$$

[10] If $\psi = 0$, the discount factor is constant and equal to $\frac{1}{1+r}$, which would imply that the long-run levels of foreign debt and consumption depend on the initial level of foreign debt and the initial realization of the endowment shock. In other words, the model is non-stationary. (Schmitt-Grohé and Uribe, 2003, 182).

To explicitly solve the model, several simplifications must be made and therefore, the following solution can only be considered as a special case of the model presented above. Assuming constant returns to scale, ie $\alpha = \eta = 1$ implies that the labour supply must be constant. Moreover, it is assumed that the discount factor depends solely on consumption, ie $\mu = \varphi = 0$ and $\lambda = 1$ and that non-traded sector productivity is fixed at $A_{Nt} \equiv \overline{A}_N$. These changes allow us to produce the following solution to the model

$$\widetilde{C}_t = \left(r + \psi\overline{C}\right)\left(\frac{\widetilde{F}_{t-1}}{\overline{P}}\right) + \zeta\widetilde{A}_{Tt}. \tag{2.49}$$

$$\frac{\widetilde{F}_t}{\overline{P}} = \left(1 - \psi\overline{C}\right)\left(\frac{\widetilde{F}_{t-1}}{\overline{P}}\right) + \xi\widetilde{A}_{Tt} \tag{2.50}$$

where

$$\zeta = \frac{\left(r + \psi\overline{C}\right)}{(1 + r - \rho)}\left[\gamma\overline{L}\left(\frac{\overline{A}_T}{\overline{A}_N}\right)^{\gamma-1} - r\,(1-\gamma)\,\frac{\overline{F}}{\overline{P}}\frac{1}{\overline{A}_N}\right] \tag{2.51}$$

and

$$\xi = \frac{\left(1 - \rho - \psi\overline{C}\right)}{(1 + r - \rho)}\left[\gamma\overline{L}\left(\frac{\overline{A}_T}{\overline{A}_N}\right)^{\gamma-1} - r\,(1-\gamma)\,\frac{\overline{F}}{\overline{P}}\frac{1}{\overline{A}_N}\right] \tag{2.52}$$

(see the linearized model section in the Appendix for details). The equations show that in response to a positive shock to traded sector productivity, consumption increases (assuming that the previous period deviation from steady state net foreign assets is zero or positive and that the steady state net foreign assets are zero or negative). Otherwise, the direction of the effect is unclear. For net foreign assets, the direction of the effect depends, besides the before mentioned factors, on the value given to steady state consumption $\overline{C}$. Assuming that the economy started in a steady state in the previous period with steady state net foreign assets equaling zero, the response of a positive shock to traded sector productivity would be a positive deviation from the steady state net foreign assets, if steady state consumption was small enough $\left(\overline{C} < \frac{1-\rho}{\psi}\right)$ and negative otherwise.

3 Calibration and simulation

To determine the steady state and its response to the different productivity shocks, numerical methods are employed. Here, two forms of the discount factor are employed, both of which abstract from the other variables besides consumption in the discount factor, thus setting $\mu = \varphi = 0$. In the first case, the household smooths consumption in terms of consumption/output, while in the second case, the smoothing takes place in terms of traded goods consumption/traded goods production. These formulations enable the definition of the constant in the discount factor as a share of output or traded sector output rather than as a constant level.

In the first case, the discount factor and the first order condition are written in terms of consumption per output, which makes sense as the ratio of consumption to output has remained relatively constant over time. Hence, the first order condition (2.28) is written as follows

$$\frac{1}{C_t/Y_t} = \{1 + \lambda [(C_t/Y_t) - \overline{c}]\}^{-\psi} E_t \frac{1}{(C_{t+1}/Y_{t+1})} \left(\frac{Y_t}{Y_{t+1}} \right), \tag{3.1}$$

where $\overline{c} = \frac{\overline{C}}{\overline{Y}}$. The short-coming in this formulation is the demands it sets on the formulation of the government side. A more detailed design of government policy, which is beyond the scope of this paper, would provide more insightful results. Thus, we limit ourselves on a few simple cases here and leave a more careful formulation of the government side for later work.

In the second case, the discount factor and the Euler equation are written in terms of traded consumption/traded production. It could be assumed that consumption smoothing could only take place through traded goods. This case gives the following form for the Euler equation

$$\frac{1}{C_{Tt}/Y_{Tt}} = [1 + \lambda [(C_{Tt}/Y_{Tt}) - \overline{c}_T]]^{-\psi} E_t \frac{1}{C_{Tt+1}/Y_{Tt+1}} \left(\frac{Y_{Tt}}{Y_{Tt+1}} \right), \tag{3.2}$$

where $\overline{c}_T = \frac{\overline{C}_T}{\overline{Y}_T}$.[11] From now on consumption smoothing with regard to consumption/output will be referred to as Case 1 and consumption smoothing with regard to traded goods consumption/traded goods output as Case 2.

3.1 Parameters

The parameter values were chosen in line with appropriate literature and available actual data was consulted. Here, the Baltic states were used as reference countries, as they were considered to be a suitable benchmark for small open economies with fixed exchange rate regimes and the front-runners with regard to the adoption of the euro.

α and η represent labour's share of the income generated in the traded and non-traded sectors, respectively. As noted by Obstfeld and Rogoff, empirically non-traded goods tend to be at least as labour-intensive as traded goods, which implies that $\eta \geq \alpha$ (1998, 209). The numerical values of α and η, 9/20 and 21/40, were chosen together with the labour supply parameters κ and ω, so that the labour market equilibrium would be as close as possible to labour supply and sectoral labour employments in the Baltic states.[12] The value for the inverse of labour supply elasticity ω is set at 1.5 implying a labour supply elasticity with respect to wages of 0.67. In line with Cooley and Prescott, the

[11] Traded goods consumption/traded goods production can be defined as follows

$$\overline{c}_T = \frac{\overline{C}_T}{\overline{Y}_T} = \frac{\overline{C}_T}{\overline{C}} \frac{\overline{Y}}{\overline{Y}_T} \frac{\overline{C}}{\overline{Y}} = \gamma \frac{\overline{C}}{\overline{Y}} \frac{\overline{PY}}{\overline{P}_T \overline{Y}_T}.$$

[12] According to IMF statistics, the share of the non-traded sector (namely services) in total employment has been around 60% in Estonia, Latvia and Lithuania (2003a, b and c).

value for the parameter κ is chosen so that the steady state labour supply is equal to approximately one-third (1995, 21). To calculate κ, we assume that the share of consumption and wages in GDP correspond to observed data.[13]

γ and δ are the shares of traded goods in the household and government consumption, respectively. In the beginning of transition, traded goods form the most part of household consumption with the share of non-traded consumption increasing as transition progresses. Therefore, different values for γ are experimented and the results reported. As a benchmark, the weights in the consumer price index are used, as they describe actual expenditure in a country, which would indicate a value of 0.65 for γ.[14] Public consumption can be considered to be biased towards the consumption of non-traded goods, ie services, so δ is set at 0.2. χ is the utility of money parameter, which is set at 0.005.

ψ defines the minus elasticity of the discount factor, which determines the stationarity of the model and the speed of convergence to the steady state. In line with Scmitt-Grohé and Uribe (2003), this value is set at 0.01 but other values are also examined. The remaining parameters in the discount factor are set so that discount factor depends only on consumption, ie $\mu = \varphi = 0$ and $\lambda = 1$. The parameter $\bar{c}$ is set in line with the current share of consumption in GDP in the Baltic states, at 60%, while the parameter $\bar{c}_T$ is set equal to 1.5γ.[15,16]

The real interest rate for the monetary union, ie the euro area, is the standard one used in the literature, 0.04. Cooley and Prescott (1995) set a quarterly value of ρ at 0.95, which implies an annual value of $\rho = 0.81$. The chosen parameter values are summarized in Table 1.

TABLE 1 Parameter values

α	η	ρ	γ	δ	χ	κ	ω	λ	μ	φ	ψ	r
$\frac{9}{20}$	$\frac{21}{40}$	0.81	0.65	0.2	0.005	13	1.5	1	0	0	0.01	0.04

The baseline values for the exogenous variables are set so that the original steady state is characterized by a trade account close to zero (Case 1) or in a slight deficit, which may better depict the current situation in the Baltic states that all have considerable trade and current account deficits. Productivity in the non-traded sector is assumed to be 80% of that in the traded sector. The level of real government consumption is set so that it amounts to close to 40% of GDP at least in the initial situation, which is consistent with the current level of government expenditure of GDP in the Baltic states.

[13] Private consumption has been around 60% of GDP in Estonia, Latvia and Lithuania, while wages have amounted to about 50% of GDP (IMF 2003a, b and c).

[14] The share of services is 35% in the consumer price index based on average consumer expenditure structure of the previous year, while in the harmonised index (HICP), which is computed from the expenditure of the last month of the year, it is 28.5% (Bank of Estonia 2004, 24).

[15] In the literature, the often used value for steady state consumption to output in developed countries is 75%.

[16] As the share of the traded sector in total output is 40% in the Baltic states, the formula in footnote 11 gives this value.

3.2 Simulation

3.2.1 Steady state model

It is shown that the model converges to a unique steady state with both formulations of the discount factor.[17] The results of the simulations for the two different cases are presented in Table 2.

TABLE 2 Selected variables in the steady state

	Case 1	Case 2
Consumption/output	60%	67%
Traded consumption/output	39%	43%
Non-traded consumption/output	21%	23%
Traded production/output	47%	45%
Non-traded production/output	53%	55%
Trade balance/output	0%	-6.9%
Wages/output	49%	49%
Labour supply	0.33	0.32
– share of traded sector	43%	45%
– share of non-traded sector	57%	55%

As can be seen from Table 2, consumption per output is slightly higher, when consumption smoothing takes place in traded goods. The labour supply settles around 0.33 in both cases with 57% and 55% of the labour force, respectively, being employed by the non-traded sector. In Case 1, the trade balance is 0, as the formulation implies that domestic consumption equals domestic output. In the second case, a trade balance deficit of close to 7% appears. If the value of γ is higher than 0.65, the share of consumption in output increases and a larger trade account deficit surfaces, while increasing the share of non-traded goods in consumption, ie decreasing the value of γ from 0.65, produces a slight trade account surplus, with lower consumption/output. The effects of different values of γ will be returned to in the next section.

3.2.2 Permanent shock

To begin with, we look at the effects of a permanent productivity shock, ie convergence, in the traded goods sector. Then, other changes are added. Three productivity shocks are looked at, where in the first one, traded sector productivity rises by 10%. In the second one, the traded sector productivity level in the home economy in the initial situation is assumed to be around two-thirds of the monetary union level, which implies a productivity increase of 50%, while in the last one, the initial level is assumed to be 60% of that in the monetary union, and thus the rise in productivity is 70%. Non-traded sector productivity is assumed to be at the same level as that of the monetary union, ie there is no convergence, ie shocks, in the non-traded sector.

[17] Government consumption in both cases is set as a fixed share of output, 40%, or as a corresponding lump-sum.

Following a permanent shock, the variables immediately jump to the new steady state level. The percentage changes from the relevant baseline steady states are presented in Table 3.

TABLE 3 Changes in steady state variables*

Traded sector productivity growth	10%	50%	70%
Real output	6.4%	30%	41%
Relative price	10%	50%	70%
Real exchange rate	3.4%	15.2%	20.4%

*Government consumption defined as a constant share of output.

The results for cases 1 and 2 are essentially the same. Real output and consumption rise in both cases by the same amount, while all nominal variables rise by the amount of the productivity shock as do the traded sector variables.

As can be seen from Table 3, the Balassa-Samuelson effect is pronounced. Following the productivity shock, the real exchange rate appreciates by 3.4%, 15% and 20.4%, respectively, while the relative price rises by 10%, 50% and 70%. This is in line with Begg et al. (2003), who show that a 10% increase in traded sector productivity raises the relative price by 3% in the short-run.

Basically, the only difference with the two cases concerns the trade balance. While in Case 1, a balanced trade account is guaranteed by the formulation, where domestic consumption always equals domestic output, in Case 2, the trade balance deficit rises at the same pace as the traded sector variables. Hence, the formulation of the discount factor ensures that trade balance/output stays constant. As there is a constant trade account deficit with the domestic demand of traded goods exceeding their supply, the economy accumulates negative net foreign assets, which are visible as a current account deficit. The negative net foreign assets can easily reach unsustainable levels.[18]

If government expenditure are defined as lump-sum, different results emerge. These results are summarized in Table 4.

[18] IMF (2003) sets the steady state level of net foreign assets to 70% of GDP for the Baltic countries. In general the rule is that the sustainable level of the net foreign assets to GDP is 60% when exports to GDP are 20% and 60–80% when export to GDP are between 20–40%. Sensitivity analysis with a ± 5 percentage point change in the net foreign assets to GDP ratio did not lead to substantially different results.

TABLE 4 Changes in steady state variables*

	Case 1		**Case 2**	
Traded sector productivity growth	10%	50%	10%	50%
Real output	5.7%	27.2%	5.4%	25.7%
Traded consumption	7.9%	39.6%	10.8%	54%
Non-traded consumption**	1.7%	7.2%	2.9%	11.9%
Traded production	11.9%	59.9%	10.8%	54%
Non-traded production**	-1.6%	-6.7%	-1.5%	-5.8%
Trade deficit			1.3%	5%
Wages	7.7%	38.7%	9.1%	45.2%
Relative price	6.2%	30.3%	7.6%	37.6%
Real exchange rate	2.1%	9.7%	2.6%	11.8%

*Government consumption defined as a lump-sum corresponding to the constant share of output in the initial situation.

** In real terms.

Following a productivity shock in the traded sector, with the government lump-sum consumption unchanged, total output rises slower than above, while growth in traded sector production is faster and non-traded sector production falls in both cases. The Balassa-Samuelson effect on the relative price and the real exchange rate is somewhat weakened from above.

Unchanged lump-sum government consumption implies that in Case 1 a trade balance surplus develops, at 2.2% and 8.6% of output, respectively, and the home economy cumulates positive net foreign assets. The continued cumulation of positive net foreign assets can not be considered as a sustainable line of development. In Case 2, the effect on the trade account deficit is now dampened and the trade account deficit as a share of output decreases from 6.9% to 6.4% and 5.1%, respectively. This implies that lower government consumption can help bring about a trade account surplus or help correct external imbalances. It is, however, questionable if unchanged lump-sum government expenditure can be thought as a good description of the development of government expenditure, especially in transition countries. Hence, the results show that the formulation of the government side is essential for the model but this is unfortunately beyond the scope of this paper.

The Balassa-Samuelson effect is a supply side phenomenon. As pointed out by Begg et al (2003), if demand growth for traded and non-traded goods is equal, demand is neutral and the supply side effect dominates. Nonetheless, if demand growth were higher in the traded goods, the supply side effect would be offset, at least partly, or completely undone. Usually, however, demand growth is biased towards non-traded goods, which enforces the supply side effect.

Hence, we now combine the productivity rise with a rise in the share of non-traded goods in consumption, ie a fall in γ. It is assumed that 10% and 50% increases in traded sector productivity are linked with an 8% decrease in γ. The results are summarized in Table 5.

TABLE 5 Changes in steady state variables in Case 2*

Traded sector productivity growth	10%	50%
Output	5.6%	27.2%
Traded consumption	0.1%	36.6%
Non-traded consumption	8%	8%
Traded production	8.5%	47.9%
Non-traded production	2.9%	2.9%
Trade deficit	–38%	–15.5%
Wages	11.9%	52.6%
Relative price	14.8%	56.5%
Real exchange rate	7.8%	22%

*Government consumption defined as a constant share of output.

The results show that the decrease in γ, indeed strengthens the Balassa-Samuelson effect, ie the relative price rises and the real exchange rate appreciates more strongly than before. However, the effects on the trade account are positive, ie the deficit diminishes notably from 6.9% of GDP to 3.8%. Hence, it would appear that the catch-up related change in the composition of consumption might naturally help to correct external imbalances.

3.2.3 Transitory shock

The transitory shock is a stochastic shock on traded sector productivity. The impulse responses of a stochastic shock are better suited for examining the adjustment paths than those of a deterministic shock. As the response to the shocks is similar in the baseline case and the case with endogenous government expenditure, the impulse responses only to the former case are presented. The deviations from the steady state in response to the shock are presented in Figure 1.

Consistent with the Balassa-Samuelson proposition, the relative price, the real exchange rate and wage rise following the shock. Moreover, total output increases temporarily, as the output in the traded goods sector rises and that in the non-traded goods sector falls.

Due to higher income, consumption rises but less than output, which implies that trade balance surplus develops – or that saving increases – causing positive net foreign assets. As output quickly returns to the steady state level, the trade balance surplus is eliminated. After the initial rise, the relative price starts falling back to the steady state level. The falling relative price brings a rise to the consumption-based interest rate, which implies a substitution from current to future consumption. Thus, consumption is lower but still above the steady state levels, which is financed by the interest income from the positive net foreign assets. This process continues until the net foreign assets have evaporated and consumption and net foreign assets are again at the steady state levels. Higher consumption induces lower labour demand.

Examining the effects of different values of ψ, gives results that are in line with Schmitt-Grohé and Uribe (2003). It was found that the speed of mean

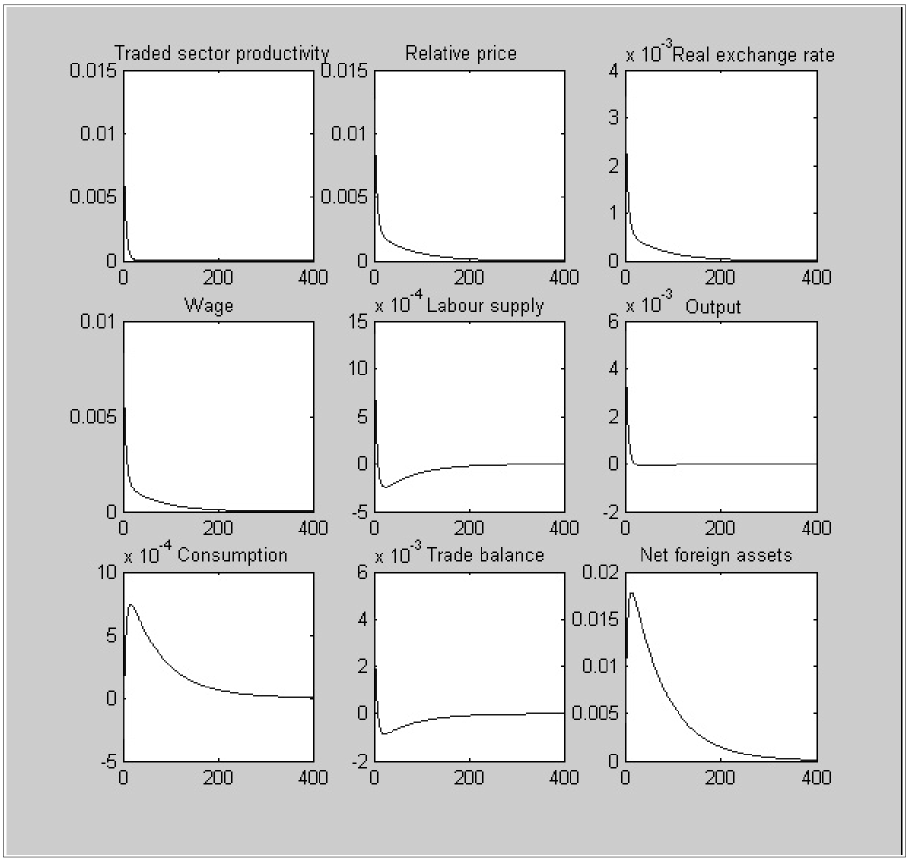

Figure 1: Response to a stochastic productivity shock in the traded goods sector

reversion increases with the value of ψ. Moreover, the response of net foreign assets to productivity shocks also decreases, when the value of ψ increases.

4 Conclusions

Differences in growth, productivity and inflation levels are going to be a prominent feature of the future EMU, as the convergence process is still on-going in the new Member States. This convergence process can be described by the Balassa-Samuelson proposition.

The aim in this study has been to build a framework that is suited for analyzing convergence/growth related questions in small open economies with fixed exchange rate regimes. The model presented here is a fairly standard intertemporal small open economy model, where the home economy pegs its currency to the currency of a monetary union and thus takes the interest rate as exogenous. The home economy produces a traded and a non-traded good using labor as the only input. It is assumed that growth differentials stem from differences in productivity growth, ie the home country will experience faster productivity growth in its traded than its non-traded sector, in line with the Balassa-Samuelson model.

The major difference in the model introduced in Chapter 2 in comparison with the majority of other small open economy models is the use of an endogenous discount rate, which is done to induce stationarity into the small open economy model. The endogenous discount factor is formulated in line with Schmitt-Grohé and Uribe (2003) and it depends on the average per capita levels of either consumption as a share of output or traded goods consumption as a share of traded goods production.

The model appears to be suitable for examining the intended issues. However, it might be useful to add capital and investment to the model, especially as they play an important role in the convergence process.[19] Moreover, they have been identified as a major cause behind external imbalances. Additionally, applying other forms of the discount factor might give different results from the formulations presented here. Finally, the study would benefit from a more detailed specification of the government side, where clear differences between countries emerge. This could be done eg by imposing different fiscal policy rules.

To determine the existence of a steady state and the effects of different productivity shocks, numerical methods were employed. Parameter values were collected from the relevant literature and actual data was also consulted. The Baltic states were chosen to be the reference group with regard to actual data, as they can be thought as good examples of small open economies with fixed exchange rate regimes. Two main types of shocks were examined: a permanent shock, where the traded sector productivity level of the home

[19] Schaedler et al (2004) find that investment is higher in the Central European Countries than the current euro area, as the countries are currently relatively labour-rich and capital-poor.

economy converges to that of the monetary union, and a transitory stochastic shock to traded sector productivity.

The estimations in Chapter 3 provided support for the Balassa-Samuelson effect, ie faster productivity growth in the traded than in the non-traded goods sector shows up as an increase in the price of the non-traded good and an appreciation of the real exchange rate. However, the focus in this study goes beyond this supply-side effect to the implications on the external balance. The simulations showed that permanent shocks in productivity, ie convergence, can have significant effects on the trade account and the net foreign asset position of a small open economy. Trade account deficits (surpluses) are easily created, which leads to the accumulation of negative (positive) net foreign assets. This implies an increased vulnerability of the economy.

Hence, it would appear that besides the real exchange rate – and therefore inflation, as in fixed exchange rate regimes the Balassa-Samuelson effect is visible as higher inflation – faster productivity growth in the traded than in the non-traded sector has an effect on the external balance of an economy. It would appear that this line of development might have more consequences than the traditional Balassa-Samuelson effects.

However, convergence is often related to a shift in consumption preferences. Typically, as an economy catches up, the share of non-traded goods, ie services, in total consumption tends to increase. This reinforces the supply side Balassa-Samuelson effect, ie the relative price and the real exchange rate rise more strongly, but reduces the effects on the external balance. It seems that as the share of non-traded goods in consumption increases, the trade balance deficit improves. Hence, trade account deficits would appear to be a temporary phenomenon in countries that are still catching-up.

Although it is clear that a more careful formulation of the government side is warranted, it already seems apparent based on the findings here that the government's policies have a key role to play in keeping the external balance in line. Still, it should be kept in mind that the observed behavior can also be due to other factors than those discussed here.

The Baltic states, used as reference countries here, all have significant trade and current account deficits, which lends support to the findings here. Nevertheless, based on the findings in this study, it would appear that the large trade and current account deficits may not be such a serious cause of concern after all. Changes in the composition of consumption that are characteristic to the transition process may provide a natural correction in the course of catch-up.

Yet, a careful monitoring of the development of the net foreign asset position should not be neglected. Indeed, strong private sector credit growth has been seen in the Baltic states, which underlines the need to ensure a proper functioning of the financial markets and an effective financial supervision. However, as pointed out by Cottarelli et al (2003), the credit growth rates have not yet reached the excessive rates seen in some Asian countries in the 1990s.

Although it may be premature to suggest conclusive policy implications from these results, it would appear safe to say that prudent fiscal policy has an important role to play. Firstly, fiscal policy has a crucial part in keeping the trade and current account deficits in check, which was the focus in this study. Secondly, fiscal policy also helps bring down inflation that is also to some extent influenced by the Balassa-Samuelson effect. Thirdly, fiscal policy is key in containing pressures for over-heating that may appear in fast growing economies and finally, prudent fiscal policy is a requirement for meeting the Maastricht fiscal criteria. The role of sound fiscal policy is also underlined by the ECB in its latest (2004) convergence report.

Based on these results, one can draw some guidelines for future research. As noted earlier, capital and investment could be added to the model to improve the description of the convergence process. Moreover, numerical methods could be further developed and the group of reference countries widened to include the Central European Countries, who are likely to join the ERM II in the next years. Most importantly, the study would benefit from an explicit formulation of the government side. Differences with regard to fiscal discipline are visible between the Baltic states but especially in the case of the Central European Countries, public sector deficits can be considered the largest obstacle on the way towards adoption of the euro. Hence, the integration of growth and fiscal sustainability is a priority in future work.

Nevertheless, the model presented here provides a good starting point for the analysis of different convergence related questions in small open economies participating in a fixed exchange rate regime or a monetary union.

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Appendix

A. Steady state model

In the steady state, the discount rate reduces to

$$\beta\left(C_t, m_t, L_t\right) = \frac{1}{1+r}. \tag{4.1}$$

Following, one can calculate the steady state consumption for the home economy using the steady state budget constraints for the household, government and central bank:

$$\overline{C}_T + p\overline{C}_N = \overline{r}\left(\frac{\overline{B}_H + \overline{B}_F + \overline{B}_m - \overline{D}}{\overline{P}_T}\right) + \overline{Y}_T + p\overline{Y}_N - \overline{G}_T - p\overline{G}_N. \tag{4.2}$$

Equation (4.2) states that in the steady state, consumption must equal real income. Employing the non-traded goods market equilibrium condition $C_N + G_N = Y_N$ on equation (4.2) gives the current account equation for the home economy:

$$\overline{TB} = -\overline{r}\frac{\overline{F}}{\overline{P}_T}, \tag{4.3}$$

where $\overline{TB} = \overline{Y}_T - \overline{C}_T - \overline{G}_T$ is the steady state trade balance and $\overline{F} = \overline{B}_H + \overline{B}_F + \overline{B}_m - \overline{D}$ the steady state net foreign assets.

By substituting private and public demands for the non-traded good, (2.18) and (2.35), the supply of the non-traded good (2.2)as well as the demand for labour in the non-traded sector (2.6) into the equilibrium condition of the non-traded goods sector (2.44), we can solve the equilibrium value of P_N

$$p = A_N^{\frac{1}{\gamma\eta-\gamma-\eta}}\left(\frac{W}{\eta}\right)^{\frac{\eta}{\gamma+\eta-\gamma\eta}}\left[\left(1-\gamma\right)C + \left(1-\delta\right)G\right]^{\frac{\eta-1}{\gamma\eta-\gamma-\eta}} \tag{4.4}$$

and respectively for the foreign economy. Thus, the equilibrium real exchange rate can be written as

$$\frac{p}{p^*} = \frac{\left(A_N\right)^{\frac{1}{\gamma\eta-\gamma-\eta}}\left(\frac{W}{\eta}\right)^{\frac{\eta}{\gamma+\eta-\gamma\eta}}\left[\left(1-\gamma\right)C + \left(1-\delta\right)G\right]^{\frac{\eta-1}{\gamma\eta-\gamma-\eta}}}{\left(A_N^*\right)^{\frac{1}{\gamma\eta-\gamma-\eta}}\left(\frac{W^*}{\eta}\right)^{\frac{\eta}{\gamma+\eta-\gamma\eta}}\left[\left(1-\gamma\right)C^* + \left(1-\delta\right)G^*\right]^{\frac{\eta-1}{\gamma\eta-\gamma-\eta}}}. \tag{4.5}$$

B. Linearized model

The first-order conditions (2.28), (2.29) and (2.30) are written in linearized form as follows:

$$\begin{aligned} E_t\widetilde{C}_{t+1} &= \widetilde{C}_t - \psi\overline{C}\left(\lambda\widetilde{C}_t + \mu\widetilde{m}_t + \varphi\widetilde{L}_t\right) \\ &= \left(1-\psi\overline{C}\right)\widetilde{C}_t - \psi\overline{C}\left(\mu\widetilde{m}_t + \varphi\widetilde{L}_t\right) \end{aligned} \tag{4.6}$$

$$\widetilde{m}_t = \chi \left(\frac{R}{R-1} \right) \widetilde{C}_t \tag{4.7}$$

and

$$\omega \frac{\widetilde{L}_t}{\overline{L}} = \frac{\widetilde{W}_t}{\overline{W}} - \frac{\widetilde{P}_{Tt}}{\overline{P}_T} - \frac{\widetilde{C}_t}{\overline{C}}. \tag{4.8}$$

Combining the linearized household, government and central bank budget constraints and recalling that the exchange rate and the price of the traded good are fixed gives the economy wide linearized budget constraint

$$\begin{aligned} \frac{\widetilde{B}_{Ht}}{\overline{P}_T} + \frac{\widetilde{B}_{Ft}}{\overline{P}_T} + \frac{\widetilde{B}_{mt}}{\overline{P}_T} - \frac{\widetilde{D}_t}{\overline{P}_T} &= (1+r) \left(\frac{\widetilde{B}_{Ht-1}}{\overline{P}_T} + \frac{\widetilde{B}_{Ft-1}}{\overline{P}_T} + \frac{\widetilde{B}_{mt-1}}{\overline{P}_T} - \frac{\widetilde{D}_{t-1}}{\overline{P}_T} \right) \\ &+ \widetilde{Y}_{Tt} - \widetilde{C}_{Tt} - \widetilde{G}_{Tt} + \overline{P}_N \left(\widetilde{Y}_{Tt} - \widetilde{C}_{Tt} - \widetilde{G}_{Tt} \right) \\ &+ \widetilde{P}_{Nt} \left(\overline{Y}_T - \overline{C}_T - \overline{G}_T \right). \end{aligned} \tag{4.9}$$

Employing the non-traded goods market equilibrium and denoting net foreign assets $\frac{\widetilde{B}_{Ht}}{\overline{P}} + \frac{\widetilde{B}_{Ft}}{\overline{P}} + \frac{\widetilde{B}_{mt}}{\overline{P}} - \frac{\widetilde{D}_t}{\overline{P}} = \frac{\widetilde{F}_t}{\overline{P}}$ produces

$$\frac{\widetilde{F}_t}{\overline{P}_T} = (1+r) \frac{\widetilde{F}_{t-1}}{\overline{P}_T} + \widetilde{Y}_{Tt} - \widetilde{C}_{Tt} - \widetilde{G}_{Tt}. \tag{4.10}$$

In terms of whole consumption, the linearized combined budget constraint can be written as follows

$$\frac{\widetilde{F}_t}{\overline{P}} = R \frac{\widetilde{F}_{t-1}}{\overline{P}} + \widetilde{Y}_t - \widetilde{C}_t - \widetilde{G}_t - (R-1) \frac{\overline{F}}{\overline{P}} \frac{\widetilde{P}_t}{\overline{P}} \tag{4.11}$$

Noting that $\widetilde{G}_t = 0$ and assuming that $\alpha = \eta = 1$, ie constant returns to scale, and a constant labour supply we get:

$$\frac{\widetilde{F}_t}{\overline{P}} = (1+r) \frac{\widetilde{F}_{t-1}}{\overline{P}} + \gamma \overline{L} \left(\frac{\overline{A}_T}{\overline{A}_N} \right)^{\gamma-1} \widetilde{A}_{Tt} - \widetilde{C}_t - r(1-\gamma) \frac{\overline{F}}{\overline{P}} \frac{\widetilde{A}_{Tt}}{\overline{A}_T} \tag{4.12}$$

Forward by one period, subtract $\left(1 - \psi \overline{C}\right) \left(\frac{\widetilde{F}_t}{\overline{P}} \right)$ from both sides and assume that $\mu = \varphi = 0$ and $\lambda = 1$, which allows the previous equation to be written as follows:

$$\begin{aligned} \frac{\widetilde{F}_{t+1}}{\overline{P}} - \left(1 - \psi \overline{C}\right) \left(\frac{\widetilde{F}_t}{\overline{P}} \right) &= (1+r) \left[\frac{\widetilde{F}_t}{\overline{P}} - \left(1 - \psi \overline{C}\right) \left(\frac{\widetilde{F}_{t-1}}{\overline{P}} \right) \right] \\ + \gamma \overline{L} \left(\frac{\overline{A}_T}{\overline{A}_N} \right)^{\gamma-1} &\left[\widetilde{A}_{Tt+1} - \left(1 - \psi \overline{C}\right) \widetilde{A}_{Tt} \right] - \left[E_t \widetilde{C}_{t+1} - \left(1 - \psi \overline{C}\right) \widetilde{C}_t \right] \\ - r(1-\gamma) \frac{\overline{F}}{\overline{P}} \frac{1}{\overline{A}_N} &\left[\widetilde{A}_{Tt+1} - \left(1 - \psi \overline{C}\right) \widetilde{A}_{Tt} \right] \end{aligned} \tag{4.13}$$

which, taking into consideration the first-order-condition (4.6) , the process for A_T and that government expenditure is exogenous, reduces to

$$\left(1-\frac{L^{-1}}{(1+r)}\right)\left[\frac{\widetilde{F}_t}{\overline{P}}-(1-\psi\overline{c})\left(\frac{\widetilde{F}_{t-1}}{\overline{P}}\right)\right] \tag{4.14}$$
$$=\frac{1}{(1+r)}\left[\gamma\overline{L}\left(\frac{\overline{A}_T}{\overline{A}_N}\right)^{\gamma-1}-r\left(1-\gamma\right)\frac{\overline{F}}{\overline{P}}\frac{1}{\overline{A}_T}\right]\left(1-\rho-\psi\overline{C}\right)\widetilde{A}_{Tt}$$

where the forward operator is defined as $L^{-k}X_t \equiv E_tX_{t+k}$. From here we can solve for equations (2.49) and (2.50) in the text.

$$\widetilde{C}_t=\left(r+\psi\overline{C}\right)\left(\frac{\widetilde{F}_{t-1}}{\overline{P}}\right)+\frac{\left(r+\psi\overline{C}\right)}{(1+r-\rho)}\left[\gamma\overline{L}\left(\frac{\overline{A}_T}{\overline{A}_N}\right)^{\gamma-1}-r\left(1-\gamma\right)\frac{\overline{F}}{\overline{P}}\frac{1}{\overline{A}_N}\right]\widetilde{A}_{Tt}. \tag{4.15}$$

$$\frac{\widetilde{F}_t}{\overline{P}}=\left(1-\psi\overline{C}\right)\left(\frac{\widetilde{F}_{t-1}}{\overline{P}}\right)+\frac{\left(1-\rho-\psi\overline{C}\right)}{(1+r-\rho)}\left[\gamma\overline{L}\left(\frac{\overline{A}_T}{\overline{A}_N}\right)^{\gamma-1}-r\left(1-\gamma\right)\frac{\overline{F}}{\overline{P}}\frac{1}{\overline{A}_N}\right]\widetilde{A}_{Tt} \tag{4.16}$$

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