EU-ENLARGEMENT, THE ECONOMIC CONVERGENCE BETWEEN EU-15 AND CEECS, AND THE TRANSITIONAL DYNAMICS OF THE REAL EURO-DOLLAR EXCHANGE RATE

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Abstract

On May 1st, 2004 eight CEECs entered the EU together with Malta and Cyprus. The Fifth Enlargement initiates the biggest convergence process which has ever taken place within the EU, strongly affecting the economic relations between the EU-25 and other large world economies. This paper presents a new non-scale growth model of the world economy consisting of the Euro and Dollar areas mainly connected by the real exchange rate. The CGE analysis focuses on the impacts of the post-Enlargement convergence process on the real Euro-Dollar exchange rate. The immediate effect of the Enlargement is a sudden real depreciation of the Euro and a strong decline of EU-15-capital intensity. Afterwards the Euro keeps on depreciating and both the EU-15 and the CEEC capital intensity increase towards the steady state of full convergence.

JEL classification numbers: F15, F11, D58.

1 Introduction

On May 1st, 2004 eight CEECs entered the EU together with Malta and Cyprus. The Fifth Enlargement initiates the biggest convergence process which has ever taken place within the EU, strongly affecting the economic relations between the EU-25 and other large world economies, mainly connected by the real exchange rate. To the best of these authors' knowledge, how the intra-EU convergence will affect the real exchange rate between the enlarged EU and other large open economies like the US or Japan is an open question.

This paper presents a new non-scale growth model of the world economy consisting of two large open economies, the Euro and the Dollar area. The theoretical model and the subsequent CGE analysis explore the impacts of the post-Enlargement convergence process on the real Euro-Dollar exchange rate.

The theoretical analysis exhibits that in the long run the real exchange rate increases (the Euro depreciates in real terms against the Dollar) while the other main economic variables (national capital intensities) remain unchanged. In the short run, the real exchange rate jumps upward immediately after the Enlargement shock whereas the national capital intensities decrease (more strongly within the EU-15 than in the US). As convergence goes

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ahead, capital intensities start to increase again and the real exchange rate continues to increase up to the new steady state (the Euro depreciates in real terms against the Dollar).

The related literature about EU-enlargement focuses on the costs and benefits of integration (Breuss, 2002) without considering the effects of the intra-EU convergence on the world economy. Walz (1997) considers the external effects of regional integration, however, he models a one-currency-world economy. Walz (1998) studies convergence under international integration within a model setting not capable to depict the convergence effects on the real exchange rate.

Zee (1987) and Farmer (1998) develop a two-currency model economy consisting of large open homogeneous countries. In these models the effects of national fiscal policies on the real exchange rate and national capital intensities are studied. Funke and Strulik (2000, 2002), on the other hand, present a heterogeneous one-currency-model, in which the effects of a deliberate convergence policy on the dynamics of the regional capital intensities are studied.

The present paper combines the Zee-Farmer framework with the Funke-Strulik approach. It contributes to the existing literature in three ways. First, it extends the Zee-Farmer model by introducing regional disparities within one of the two world countries (i.e. the EU-25). Second, the effects of an intra-EU convergence policy on the national capital intensities as well as on the real exchange rate are theoretically modelled. Third, by extending Zee (1987), not only the steady state effects of the Enlargement shock but also the transition path is numerically calculated by utilizing GAMS.

The paper is organised as follows. In Section 2 the main structure of the model is depicted, leaving to Section 3 the description of the dynamics of the two-countries-two-sectors model. In Section 4 we look at numerical specification of the baseline scenario. In section 5 the convergence process after the enlargement and the dynamic transition of the exchange rate are explored. Section 6 concludes.

2 The Two-Countries-Two-Regions Model

As mentioned above, the model presented in this paper originates from the combination of two modelling frameworks. The first consists of the Zee (Zee, 1987) and Farmer approach (Farmer, 1998) which represents a two-country version of the traditional OLG-Diamond model of a closed economy with exogenous technological progress (Diamond, 1965). The other relies on Funke and Strulik (2000, 2002) who develop an endogenous growth model of a closed economy composed of two unequally developed regions. The representative agent in Funke-Strulik's model is infinitely lived, while the technical progress follows Barro's (1990) specification.

The present model portrays a world economy with two large interdependent countries, such as the EU and the US, which are assumed to be identical with respect to factor endowments and technology. One of the two countries, the EU, is composed of two regions differing in terms of private capital intensities (per-capita-incomes) and (per-capita-) public infrastructure. In each country, one homogeneous good is produced which can be used for consumption as well as for public and private investment. The same good can be traded internationally but is used only for consumption.

2.1 *Households*

Two generations (a young one and an old one) overlap in each period $t = 1,...,..$. They are differentiated by their area of residence $j = E, M, US$ (*E* = EU-15, *M* = CEECs). Each generation lives for two periods. In the following, the superscript 1 (2) refers to the first (second) period of life. We denote by L_t^j the young population residing in area j ($j = E, M, US$) in period t [1]. In each period t, the population of each area grows according to an exogenously fixed factor G^L. The population does not migrate. The CEE

[1] The two regions, EU-15 and CEECs, will be referred to by the index r.

young population, L_t^M is defined as a fixed share ξ of the EU-15 population. The population of the enlarged EU is therefore given by:

$$L_t^{EU} = \left(1+\xi\right) L_t^E . \qquad (1)$$

During each period, the young generation supplies one unit of labour inelastically receiving a real wage w_t^j [2] while the old generation lives its retirement period relying on the rental and interest income from first period savings. In addition, young generations receive net real transfers z_t^j from the national government. Net income is allocated to consumption and to savings s_t^j for financing the retirement consumption. In each period of life, EU-15 and CEE (US) households choose between domestic consumption, $c_t^{EU,r,n}$ ($c_t^{US,US,n}$) and foreign consumption, $c_t^{US,r,n}$ ($c_t^{EU,US,n}$) consumption (n = 1, 2)[3]. The budget constraints (in real terms) of the household living in the EU-15 and in the CEECs, are as follows[4]:

$$\text{I} \quad c_t^{EU,r,1} + e_t c_t^{US,r,1} + s_t^r = \left(1-\varphi^{EU}\right) w_t^r + z_t^r , \qquad (2)$$

$$\text{II} \quad c_{t+1}^{EU,r,2} + e_{t+1} c_{t+1}^{US,r,2} = \left(1+i_{t+1}\right) s_t^r . \qquad (3)$$

Households are identical within as well as across generations and areas. Their preferences are represented by the following intertemporal log-linear function:

$$U_t^j = \ln c_t^{j,1} + \beta \cdot \ln c_{t+1}^{j,2}, \qquad j = r, US , \qquad (4)$$

where $c_t^{j,1}$ is the consumption of the first life period and $c_t^{j,2}$ is the consumption of the second life period. Parameter β denotes the time preference factor of the young generation. Each household maximizes the utility U_t^j function subject to the budget constraints depicted by equations (2) and (3). The optimal consumption and savings' quantities for the EU-15, the CEE and the US household are given in the appendix (see equation A.3 to A.7 and A.12 to A.16).

The EU-15 and CEE (US) households allocate their savings to two assets, nation-specific productive capital and US bonds. These assets are valued by their national nominal price levels P_t^{EU} and P_t^{US}, while the US bonds are valued by $E_t P_t^{US}$ in the EU, being E_t the nominal Euro-Dollar exchange rate[5].

It is assumed that productive capital is fully mobile within the EU-25 (see Section 5). Because of regional disparities in the capital intensity within the EU-25 before Enlargement, the Enlargement shock provokes spontaneous capital inflows towards the region with the higher marginal product q_t^r of private capital (i.e. to the CEECs). These intra-period capital movements between EU-15 and CEEC come to an end, if the following real interest parity condition between the EU-15 and the CEECs holds:

$$q_t^E = q_t^M . \qquad (5)$$

In the US, the net return factor on real capital i_t^{US} equals the US nominal interest factor divided by the US inflation factor (being τ^{US} the capital income tax and δ^{US} the depreciation rate of US capital):

[2] Lower-case variables indicate real prices obtained by dividing the respective nominal variable by the national price level (e.g. $w_t^j = W_t^j / P_t^i$).

[3] The first superscript indicates the origin of the good, the second the nationality of the consumer, the third the life period of the consumption

[4] Similar constraints for the US household are to be found in the Appendix (see equations A.10 and A.11).

[5] E_t indicates the amount of Euro currency per one Dollar currency unit.

$$\frac{1+r_{t+1}^{US}}{P_{t+1}^{US} / P_t^{US}} = 1 + i_{t+1}^{US} \equiv 1 + \left[\left(1-\tau^{US}\right) q_t^{US} - \delta^{US}\right]. \qquad (6)$$

We assume that US bonds are perfectly mobile across the three regions of the world. Hence, an international interest parity condition between EU-25 and US holds:

$$1 + i_{t+1}^{EU} = \frac{e_{t+1}}{e_t} \cdot \left(1 + i_{t+1}^{US}\right), \qquad (7)$$

where $e_t \equiv \left(E_t P_t^{US}\right) / P_t^E$ denotes the real Euro-Dollar exchange rate.

2.2 *Firms*

A large number of identical firms operate under perfect competition in the EU-15, in the CEECs as well as in the US. They are provided with the same technology which is specified according to a Cobb-Douglas production function, and employ private capital services K_t^j together with labour services N_t^j to produce output Y_t^j under constant returns of scale:

$$Y_t^j = A_t^j \left(K_t^j\right)^{\alpha} \left(N_t^j\right)^{1-\alpha}. \qquad (8)$$

Since firms operate in a fully competitive environment, the production elasticity of capital (labour) services, α $\left(1-\alpha\right)$, represents the capital (labour) income share.

The total factor productivity A_t^j is specified according to Barro´s (1990) specification of the productivity effects of public infrastructure:

$$A_t^j = A \cdot \left(\frac{G_t^j}{L_t^j}\right)^{\eta} \qquad A > 0 \qquad \eta < 1-\alpha, \qquad (9)$$

A being an exogenously fixed level parameter of total factor productivity, equal for all areas. G_t^j denotes infrastructure (public capital) of area *j* in period *t*. Firms’ production is supposed to be positively affected by the public infrastructure[6]. In contradistinction to Barro (1990), diminishing returns to scale to private and public capital are assumed ($\eta < 1-\alpha$).

Profit maximization implies:

$$q_t^j = \alpha \cdot A_t^j \left(\frac{K_t^j}{N_t^j}\right)^{\alpha-1}, \qquad (10)$$

$$w_t^j = \left(1-\alpha\right) \cdot A_t^j \left(\frac{K_t^j}{N_t^j}\right)^{\alpha}. \qquad (11)$$

Private and public capital accumulates over time as follows:

$$K_{t+1}^j = I_t^j + \left(1-\delta^j\right) K_t^j, \qquad (12)$$

$$G_{t+1}^j = I_t^{g^j} + \left(1-\delta^j\right) G_t^j. \qquad (13)$$

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[6] In order to avoid unwanted scale effects, infrastructure stock per capita is assumed to determine total factor productivity.

2.3 *The public sector*

As known, the EU as a whole runs a balanced budget while the US government in part finances its expenses through the emission of public debt. In both countries, public revenues include labour and capital income taxes. The tax rate on labour income is denoted by φ^{EU} in the EU[7] and φ^{US} in the US. Individual capital earnings are taxed according to a tax rate τ^{i} ($i = EU, US$). In the EU, total public expenditures are defined as a share Γ^{EU} of regional GDP, Y_t^r. In the US a similar definition applies, being Γ^{US} the share of US GDP spent by the public sector. In the EU as well as in the US, tax earnings are spent on public investments and on transfers to private households. After the Enlargement, however, the EU-25 expenditure policy takes into account the regional disparities between old and new member countries. Denoting by $0 < q_j < 1$ the share spent on public capital accumulation, the investments into public capital read as follows:

$$I_t^{g^j} \equiv q_j \Gamma^i \cdot Y_t^j, \qquad i = EU, US, \qquad j = r, US, \tag{14}$$

while transfers are specified by:

$$Z_t^E \equiv \left(1 - q_E - x\right) AU_t^E, \tag{15a}$$

$$Z_t^M \equiv \left(1 - q_M\right) AU_t^M + x \cdot AU_t^E, \tag{15b}$$

$$Z_t^{US} \equiv \left(1 - q_{US}\right) AU_t^{US}, \tag{15c}$$

where x is the fraction of tax earnings collected in the EU-15 and transferred to the CEECs' (see Section 2.4 about the interregional redistribution policy of the EU-25) and AU_t^j denotes total public expenditures in area j.

Balancing the EU-25 budget implies:

$$\varphi_t^{EU} \cdot \left(w_t^E + \xi \cdot w_t^M\right) + \tau^{EU} \left(q_t^E k_t^E + q_t^M \xi \cdot k_t^M\right) = i_t^{g^E} + \xi \cdot i_t^{g^M} + z_t^E + \xi \cdot z_t^M, \tag{16}$$

while the budget constraint of the US government reads as follows:

$$G^L b_{t+1}^{US} + \varphi^{US} w_t^{US} + \tau^{US} q_t^{US} k_t^{US} = \left(1 + i_t^{US}\right) \cdot b_t^{US} + i_t^{g^{US}} + z_t^{US}. \tag{17}$$

2.4 *The convergence policy of EU-25*

A new variable, the convergence indicator θ_t is introduced to measure the regional disparities within the EU after Enlargement[8]:

$$\theta_t \equiv \frac{Y_t^M}{L_t^M} \bigg/ \frac{Y_t^E}{L_t^E}. \tag{18}$$

Combining the production function (8) and the real interest parity condition between the EU-15 and the CEECs, yields:

$$\theta_t \equiv \frac{y_t^M}{y_t^E} = \frac{k_t^M}{k_t^E} = \left(\frac{g_t^M}{g_t^E}\right)^{\frac{\eta}{1-\alpha}}, \tag{19}$$

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[7] Counter factually, we assume identical income tax rates within the enlarged EU.

[8] The notion of θ_t is based on Funke and Strulik (2000, p. 367).

Equation (19) shows that the intra-EU convergence process is governed by the ratio of public capital of CEECs and EU-15, which themselves are determined by the policy instrument q^r. Inserting (14) into (13), assuming full depreciation of the public capital stock within a one period and considering (19), we obtain:

$$\theta_t = \left(\frac{q_M}{q_E} \cdot \theta_{t-1} \right)^{\frac{\eta}{1-\alpha}} . \tag{20}$$

Since $\eta < 1 - \alpha$, (20) implies:

$$\lim_{t \to +\infty} \theta_t = \left(\frac{q_M}{q_E} \right)^{\frac{\eta}{1-\alpha-\eta}} , \tag{21}$$

which shows that full convergence is reached only if the same investment policy ratio is introduced in both regions ($q_M = q_E$). However, due to decreasing returns to scale of private and public capital ($\eta < 1 - \alpha$), there would be no need for any policy intervention in our model in order to induce CEECs' recovery. Nonetheless, we follow Funke and Strulik (2000) and adopt a policy function of the EU as a whole. We assume that the EU seeks to initiate CEECs growth faster than the convergence rate provided by decreasing returns to scale of private and public capital. . Funke-Strulik's policy function reads as follows:

$$q_M \equiv p_t^M = \left[f\left(\theta_t\right) + 1 \right] \cdot q_E , \tag{22}$$

with

$$f'\left(\theta_t\right) < 0,$$
$$f\left(1\right) = 0.$$

Inserting (22) into (21) reveals that the CEECs' recovery process is faster in the first periods after the Enlargement than in case of laissez faire.

Clearly, the convergence policy of the EU aims at faster growth of CEECs' GDP in the periods following the Enlargement shock. Nonetheless, wage income in the CEECs remains at considerably lower levels than in EU-15. Consequently, CEECs' households are in part compensated by the EU interregional income redistribution policy, which is intended to equalize disposable income in the two regions. In the period when Enlargement occurs, old generations in the EU-15 are obviously better off than those in the CEECs. This is due to the bad economic performance of the CEECs before the Enlargement and lies therefore outside of the policy range of the EU. The EU is therefore concerned with the equalization of the disposable income of the young generations by the Enlargement period t_0 on, i.e.:

$$\left(1 - \varphi^{EU}\right) w_t^M + z_t^M = \left(1 - \varphi^{EU}\right) w_t^E + z_t^E \qquad t \geq t_0 , \tag{22a}$$

The parameter of interregional income redistribution policy x will be therefore designed in order to guarantee (22a) in every period since the Enlargement:

$$x = \frac{\xi}{\Gamma^{EU}\left(1+\xi\right)} \left\{ \left[\left(1-\alpha\right)\left(1-\varphi^{EU}\right) + \left(1-q_E\right)\Gamma^{EU} \right] \left(1-\theta_t\right) + q_E \cdot f\left(\theta_t\right) \Gamma^{EU} \cdot \theta_t \right\} .$$

2.5 *Market equilibrium*

In this section, main market clearing conditions are briefly described.

Market clearing on the three regional labour markets requires:

$$N_t^j = L_t^j, \qquad j = E, M, US. \tag{23}$$

The international capital market clearing condition requires that the total amount of savings in the world equal the total demand:

$$s_t^E + \xi \cdot s_t^M + e_t s_t^{US} = G^L \left[\left(1 + \xi \cdot \theta_{t+1}\right) k_{t+1}^E + e_t k_{t+1}^{US} + e_t b_{t+1}^{US} \right]. \tag{24}$$

The EU product market clearing condition reads as follows:

$$\begin{aligned} y_t^E + \xi y_t^M &= c_t^{EU,E,1} + \frac{1}{G^L} c_t^{EU,E,2} + \xi c_t^{EU,M,1} + \xi \frac{1}{G^L} c_t^{EU,M,2} + \\ &\quad + G^L g_{t+1}^E + G^L k_{t+1}^E + \xi G^L g_{t+1}^M + \xi G^L k_{t+1}^M + c_t^{EU,US,1} + \frac{1}{G^L} c_t^{EU,US,2}. \end{aligned} \tag{25}$$

while US product market clearing demands:

$$\begin{aligned} y_t^{US} &= c_t^{US,US,1} + \frac{1}{G^L} c_t^{US,US,2} + G^L k_{t+1}^{US} + G^L g_{t+1}^{US} + \\ &\quad + c_t^{US,E,1} + \frac{1}{G^L} c_t^{US,E,2} + \xi \cdot c_t^{US,M,1} + \xi \frac{1}{G^L} \cdot c_t^{US,M,2}. \end{aligned} \tag{26}$$

3 The intertemporal equilibrium dynamics and the steady state

This section is devoted to derive the intertemporal equilibrium dynamics from the optimization and market clearing conditions described in Section 2 and to study its steady state properties. In order to simplify the complex algebra a little bit, we make the following simplifying assumptions

$$L_t^E = L_t^{US} = L_t, \tag{27}$$

$$\delta^j = 1, \qquad j = E, M, US, \tag{29}$$

which do not alter the qualitative nature of the results.

From the international Fisher relation (7) together with (8) – (10), the equation of motion of the real exchange rate follows:

$$e_{t+1} = e_t \cdot \frac{1-\tau^{EU}}{1-\tau^{US}} \cdot \frac{\left(g_{t+1}^E\right)^\eta \left(k_{t+1}^E\right)^{\alpha-1}}{\left(g_{t+1}^{US}\right)^\eta \left(k_{t+1}^{US}\right)^{\alpha-1}}. \tag{30}$$

By inserting the optimal savings functions (A.7 and A.16) into the international capital market clearing condition (24), the following difference equation is obtained:

$$\begin{aligned} \left(1 + \xi \cdot \theta_{t+1}\right) k_{t+1}^E + e_t k_{t+1}^{US} + e_t b_{t+1}^{US} &= \sigma \frac{A}{G^L} \cdot \left(g_t^E\right)^\eta \left(k_t^E\right)^\alpha \cdot \\ &\quad \cdot \left[\left(1 - \alpha + \tau^{EU}\alpha - q_E \Gamma^{EU}\right)\left(1 + \xi \cdot \theta_t\right) - \xi q_E \Gamma^{EU} a \left(\frac{1-\theta_t}{\theta_t}\right)^\varepsilon \theta_t \right] + \\ &\quad + \sigma \frac{A}{G^L} \cdot \left(g_t^{US}\right)^\eta \left(k_t^{US}\right)^\alpha e_t \left[\left(1 - \varphi^{US}\right)\left(1 - \alpha\right) + \left(1 - q_{US}\right)\Gamma^{US} \right]. \end{aligned} \tag{31}$$

From the equation of motion of the public capital (13), the following difference equations can be easily derived:

$$g_{t+1}^{E} = \frac{q_E \Gamma^{EU}}{G^L} A\left(g_t^E\right)^{\eta}\left(k_t^E\right)^{\alpha}, \tag{32}$$

$$g_{t+1}^{US} = \frac{q_{US} \Gamma^{US}}{G^L} A\left(g_t^{US}\right)^{\eta}\left(k_t^{US}\right)^{\alpha}. \tag{33}$$

We borrow from Funke and Strulik (2000) the following specification of the policy function: $f\left(\theta_t\right) = a \cdot \left(\frac{1-\theta_t}{\theta_t}\right)^{\varepsilon}, a > 0, \varepsilon > 1$. Inserting this policy function into (20), yields:

$$\theta_{t+1} = \left\{\theta_t \cdot \left[a \cdot \left(\frac{1-\theta_t}{\theta_t}\right)^{\varepsilon} + 1\right]\right\}^{\frac{\eta}{1-\alpha}}. \tag{34}$$

Using the fact that $i_{t+1}^{US} \equiv \left(1-\tau^{US}\right) q_t^{US} - \delta^{US}$ holds, the US public budget constraint corresponds to the following dynamic equation:

$$b_{t+1}^{US} = \frac{A}{G^L} \cdot \left(g_t^{US}\right)^{\eta}\left(k_t^{US}\right)^{\alpha}\left[\alpha\left(1-\tau^{US}\right)\frac{b_t^{US}}{k_t^{US}} - (1-\alpha)\varphi^{US} - \alpha\tau^{US} + \Gamma^{US}\right]. \tag{35}$$

From the two national product market clearing conditions (25) and (26), the seventh dynamic equation is obtained:

$$\begin{aligned}\left(1+\xi\theta_{t+1}\right)k_{t+1}^{E} - \frac{\zeta}{1-\zeta}\cdot e_t k_{t+1}^{US} &= \left\{\left(1-q_E\Gamma^{EU}\right)\left(1+\xi\theta_t\right) - \xi q_E \Gamma^{EU} a\left(\frac{1-\theta_t}{\theta_t}\right)^{\varepsilon}\theta_t\right\}\cdot \\ &\cdot \frac{A}{G^L}\left(g_t^E\right)^{\eta}\left(k_t^E\right)^{\alpha} - \frac{\zeta}{1-\zeta} e_t\left(1-q_{US}\Gamma^{US}\right)\frac{A}{G^L}\left(g_t^{US}\right)^{\eta}\left(k_t^{US}\right)^{\alpha}\end{aligned} \tag{36}$$

Equations (30) to (36) represent the seven-dimensional dynamic system of the two-countries-two-regions-model. The dynamic variables read as follows: $e_t, k_t^E, k_t^{US}, g_t^E, g_t^{US}, b_t^{US}, \theta_t$.

The steady state is defined as a fixed point of the dynamic system (30) to (36). To investigate the existence of a fixed point as well as its uniqueness, the time-stationary version of the dynamic system (30) to (36) is reduced to a static system of two equations, each of them representing a relation between the EU-15 capital intensity k^E and the real exchange rate e. The first of them (see figure 1a) is the geometrical locus of all the pairs $\left(k^E, e\right)$ which assures the international capital market clearing, and is called the KK-locus. The second (see figure 1b) represents the condition of clearing the product markets in both countries and is called the GG-locus.

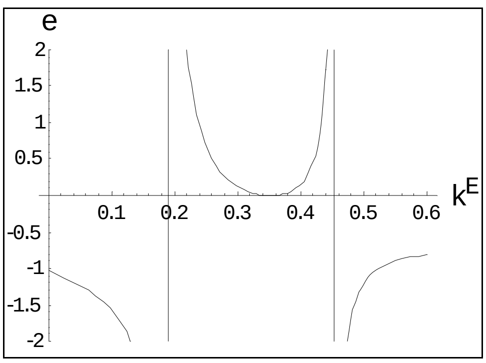

Figure 1a - The KK-locus

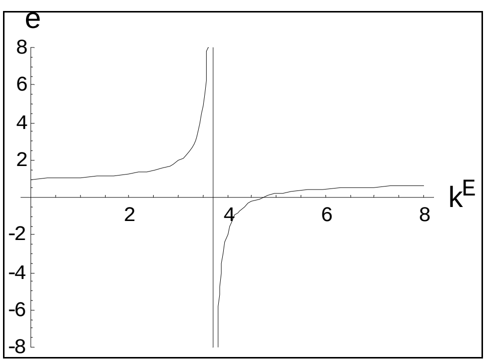

Figure 1b - The GG-locus

By collapsing the KK- and GG-locus, we obtain one cubic equation to determine k^E. For a broad range of numerically specified parameters, there are three real roots. The other (dynamic) variables are obtained as functions of k^E as follows:

$$\begin{cases} e = (1+\xi)\dfrac{1-\zeta}{\zeta}\left(\dfrac{1-q_E\Gamma^{EU}}{q_E\Gamma^{EU}}U-\left(k^E\right)^{1-\frac{\alpha}{1-\eta}}\right)\Bigg/\left(\dfrac{1-q_{US}\Gamma^{US}}{q_{US}\Gamma^{US}}V-T\cdot\left(k^E\right)^{1-\frac{\alpha}{1-\eta}}\right) \\ k^{US} = T\cdot k^E \\ g^E = U\cdot\left(k^E\right)^{\frac{\alpha}{1-\eta}} \\ g^{US} = V\cdot\left(k^E\right)^{\frac{\alpha}{1-\eta}} \\ b^{US} = \dfrac{\left[(1-\alpha)\varphi^{US}+\alpha\tau^{US}-\Gamma^{US}\right]TV}{\alpha\left(1-\tau^{US}\right)V\cdot\left(k^E\right)^{\frac{\alpha}{1-\eta}}-q_{US}\Gamma^{US}T\cdot k^E}\cdot\left(k^E\right)^{\frac{\alpha}{1-\eta}+1} \end{cases} \tag{37}$$

whereby the following abbreviations hold:

$$\begin{cases} T \equiv \left(\dfrac{1-\tau^{EU}}{1-\tau^{US}}\right)^{\frac{1-\eta}{\alpha+\eta-1}}\left(\dfrac{q_E\Gamma^{EU}}{q_{US}\Gamma^{US}}\right)^{\frac{\eta}{\alpha+\eta-1}} \\ U \equiv \left(\dfrac{Aq_E\Gamma^{EU}}{G^L}\right)^{\frac{1}{1-\eta}} \\ V \equiv \left(\dfrac{Aq_{US}\Gamma^{US}}{G^L}\right)^{\frac{1}{1-\eta}}\left(\dfrac{1-\tau^{EU}}{1-\tau^{US}}\right)^{\frac{\alpha}{\alpha+\eta-1}}\left(\dfrac{q_E\Gamma^{EU}}{q_{US}\Gamma^{US}}\right)^{\frac{\eta\alpha}{(\alpha+\eta-1)(1-\eta)}} \end{cases}$$

Which of the real solutions turns out to be economically significant will be shown graphically. The graphical representation shows that the solution with the highest capital intensity corresponds to a negative value of the exchange rate (figure 2b), being the other two solutions (figure 2a) positive and economically plausible. The numerical calculation of the other system variables shows, however, that the US bonds' stock gets out to be negative if the solution 2 (given by $k^E = 0.433411$ and by $e = 1.02344$) in figure 2a is considered.

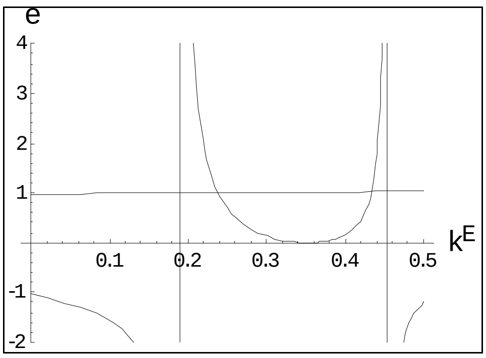

Figure 2a - Steady-state solutions 1 and 2

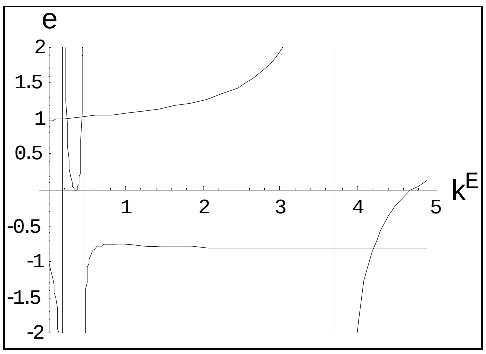

Figure 2b - Steady-state solution 3

The conditions for a feasible steady state solution are therefore:

$$\begin{cases} \left(\dfrac{1-q_E\Gamma^{EU}}{q_E\Gamma^{EU}}U-\left(k^E\right)^{1-\frac{\alpha}{1-\eta}}\right)\Big/\left(\dfrac{1-q_{US}\Gamma^{US}}{q_{US}\Gamma^{US}}V-T\cdot\left(k^E\right)^{1-\frac{\alpha}{1-\eta}}\right)>0 \\ \dfrac{\left[(1-\alpha)\varphi^{US}+\alpha\tau^{US}-\Gamma^{US}\right]TV}{\alpha\left(1-\tau^{US}\right)V\cdot\left(k^E\right)^{\frac{\alpha}{1-\eta}}-q_{US}\Gamma^{US}T\cdot k^E}>0 \end{cases}.$$

In order to study the local stability of the steady state, we remind the reader that the steady state solution remains unchanged if constant budget deficit policies are introduced (as in Diamond, 1965). This assumption allows a further reduction of the dimension of the dynamic system. Considering $b_{t+1}^{US}=b_t^{US}=b^{US}$, implies:

$$\varphi_t^{US}=\frac{\dfrac{A}{G^L}\left(g_t^{US}\right)^{\eta}\left(k_t^{US}\right)^{\alpha}\left[\alpha\left(1-\tau^{US}\right)\dfrac{b^{US}}{k_t^{US}}-\alpha\tau^{US}+\Gamma^{US}\right]-b^{US}}{(1-\alpha)\dfrac{A}{G^L}\left(g_t^{US}\right)^{\eta}\left(k_t^{US}\right)^{\alpha}}.$$

In order to check the local stability properties of the now six-dimensional dynamic system, the equilibrium dynamics is linearised in a small neighbourhood of the above mentioned steady state solution. The numerical calculation of the eigenvalues of the Jacobian matrix of the dynamic system at the old and the new steady state (pre- and post-Enlargement) indicates that 5 eigenvalues are less than 1, and one is larger than 1. Hence, both the pre- and the post-Enlargement steady states are saddle path stable. This conclusion holds for a broad range of plausible behavioural and political parameters.

4 The baseline scenario

We assume that before the Enlargement two distinct regions compose the world economy, the EU-15 and the US on the one hand and the CEECs on the other hand. Counterfactually, before the Enlargement the two areas are supposed to live a full autarky status, under which no international economic relations occur. The absence of any economic integration between the EU-15 and the CEECs is depicted in our model by fixing $\xi=0$, whereby ξ denotes the ratio of the CEE population to that of the EU-15. The EU-15 and the US are modelled as interdependent open economies under completely free trade of goods and services and internationally immobile labour and real capital, while free and costless movements of US-government bonds between EU-15 and the US are assumed.

The following numerical version of the international OLG model that we presented analytically in the foregoing sections does not comply with the usual standard of a fully calibrated CGE model. However, we hasten to state that main model parameters are numerically specified in accordance with stylized facts of the world macrodynamics before the EU-Enlargement.

Following EUROSTAT (2004) und CENSUS (2003), the average growth rate of the world active population is specified at around 0.54% yearly. Due to the small influence of the CEE active population on the total population, this figure is only slightly affected by the Enlargement. The population growth rate is therefore left unchanged in the simulation scenario. The corresponding growth factor, G^L, over a 25 years' period is 1.1441. The utility discount factor, β, is set equal to 0.6. This figure is equivalent to a subjective time preference rate of 0.2 per year. To simplify the algebra, we assume that the expenditure share of domestic consumption, ζ, can be set equal to 0.5 in both countries (EU-25 and US). This is consistent with the long-term focus of our analysis, according to which the economic integration between EU-25 and US will further develop. Estimates of the scale parameter A range from low values (e.g. 0.504 and 0.655 in Funke and Strulik, 2000) to higher values (e.g. 10 in Auerbach and Kotlikoff, 1998, 260). In accordance with the latter, we assume $A=5$. Under perfect competition, the production elasticity of labour $1-\alpha$ corresponds to the wage share, which is roughly equal to two thirds in developed countries. We therefore choose $\alpha=0.35$. The production elasticity of public capital η is set equal to

0.3 as in Funke and Strulik (2000). The complete parameter set, including the fiscal policy parameters for the two economies, is summarised in table 1.

Table 1 - The baseline parameter set

Parameter		Value	Parameter		Value
Population parameters			EU-15 (EU-25) fiscal policy parameters		
ratio of the CEE population	ξ	0	capital income tax rate	τ^{EU}	0.25
population growth factor	G^L	1.1441	public expenditures' GDP share	Γ^{EU}	0.42
time preference factor	β	0.6	public investment share on total public expenditures	q_E	0.12
expenditure share of domestic consumption	ζ	0.5	wage income tax rate	φ^{EU}	0.51
Production parameters			US fiscal policy parameters		
level parameter of total factor productivity	A	5	capital income tax rate	τ^{US}	0.15
production elasticity of private capital	α	0.35	public expenditures' GDP share	Γ^{US}	0.25
production elasticity of public capital	η	0.3	public investment share on total public expenditures	q_{US}	0.18
depreciation rate	δ^i	1	wage income tax rate	φ^{US}	0.32

The parameter set illustrated above allows a rough numerical reproduction of the world economy in the pre-Enlargement scenario. At this time, the relation between active population in the two regions of the enlarged Union and the respective GDP (in PPP) is $\theta_0 = 0,46$ (EUROSTAT, 2004). Main economic indicators of the EU-15 and the US as calculated from a steady state equilibrium of the above OLG-model before Enlargement (i.e. $\xi = 0$) are reported in table 2.

Table 2 - The world economy in baseline scenario (per capita figures)

Euro-Dollar exchange rate		0.996	Old consumption	EU-15	0.462
interest rate (on year basis)		1.37%		US	0.448
Output	EU-15	1.276	Savings	EU-15	0.329
	US	1.312		US	0.319
Private capital intensity	EU-15	0.238	Consumer welfare	EU-15	0.411
	US	0.277		US	0.400
Public capital intensity	EU-15	0.056	Public revenues	EU-15	0.536
	US	0.052		US	0.341
Gross wage income	EU-15	0.829	Public expenditures	EU-15	0.536
	US	0.853		US	0.328
Total disposable income	EU-15	0.876	Wage taxes	EU-15	0.424
	US	0.849		US	0.272
Young consumption	EU-15	0.548	Capital income taxes	EU-15	0.112
	US	0.531		US	0.069

5 The Enlargement shock, the long-run effect and the transition dynamics of the exchange rate

The Enlargement shock is depicted through an unexpected increase in the value of the CEE population parameter share ξ. As above, we denote by $t = t_0$ the period in which the shock is introduced, and we call it the Enlargement period. The shock with respect to the population parameter has two distinct effects, an integration effect and a convergence effect. The former includes the integration of the CEE capital and good markets with the respective EU-15 markets (see equations 24 and 25)[9] as well as the integration of the CEE capital market with the world capital market (see equation 24)[10]. The latter effect consists of faster growth of the CEE economy due to free capital movements and due to the introduction of the EU-25 convergence policy (see Section 2.4), aiming at a faster public infrastructure growth in the CEECs (q_M starts rising by the Enlargement period), as well as at a rapid equalization of the per capita disposable income between the EU-15 and CEECs.

5.1 *Numerical results*

In this subsection we report the results of the numerical calculation of the Enlargement effects in the long-run and on the transition path.

In the long run, the capital intensities of the EU-15 as well as of the US economy are not affected by the Enlargement, being the real Euro-Dollar exchange rate the only variable to change in the new steady state. Compared to the pre-Enlargement level, the exchange rate increases exactly by 19.5% (i.e. the Euro depreciates in real terms). These numerical results are assured by inspecting the analytical expression of the steady state solutions for the real exchange rate and for the EU-capital intensity (37). As can easily be seen the steady state solution of (31) and (36), the EU-15 steady state capital intensity does not depend at all on the parameter ξ, while the first equation in (37) shows that the full-convergence steady state value of the real exchange rate equals $1+\xi=1.195$ times the pre-Enlargement steady state value of the exchange rate.

As expected, in contradistinction to the EU-15 and US capital intensities, the CEEC capital intensity is affected by the Enlargement, and it increases from its pre-Enlargement value of approximately 0.11 to its full-integration value of approximately 0.24. While in our model the economic integration of the CEECs into the world economy is achieved immediately after the Enlargement, the convergence process within the EU-25 is perfectly completed only after 17 periods in the baseline scenario. In practise the convergence is roughly completed after 4 – 5 periods (approximately 80 – 100 years) as table 3 shows.

In the short and medium run, the convergence process mostly concerns the two regions of the EU-25 while the impact on the US economy is of secondary magnitude. Immediately after Enlargement the real exchange rate jumps upward and continues to increase towards its new steady state value, while the EU-15 and CEE consumption and savings' patterns change in response to the EU-wide income equalisation policy. In the first period after the Enlargement, the capital intensity and the output level fall in the EU-15, but start growing again from the second period onwards. With the exception of the young consumption, all CEE variables start increasing by the first period after the Enlargement.

Table 3 - The dynamics of the convergence indicator (baseline scenario)

Periods	convergence indicator	Periods	convergence indicator
t_0	0.4600000	t_0+12	0.9998849
t_0+1	0.7180330	t_0+13	0.9999473
t_0+2	0.8646561	t_0+14	0.9999758
t_0+3	0.9374120	t_0+15	0.9999889
t_0+4	0.9714801	t_0+16	0.9999949
t_0+5	0.9870644	t_0+17	0.9999977
t_0+6	0.9941351	t_0+18	1.0000000
t_0+7	0.9973375	t_0+19	1.0000000
t_0+8	0.9987891	t_0+20	1.0000000
t_0+9	0.9994482	t_0+21	1.0000000
t_0+10	0.9997481	t_0+22	1.0000000

[9] From this point of view, the Enlargement is a typical regional integration shock, accounting for three of the four Single Market effects (the free movement of people excluded, see Breuss, 2002).

[10] This assumption allows to model also partial globalisation effects (see Breuss, 1997) of the Enlargment.

Convergence proceeds monotonically, as showed in figure 3, inducing all CEE variables to follow the same transition path as long as the steady state is reached.

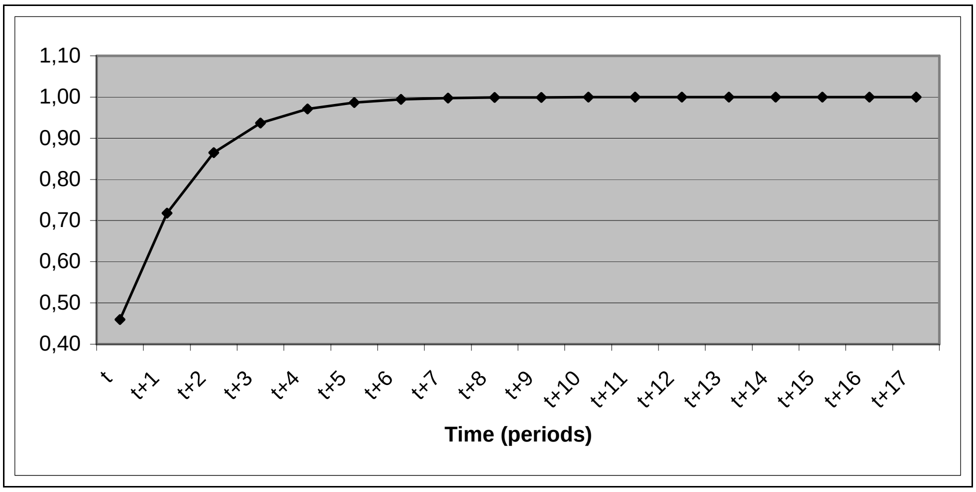

Figure 3 - The convergence process

The US production level and US capital intensity decrease only slightly but not only for one period as in the EU-15 but for -3 periods. Since in our neoclassical growth model the area-specific GDP-growth and the respective capital intensity are negatively related, the decline of the US capital intensity implies an increase of the US-GDP growth rate. Afterwards, however, the US capital intensity starts growing again, and reaches its original steady state level at the end of the transition period.

5.2 *The economic rationale behind the short-term dynamics*

This subsection intends to explain the economic rationale behind the effects of the Enlargement on the world economy in the shock period $t = t_0$ and in the first transition period $t_0 + 1$. As usual, the transition is seen as the process from the old steady state (pre-Enlargement steady state) to the new steady state (full-convergence steady state). The exchange rate is the only dynamic variable which is capable of adjusting in the Enlargement period, since the other dynamic variables (private and public capital intensities as well as the convergence indicator) remain at their pre-Enlargement level.

First, we try to explain the reasons underlying the sharp increase of the real exchange rate in the Enlargement period. To this end, the equilibrium conditions of the markets affected by the exchange rate will be studied. Since all markets are simultaneously affected by the Enlargement shock, the reasons for the overall effect on the exchange rate are to be searched on all markets contemporaneously. For ease of exposition, however, we will study each market separately, first considering the national goods' markets and then the international capital market.

Contemporary with the Enlargement, the introduction of the interregional income redistribution policy within the enlarged EU causes a decrease of the EU-15 disposable income (from 0.876414 to 0.798894 by 8.85%) and a vigorous increase of the CEE disposable income (from 0.40315 to 0.798894 by 98.16%). Accordingly, young consumption demand and savings' supply decrease in the EU-15, and increase in the CEECs (see table 4) in the Enlargement period.

The supply side of the new EU-25 goods' market is affected by the Enlargement only through the integration effect, consisting of the unification of the two former separated markets, y_t^E and y_t^M [11]:

[11] Note that ξ represents the weight of CEE variables, since the model has non-scale nature.

$$y_t^E + \xi y_t^M = c_t^{EU,E,1} + \frac{1}{G^L} c_t^{EU,E,2} + \xi c_t^{EU,M,1} + \xi \frac{1}{G^L} c_t^{EU,M,2} + $$
$$+ G^L g_{t+1}^E + G^L k_{t+1}^E + \xi G^L g_{t+1}^M + \xi G^L k_{t+1}^M + c_t^{EU,US,1} + \frac{1}{G^L} c_t^{EU,US,2}$$

Since no convergence effects arise in the Enlargement period, EU-25 (per-capita) product supply increases only through the higher CEEC to EU-15 population share. On the demand side, the unification of the two previously divided markets is accompanied by several convergence effects. Because of the variations in the disposable income, the demand for EU-15 young consumption, $c_t^{EU,E,1}$, slows down while the demand for CEE young consumption, $c_t^{EU,M,1}$, jumps up to a higher level. The consumption demand of old generations remains unchanged, since it fully depends on values of the former steady state variables:

$$c_t^{EU,r,2} = \zeta\sigma \cdot \left(1 + i_t^{EU}\right)\left[\left(1 - \varphi^{EU}\right) w_{t-1}^r + z_{t-1}^r\right].$$

In the Enlargement period, young as well as old US consumption of the EU good is affected only through the increase of the exchange rate, since the US disposable remains constant. As illustrated in next paragraph, the differentials of the rates of return on real capital make the demand for EU-15 investment goods decrease, in front of a strong upswing of the demand for CEE capital goods. The demand for public infrastructure remains unchanged in the EU-15, as indicated by the dynamic equation (32):

$$g_{t_0+1}^E = \frac{q_E \Gamma^{EU}}{G^L} A \cdot \left(g_{t_0}^E\right)^\eta \left(k_{t_0}^E\right)^\alpha .$$

Recalling that $g_{t_0}^E$ and $k_{t_0}^E$ are historically given steady state values, it follows that also $g_{t_0+1}^E$ does not change. The same does not hold for the demand for infrastructure in the CEECs. Due to the increase in the parameter q_M since the Enlargement shock, the infrastructure demand $g_{t_0+1}^M$ increases relatively to the period before, $g_{t_0}^M$ and $k_{t_0}^M$ still being historically given steady state values. Numerical calculations show that the overall effect on the demand side of the EU-25 product market is an increase up to 1.34862. Compared to the supply (1.38994) an excess supply emerges. This is fully overwhelmed by the increase of the exchange rate, which boosts up US (young and old) consumption for EU-25 products, thus providing the short term market equilibrium (at 1.38994). Table 4 describes the EU-25 product market in the old steady state and in the Enlargement period. Due to total capital depreciation over a period, the investment demand of a given period determines the capital stock of the following period.

Table 4 - The EU-25 product market in the old steady state and in the Enlargement period

Demand variable		Steady state $t<t_0$	Enlargement period t_0
Young EU-15 consumption	$c_t^{EU,E,1}$	0.273879	0.249654
Old EU-15 consumption	$c_t^{EU,E,2}$	0.23115	0.23115
Young CEE consumption	$c_t^{EU,M,1}$	-	0.249654
Old CEE consumption	$c_t^{EU,M,2}$	-	0.106329
Young US consumption	$c_t^{EU,US,1}$	0.266442	0.290226
Old US consumption	$c_t^{EU,US,2}$	0.224872	0.244946
EU-15 private investment	k_{t+1}^{E}	0.23803216	0.22750664
CEE private investment	k_{t+1}^{M}	-	0.16335728
EU-15 public investment	g_{t+1}^{E}	0.561896	0.561896
CEE public investment	g_{t+1}^{M}	-	0.02741376
EU-25 Product market equilibrium		1.27553	1.38994

In the shock period, the supply side of the US product market is not affected by the Enlargement, remaining at its steady state level of 1.31177697:

$$y_t^{US} = c_t^{US,US,1} + \frac{1}{G^L} c_t^{US,US,2} + G^L k_{t+1}^{US} + G^L g_{t+1}^{US} +$$
$$+ c_t^{US,E,1} + \frac{1}{G^L} c_t^{US,E,2} + \xi \cdot c_t^{US,M,1} + \xi \frac{1}{G^L} \cdot c_t^{US,M,2}$$

Consumption demand of both young and old US generations does not change, since the disposable income is not altered. The demand for US public infrastructure remains unchanged at its historically given steady state value for the same reasons as given above in the case of the EU-15 public investment. EU-15 young consumption decreases because of the minor disposable income. On the contrary, CEE young consumption demand increases as a consequence of the integration effect (CEECs households have free access to the US products) and the convergence effect (their disposable income is larger than before). The larger demand for US products causes a disequilibrium on the US product market which is removed by the increase in the real exchange rate and by a slight fall of US domestic demand for private investment. Table 5 illustrates the US product market before the Enlargement and in the first transition period.

Table 5 - The US product market in the steady state and in the Enlargement period

Demand variable		Steady state $t < t_0$	Enlargement period t_0
Young EU-15 consumption	$c_t^{US,E,1}$	0.272836	0.228322
Old EU-15 consumption	$c_t^{US,E,2}$	0.23027	0.211398
Young CEE consumption	$c_t^{US,M,1}$	-	0.228322
Old CEE consumption	$c_t^{US,M,2}$	-	-
Young US consumption	$c_t^{US,US,1}$	0.265427	0.265427
Old US consumption	$c_t^{US,US,2}$	0.224016	0.224016
US private investment	k_{t+1}^{US}	0.27743682	0.27732477
US public investment	g_{t+1}^{US}	0.05159511	0.05159511
US product market equilibrium		1.31177697	1.31177697

The integration of the CEE capital market with the EU-15 capital market induces spontaneous capital movements from the EU-15 to the CEECs. This is reflected on the demand side of the international capital market by a decline of the EU-15 capital intensity, k_{t+1}^{E} and by a boost in the CEE capital intensity k_{t+1}^{M}:

$$s_t^E + \xi \cdot s_t^M + e_t s_t^{US} = G^L \left[k_{t+1}^E + \xi \cdot k_{t+1}^M + e_t k_{t+1}^{US} + e_t b_{t+1}^{US} \right].$$

As proven by the analysis of the US product market, the US demand for investment slows down slightly in the first period after the Enlargement. The overall effect is an increase in the demand for savings. On the supply side, due to the interregional income redistribution policy, EU-15 savings decrease while CEE savings boost the total savings' supply[12]. Finally, also the supply side of the market increases, thus bringing about a temporary excess supply. The short term equilibrium is restored by an increase of the exchange rate, too. However, the imbalance of the capital market is only a secondary reason for the exchange rate adjustment, which is rather due to the imbalances on the two product markets. Table 6 summarizes how the international capital market adapts to the Enlargement shock.

Table 6 - The international capital market in the steady state and in the Enlargement period

Supply - Demand variable		Steady state $t < t_0$	Enlargement period t_0
EU-15 savings' supply	s_t^E	0.328655	0.299585
CEE savings' supply	s_t^M	-	0.299585
US savings' supply	s_t^{US}	0.318512	0.318512
EU-15 capital investment demand	k_{t+1}^E	0.238032	0.22746521
CEE capital investment demand	k_{t+1}^M	-	0.163357
US capital investment demand	k_{t+1}^{US}	0.277437	0.277324
US public financing demand	b_{t+1}^{US}	0.05	0.05
International capital market equilibrium		0.648385	0.706217

The separate analysis of each of the relevant markets supplies evidence of the reasons for the heavy increase of the exchange rate in the Enlargement period. This is explained by the large excess supply on the EU-15 product market, coupled with the large excess demand on the US product market. Both imbalances are removed by an increase of the real exchange value of 1 unit of US goods, i.e. by an increase in the real Euro-Dollar exchange rate.

To explain the further increase of the exchange rate in the first period after the Enlargement, consider the dynamic version of the international interest parity condition (30):

$$e_{t+1} = e_t \cdot \frac{1-\tau^{EU}}{1-\tau^{US}} \cdot \frac{\left(g_{t+1}^E\right)^{\eta} \left(k_{t+1}^E\right)^{\alpha-1}}{\left(g_{t+1}^{US}\right)^{\eta} \left(k_{t+1}^{US}\right)^{\alpha-1}}.$$

As argued above, $g_{t_0+1}^{E}$ and $g_{t_0+1}^{US}$ do not respond to the Enlargement shock, $k_{t_0+1}^{E}$ is significantly less than its previous steady state level and $k_{t_0+1}^{US}$ is only slightly smaller than its previous steady state level. From this, it follows that in the first period after the Enlargement:

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12 at aggregate level

$$\frac{1-\tau^{EU}}{1-\tau^{US}} \cdot \frac{\left(g_{t+1}^{E}\right)^{\eta}\left(k_{t+1}^{E}\right)^{\alpha-1}}{\left(g_{t+1}^{US}\right)^{\eta}\left(k_{t+1}^{US}\right)^{\alpha-1}} > 1.$$

Therefore e_{t+1} is larger than e_t .

In period t_0+1, the EU-15 (per-capita) product $y_{t_0+1}^{E}$ is also lower. Similar considerations apply to the US economy, albeit with changes of much smaller magnitude. In the CEECs, private and public capital intensities are higher than in the Enlargement period, allowing higher (per-capita) output levels $y_{t_0+1}^{M}$. This fact reverberates positively on the wage income, letting transfers from EU-15 to CEECs decrease. As a consequence, EU-15 disposable income increases, the fall in the per-capita product notwithstanding. In both the EU-15 and the CEECs consumption and savings increase accordingly, while the respective US variables continue to fall slightly. On the demand side of the US product market, this means a further upward pressure, which is again removed by the increase of the exchange rate. On the EU-25 product market, the demand for capital investment in both regions is higher, but the overall supply is also higher. The increase of the exchange rate contributes to clear the market.

5.3 *The intra-EU convergence and the world economy in the medium-run*

Beginning from the second period after the Enlargement t_0+2, the EU-15 capital intensity starts increasing again and converges monotonically to the new steady state (table 7).

Table 7 - The dynamics of the EU-15 capital intensity

Period	EU-15 capital intensity	Period	EU-15 capital intensity
Steady state	0.23803216	t_0+10	0.23756875
t_0	0.23803216	t_0+11	0.23772925
t_0+1	0.22750664	t_0+12	0.23783450
t_0+2	0.22856370	t_0+13	0.23790331
t_0+3	0.23076808	t_0+14	0.23794821
t_0+4	0.23282821	t_0+15	0.23797748
t_0+5	0.23443577	t_0+16	0.23799654
t_0+6	0.23559897	t_0+17	0.23800895
t_0+7	0.23640787	t_0+18	0.23801703
t_0+8	0.23695731	t_0+19	0.23802230
t_0+9	0.23732503	t_0+20	0.23802572

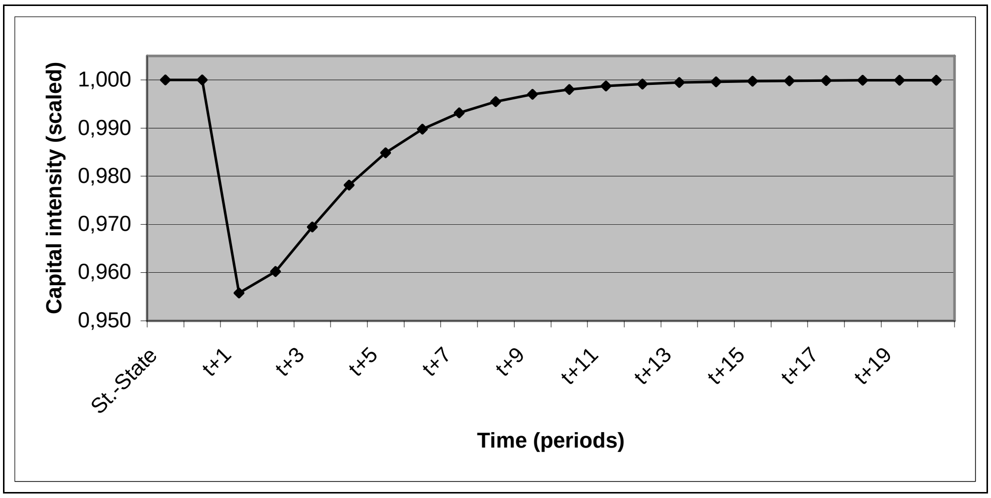

Figure 4 - The EU-15 capital intensity (scaled quantities)

This pattern (see figure 4) is consistent with the strong growth in the CEE capital intensity, as provided by the convergence policy. After two periods from the Enlargement, the CEE capital intensity has almost doubled (see table 8), thus lowering the marginal productivity and hence the real rate of return on capital in the CEECs.

Table 8 - The dynamics of the CEE capital intensity

Period	CEE capital intensity	Period	CEE capital intensity
t_0	0.109495	t_0+12	0.237702
t_0+1	0.163357	t_0+13	0.237822
t_0+2	0.197629	t_0+14	0.237898
t_0+3	0.216325	t_0+15	0.237946
t_0+4	0.226188	t_0+16	0.237976
t_0+5	0.231403	t_0+17	0.237996
t_0+6	0.234217	t_0+18	0.238009
t_0+7	0.235778	t_0+19	0.238017
t_0+8	0.236670	t_0+20	0.238022
t_0+9	0.237194	t_0+21	0.238026
t_0+10	0.237509	t_0+22	0.238026

On the other side of the Atlantic Ocean, US capital intensity is affected by the Enlargement in different way than the EU-15. As illustrated by figure 5 in terms of scaled quantities (being the steady state level set equal to 1), US capital intensity decreases less than the EU-15 intensity (see figure 4), but the fall persists longer. The main reason for the decrease in the US capital intensity is the steadily increasing consumption demand originating from the CEECs and, since the first period after the Enlargement, also in the EU-15. Together with the increasing exchange rate, the fall in US investment demand guarantees the clearing of the US product market. The slight but persistent fall in the US capital intensity together with similar reductions in the public infrastructure stock (see figure 5) has the effect (through the reduction of output per-capita) of restricting the US disposable income and thus the internal demand for consumption.

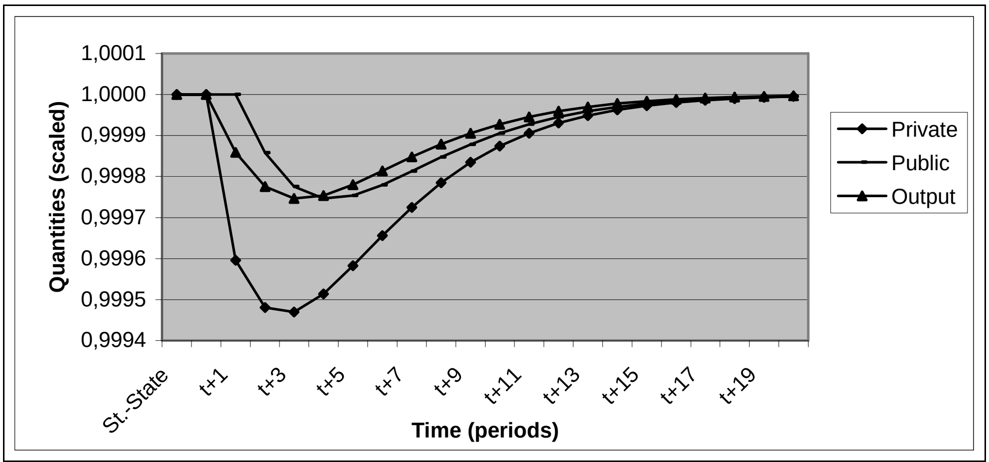

Figure 5 - The US private and public capital intensity and the US output (scaled quantities)

After the Enlargement, US internal demand slows down for three time periods. By the fourth period, US capital intensity starts growing again, leaving the entire role of market clearing to the exchange rate. The transition path of the US capital intensities is shown in table 9.

Table 9 - The dynamics of the US private and public capital intensity

Periods	US private capital	US public capital	Periods	US private capital	US public capital
Steady state	0.277437	0.051595	t_0+10	0.277402	0.05159
t_0	0.277437	0.051595	t_0+11	0.277411	0.051591
t_0+1	0.277325	0.051595	t_0+12	0.277418	0.051592
t_0+2	0.277293	0.051588	t_0+13	0.277423	0.051593
t_0+3	0.27729	0.051584	t_0+14	0.277426	0.051594
t_0+4	0.277302	0.051582	t_0+15	0.277429	0.051594
t_0+5	0.277321	0.051582	t_0+16	0.277431	0.051594
t_0+6	0.277341	0.051584	t_0+17	0.277433	0.051595
t_0+7	0.27736	0.051585	t_0+18	0.277434	0.051595
t_0+8	0.277377	0.051587	t_0+19	0.277435	0.051595
t_0+9	0.277391	0.051589	t_0+20	0.277435	0.051595

The exchange rate, as illustrated in figure 6 and in table 10, keeps on growing in order to clear the US as well as the EU-25 goods' market. By the fifth period, as the convergence

Table 10 - The dynamics of the exchange rate

Period	Exchange rate	Period	Exchange rate
Steady state	1.00382225	t_0+10	1.19803406
t_0	1.09343195	t_0+11	1.19857409
t_0+1	1.12621838	t_0+12	1.19892399
t_0+2	1.15098674	t_0+13	1.19915064
t_0+3	1.16784190	t_0+14	1.19929744
t_0+4	1.17894106	t_0+15	1.19939251
t_0+5	1.18617719	t_0+16	1.19945409
t_0+6	1.19088046	t_0+17	1.19949397
t_0+7	1.19393413	t_0+18	1.19951981
t_0+8	1.19591563	t_0+19	1.19953656
t_0+9	1.19720083	t_0+20	1.19954742

reaches higher levels, the rise of the exchange rate slows down, indicating that a smaller effort is required to clean the two national goods markets.

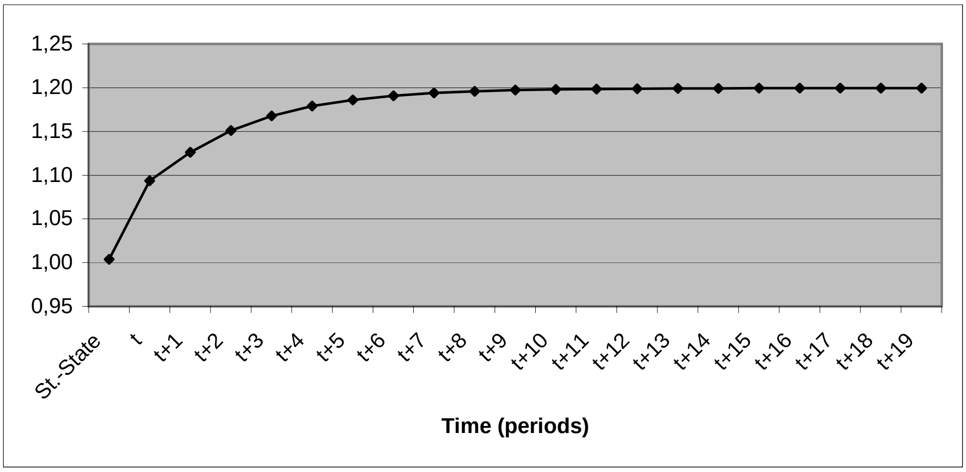

Figure 6 - The Euro-Dollar exchange rate

6 Conclusions

This paper presents a new non-scale growth model of the world economy, capable to account for the effects of the post-Enlargement convergence process on the economic relations between the enlarged EU and the rest of the world. For the sake of simplicity, a two-country framework is depicted, assuming the Rest of the World to be another large open economy like the US for instance. The analysis focuses on the real Euro-Dollar exchange rate, the main competitiveness indicator of the enlarged EU and the US.

The dynamic model is analytically solved for a steady state. Due to the high dimension of the dynamic system, existence, uniqueness and local stability of the steady state solutions are not analytically but numerically investigated, using a plausible parameter set of the international OLG economy. Being the existence of a feasible intertemporal equilibrium path assured, the dynamic effects of the intra-EU convergence on the world economy are numerically explored by using GAMS modelling software.

In the long run, only the real Euro-Dollar exchange rate and the CEE variables are affected by the Enlargement, while the EU-15 and the US capital intensities remain unaltered. The Enlargement brings about integration as well as convergence effects. The convergence between the CEECs and the EU-15 per-capita income increases monotonically from the pre-Enlargement level (whereby the CEE income is less than 50% than that of the EU-15) to full convergence which is fully completed after 17 periods, while most of convergence is achieved 4 - 5 periods after the Enlargement.

The real Euro-Dollar exchange rate, reacting to the sudden increase in demand for US goods originating from the CEECs, increases sharply immediately after the Enlargement, and it continues growing during the entire catching-up process of the CEECs. The CEECs' economy faces a monotonic upward trend over the whole convergence period, until catching the long-term EU-15 per-capita income. After the Enlargement, the EU-15 capital intensity experiences a short but strong decline due to the capital outflows towards the CEECs. As soon as real interest parity is restored inside the enlarged EU (per assumption after one period (25-30 years!)), the EU-15 capital intensity starts to increase again.

In spite of the analytical complexity of the model, the theoretical framework misses two main aspects. First, the policy function is not based on the economic theory of (EU) policy. Looking for political-economic foundations, a wider variety of convergence policy scenarios could appear. Secondly, the introduction of real capital adjustment costs would remove the perfect flexibility of investment demand on national product markets with non-negligible consequences for the adaptation profile of main dynamic variables to the Enlargement shock. This sets the agenda for future research.

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Appendixes

Appendix A. Glossary

A	level parameter of total factor productivity
AU	Public expenditures
a	Convergence parameter
α	production elasticity of private capital
B (b)	Total- (per-capita) US bond stock
β	time preference factor
c^1	per-capita young consumption (1)
c^2	per-capita old consumption (2)
x	interregional income redistribution policy parameter

δ	depreciation rate
E (e)	nominal (real) Euro-Dollar exchange rate
ε	convergence parameter
f	policy function
φ	wage income tax rate
G g	total (per-capita) public capital stock
$G^L \equiv 1 + g^L$	population growth factor
Γ	public expenditures' GDP share
I	private investments (total)
I^g	public investments (total)
i	net return factor on real capital
K k	total (per-capita) public capital stock
L	young population
N	active population
η	production elasticity of public capital
ξ	ratio of the CEE population to EU-15 population
P	price level
Q q	nominal (real) marginal product of private capital
q_j	public capital accumulation share on total public expenditures
θ	convergence indicator
S s	total (per-capita) savings
σ	savings' share
t	time index
τ	capital income tax rate
U	utility function
W w	nominal (real) wage income
Y y	total (per-capita) output
Z z	total (per-capita) public transfers
ζ	expenditure share of domestic consumption

Appendix B. Optimal consumption and savings' demand

B.1 EU-25 households

$$c_t^{r,1} \equiv \left(c_t^{EU,r,1}\right)^{\zeta} \left(c_t^{US,r,1}\right)^{1-\zeta} \tag{A.1}$$

$$c_{t+1}^{r,2} \equiv \left(c_{t+1}^{EU,r,2}\right)^{\zeta} \left(c_{t+1}^{US,r,2}\right)^{1-\zeta} \tag{A.2}$$

$$c_t^{EU,r,1} = \frac{\zeta}{1+\beta}\left[\left(1-\varphi^{EU}\right)w_t^r + z_t^r\right] \tag{A.3}$$

$$c_t^{US,r,1} = \frac{1-\zeta}{1+\beta}\frac{1}{e_t}\left[\left(1-\varphi^{EU}\right)w_t^r + z_t^r\right] \tag{A.4}$$

$$c_{t+1}^{EU,r,2} = \zeta\sigma\left(1+i_{t+1}\right)\left[\left(1-\varphi^{EU}\right)w_t^r + z_t^r\right], \tag{A.5}$$

$$c_{t+1}^{US,r,2} = \left(1-\zeta\right)\sigma\frac{1+i_{t+1}}{e_{t+1}}\left[\left(1-\varphi^{EU}\right)w_t^r + z_t^r\right]. \tag{A.6}$$

$$s_t^r = \frac{\beta}{1+\beta}\left[\left(1-\varphi^{EU}\right)w_t^r + z_t^r\right] \tag{A.7}$$

B.2 US households

$$c_t^{US,1} \equiv \left(c_t^{US,US,1}\right)^{1-\zeta}\left(c_t^{EU,US,1}\right)^{\zeta} \tag{A.8}$$

$$c_{t+1}^{US,2} \equiv \left(c_{t+1}^{US,US,2}\right)^{1-\zeta}\left(c_{t+1}^{EU,US,2}\right)^{\zeta} \tag{A.9}$$

$$c_t^{US,US,1} + \frac{1}{e_t}c_t^{EU,US,1} + s_t^{US} = \left(1-\varphi^{US}\right)w_t^{US} + z_t^{US} \tag{A.10}$$

$$c_{t+1}^{US,US,2} + \frac{1}{e_{t+1}}c_{t+1}^{EU,US,2} = \left(1+i_{t+1}\right)s_t^{US} \tag{A.11}$$

$$c_t^{US,US,1} = \frac{1-\zeta}{1+\beta}\left[\left(1-\varphi^{US}\right)w_t^{US} + z_t^{US}\right] \tag{A.12}$$

$$c_t^{EU,US,1} = \frac{\zeta}{1+\beta}e_t\left[\left(1-\varphi^{US}\right)w_t^{US} + z_t^{US}\right] \tag{A.13}$$

$$c_{t+1}^{US,US,2} = \sigma\left(1-\zeta\right)\left(1+i_{t+1}\right)\left[\left(1-\varphi^{US}\right)w_t^{US} + z_t^{US}\right] \tag{A.14}$$

$$c_{t+1}^{EU,US,2} = \sigma\zeta\left(1+i_{t+1}\right)e_{t+1}\left[\left(1-\varphi^{US}\right)w_t^{US} + z_t^{US}\right] \tag{A.15}$$

$$s_t^{US} = \frac{\beta}{1+\beta}\left[\left(1-\varphi^{US}\right)w_t^{US} + z_t^{US}\right] \tag{A.16}$$