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Entering a Monetary Union: some macroeconomic effects in the Acceding Countries

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Abstract

Some of the concerns about European Union enlargement include the effects that it might have on the economies of the incumbent countries and on the Budget of the Union. Entering an Economic and Monetary Union is not a free lunch for the acceding countries either. In this paper we analyse how the restructuring process of the CEE's economies that started with the fall of the Berlin Wall and that is made even more urgent by their willingness to acquire the full membership of the European Union affect these countries. We also show that EU membership can, paradoxically, reduce the speed of transition by introducing constraints on the use of economic policy instruments.

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ENTERING A MONETARY UNION: SOME MACROECONOMIC EFFECTS IN THE ACCEDING COUNTRIES

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1. Introduction

On the first of May 2004 the European Union (EU) has undergone one of the most important steps since its creation: the Eastern European enlargement. Eight previous planned economy countries plus Cyprus and Malta have entered the EU and more are expected to join in the immediate future[1]. There has been a lot of debate on the consequences of this enlargement for both the incumbent countries as well as the acceding ones. Some of the worries of the previous group of countries is that by admitting countries very much behind (under the economic point of view) even with respect to the poorest EU member, the economic resources that were before divided among the 15 member countries will be almost completely drained by the new entrants[2]. Other concerns about the enlargement are the effects it will have in the immediate future on the labour markets of the incumbent

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[1]The eight countries are: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia and Slovakia. By the year 2007 also Bulgaria and Romania are expected to join.

[2]Here we are referring mainly to the Structural and Cohesion funds that are distributed on the basis of the ratio of a country GDP to the average EU-GDP.

countries and on the budget of the Union itself[3]. Entering an economic and monetary union also involves costs and not just benefits for the acceding countries.

The purpose of this paper is to build a theoretical model in order to analyze the effects that the respect of the obligations necessary for acquiring membership of an economic and monetary union might have on the economy of new entrants. While the model is general and may apply to any emerging country entering a monetary union, we use it model to analyze how respecting the Maastricht Treaty constraints and the Stability Pact can influence the transition speed of the Central and Eastern European countries (CEECs) that have just joined the EU and of those that will join in the near future. Those all are expected to join the European Monetary Union (EMU) some day.

We build a dynamic disequilibrium model in which the level of activity is demand driven and to reduce unemployment, policy authorities have to stimulate consumption and investment. Moreover, in order to stress the transition characteristic of the acceding country, in our model the demand for labour depends, among other variables, on the degree of restructurization reached in the production sector, proxied by the amount of

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[3]In as much as the labour market of the incumbent countries is concerned see F. Abraham and J. Konings, 1999; T. Boeri and H.Brucker, 2000, B.J. Heijdra, C. Keuschnigg and W. Kohler, 2002. Among the few studies that analyse the implication of the accession on East European labour markets see T. Boeri, M. Burda and S. Kollo, 1998.
For general macroeconomic effects and particularly on the role of monetary and exchange rate strategies during the accession phase, see Merlvede B., J. Plasmans, A. Bas Van, 2003.
For the Budget effect see European Commission 1997, 2001; Baldwin et al. 1997; Gabrish H. 1997.

capital accumulated in the economy[4]. At the beginning of the transition period unemployment rise quickly due to the dismantling of the obsolete state owned enterprises. In a successive period, when the reconstruction of the productive system starts again, the job destruction process slows down and new jobs are created. The amount of jobs that are possible to create depends, among other things, on the productive capital existent in the economy. We show that, while the accumulation process can be increased both by direct state investment in infrastructure and by higher transfers from the government to the entrepreneurs through Active Labour Market Policies and the consumption expenditure can be stimulated by increasing the Unemployment Benefits and/or reducing the tax rate, the use of these policies is limited by the need for respecting the accession criteria[5]. So, in order to become an EU member these countries suffer a forced slow down in the transition process.

The paper is organized as follows: in the next section we present the analytical model and explain the economic theory that supports each mathematical relation. In the third section, the results of a numerical simulation are discussed and an equilibrium analysis together with a comparative dynamic analysis is carried out. Finally, we analyze the results

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[4]For capital we refer here not only to industrial machineries, but also to infrastructures (transport facilities, telecoms, and so on). Both types of capital are deficient in the transition countries. In almost all CEEC's economies the industrial sector can be compared to the industrial sector in developing countries: while in the latter the capital is insufficient, in the former the capital is mostly obsolete with the exception of some countries like Hungary, Slovenia and Poland, where the starting situation was already better and the transition speed has been faster.

[5]In the case of the European Union, these are the Adhesion Criteria that have been adopted by the European Council in Copenhagen in 1997. They also include the Maastricht Criteria among which are the respect of limits of the deficit/GDP and debt/GDP ratios respectively

and draw the conclusions. In order not to make the reading of the paper too heavy, the derivation of the steady state and the linearization process are presented in the appendix.

2. The model

2.1. The theory

The idea behind the model is that, on average, in central and eastern European countries the growth process is demand driven, but at the same time, the growth is constrained by the limited existence of infrastructure and advanced technologies. In other words, the low level of the aggregate demand does not stimulate the economic system enough in order to reduce unemployment. Additionally, the industrial sector is too small and technically obsolete. A situation like this requires large quantities of private as well as public investment. But, the amounts of resources that CEEC's governments have are limited and, contemporaneously, there is the need to reduce the public debt and/or contain the public sector deficit. In such a situation the share of public in total investment is very small. The policy authorities have then to choose how to divide the public expenditure between the welfare system (i.e. unemployment benefits and active labour market policies) and investment in infrastructure, new capital and technologies.

We present a stylized picture of a small open economy that maintains its main economic relations with the Union. Because the amount

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of 0.03 and 0.6.

of trade that is realized with the rest of the world is negligible, we do not pay attention to it in the model and we treat the world as if it was made up of only that country and the Union.

The efforts towards European Monetary Union membership are modelled by adopting a fixed exchange rate regime and choosing as the internal interest rate that fixed by the Union Central Bank[6]. Also, the small amount of public expenditure coupled with high income tax parameter, is due to the need to respect of the stability and growth pact which are part of the adhesion criteria.

2.2. The analytical structure

The model is based on a simultaneous system of non-linear differential equations, the solution of which gives us the equilibrium growth path of the endogenous variables (consumption, investment, exports, imports, income, prices, wages, employment, capital). We first present the mathematical relations and afterwards illustrate their meaning.

Consumption

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[6]In reality, the new entrant countries do not need to fix their exchange rate to the Euro from the outset. However, they are expected to do so whenever they will meet the Maastricht Criteria (see footnote 5). They do not have the so called opting out choice like Great Britain and Denmark. So, for these countries joining the economic union means automatically having to respect the EMU criteria. At the current moment they *can be* members of the ERM II, with a fluctuation band up to $\pm 15\%$. Already Cyprus, Estonia, Lithuania, Slovenia and the Czech Republic have declared that they will adopt the euro in the near future and have linked their currencies to the Euro.

$$\frac{1}{C(t)}\frac{\mathrm{d}C(t)}{\mathrm{d}t} = c_1\left(\log\frac{\tilde{C}(t)}{C(t)}\right), \tag{1}$$

where

$$\tilde{C}(t) = \Gamma_1\left[\frac{W(t)}{P(t)}L(t)(1-\Gamma_2)\right]^{\beta_1}(UB(t)\varkappa(t)LF(t))^{\beta_2}[PR(t)(1-\Gamma_2)]^{\beta_3}, \tag{2}$$

Investment

$$\frac{1}{Inv_p(t)}\frac{\mathrm{d}Inv_p(t)}{\mathrm{d}t} = c_2\left(\log\frac{\tilde{Inv}_p(t)}{Inv_p(t)}\right), \tag{3}$$

where

$$\tilde{Inv}_p(t) = \Gamma_3 e^{-\beta_5 i(t)}e^{\beta_6 D\log Y(t)}ALMP(t)^{\beta_7}; \tag{4}$$

Exports

$$\frac{1}{X(t)}\frac{\mathrm{d}X(t)}{\mathrm{d}t} = c_3\left(\log\frac{\tilde{X}(t)}{X(t)}\right), \tag{5}$$

where

$$\tilde{X}(t) = \Gamma_4 Y_f^{\beta_8}\left(\frac{P(t)}{P_f(t)S}\right)^{\beta_9}; \tag{6}$$

Imports

$$\frac{1}{M(t)}\frac{\mathrm{d}M(t)}{\mathrm{d}t} = c_4\left(\log\frac{\tilde{M}(t)}{M(t)}\right) \tag{7}$$

where

$$\tilde{M}(t) = \Gamma_5 Y(t)^{\beta_{10}} \left(\frac{P(t)}{P_f(t)S} \right)^{\beta_{11}};$$

(8)

Public Expenditure

$$G(t) = Inv_g(t) + ALMP(t) + [UB(t)\varkappa(t)LF(t)],$$

(9)

where the $\varkappa(t)$ is the *unemployment rate* defined as

$$\varkappa(t) = \left[\frac{LF(t) - L(t)}{LF(t)} \right],$$

(10)

Unemployment Benefit

$$UB(t) = \Gamma_{10} \left(\frac{W(t)}{P(t)} \right),$$

(11)

Active Labour Market Policy

$$ALMP(t) = \Gamma_6 Y(t),$$

(12)

Public Investment

$$Inv_g(t) = \Gamma_{11} Y(t);$$

(13)

Output

$$\frac{1}{Y(t)} \frac{\mathrm{d}Y(t)}{\mathrm{d}t} = c_5 \left(\log \frac{AD(t)}{Y(t)} \right),$$

(14)

where

$$AD(t) = C(t) + Inv_p(t) + X(t) - M(t) + G(t);$$

(15)

Price

$$\frac{1}{P(t)}\frac{\mathrm{d}P(t)}{\mathrm{d}t} = c_6\left(\log\frac{\tilde{P}(t)}{P(t)}\right), \tag{16}$$

where

$$\tilde{P}(t) = \Gamma_7 W(t)^{\beta_{13}}(P_f(t)S)^{\beta_{14}}[\varkappa(t)LF(t)]^{-\beta_{15}}; \tag{17}$$

Wage

$$\frac{1}{W(t)}\frac{\mathrm{d}W(t)}{\mathrm{d}t} = c_7\left(\log\frac{\tilde{W}(t)}{W(t)}\right), \tag{18}$$

where

$$\tilde{W}(t) = \Gamma_8 P(t)^{\beta_{16}}[\varkappa(t)LF(t)]^{-\beta_{17}}; \tag{19}$$

Labour Demand

$$\frac{1}{L(t)}\frac{\mathrm{d}L(t)}{\mathrm{d}t} = c_8\left(\log\frac{\tilde{L}(t)}{L(t)}\right), \tag{20}$$

where

$$\tilde{L}(t) = \Gamma_9 Y(t)^{\beta_{18}}\left(\frac{W(t)}{P(t)}\right)^{-\beta_{19}} K(t)^{\beta_{20}} ALMP(t)^{\beta_{21}}; \tag{21}$$

Labour Force

$$\frac{1}{LF(t)}\frac{\mathrm{d}LF(t)}{\mathrm{d}t} = \delta_{1;} \tag{22}$$

Uncovered Interest Parity Condition

$$E\left[\frac{1}{S(t)}\frac{\mathrm{d}S(t)}{\mathrm{d}t}\right] = i(t) - i_f;$$

(23)

Capital stock

$$\frac{1}{K(t)}\frac{\mathrm{d}K(t)}{\mathrm{d}t} = \frac{Inv_p(t) + Inv_g(t)}{K(t)};$$

(24)

Profits

$$PR(t) = Y(t) - \frac{W(t)}{P(t)}L(t);$$

(25)

and *Taxes*

$$T(t) = \Gamma_2 Y(t);$$

(26)

Equations (1-13) describe the components of the aggregate demand in real terms and their behaviour. Each component adjusts to its desired value with a speed of adjustment represented by the parameter c_i.

In equation (2) real consumption is a function of real disposable income which is divided into its component parts: salary, unemployment benefits, and profits. This formalization emphasizes that earners of different streams of income have different consumption elasticities: very high for the unemployed and workers, smaller for entrepreneurs ($\beta_2 \geq \beta_1 > \beta_3$)[7].

In equation (4), the decision to invest is influenced by the cost of

[7]The idea of different elasticity of consumption for different categories of consumers was already advanced by J.M. Keynes in his *General Theory*. It was then further developed by other economists among which N. Kaldor, 1971 and J. Robinson, 1961.
For simplicity, we assumed that the populations is completely divided into three groups:

capital as well as by the income growth rate (the typical accelerator component). In addition, we assume that entrepreneurs are favourably influenced in their investment decisions by the money transferred from the public sector budget to the firms under the Active Labour Market Policies ($\beta_7 > 0$). If we think this money has to be used for training programs and/or takes the form of employment subsides[8] then, we can assume they stimulate investments[9].

In equation (6) the demand for real exports is described. It depends on foreign income and on competitiveness, given by the ratio of internal prices to foreign prices. Analogously, equation (8) describes the demand for real imports which depends on national income and competitiveness. The effect of this last variable is positive on imports and negative on exports.

Equation (9) describes the public expenditure as a sum of three components: public investment (state investment in infrastructures), the

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unemployed, workers and entrepreneurs. There are not people without income.

[8]One example can be the Contratti di formazione e lavoro intensively used in Italy.
See Layard R., S. Nickel and R. Jackman, (1999), pag. 102-108.

[9]We are aware of the fact that the final impact of ALMPs has not been clearly ascertained (see L. Calmfors, 1994; J. Kluve and C.M. Schmidt, 2002), but if we assume that the effect is to increase the productivity of workers and to reduce the unit cost of production, then the positive effect on investments is plausible. It can be argued that because of the increased productivity of labour, entrepreneurs would rather adopt a more labour intensive technique and reduce demand for capital. However, if we agree on the fact that profits positively influence investment, then ALMPs by increasing profits also increase investment. For an explanation of the theory of investment in which profits are considered a positive determinant, see W. Baumol, 1959 and 1962.
In the current version of the paper the positive effect of ALMPs on profit is not explicitly formalized. In another version the price equation explicitly contains the work productivity as a growing function of the job training programs. The preliminary results of this second paper seem to strengthen the conclusion reached with this work.

expenditure on Active Labour Market Policies (ALMP) and the total amount of Unemployment Benefits (UB, per-capita benefit times the number of unemployed). While the first two components increase proportionally with the national income (equations 12 and 13), the third grows when either the unemployment rate or the amount of per-capita unemployment benefit increases (equations 10 and 11). The idea being that the higher is national income the higher is the expenditure capacity of the government for national welfare, labour policies and for state investments.

Equation (14) tells us that the level of economic activity is demand driven: output adjusts to aggregate demand (15) at a rate equal to c_5 .

Equation (16) indicates that prices adjust to their desired level $\tilde{P}(t)$ with the adjustment speed equal to c_6. The desired level, as shown by equation (17) depends on production costs; wages and imported raw material or semi-product, on which a variable mark-up is applied. The mark-up varies with the level of activity proxied by the unemployment level. The higher is the level of activity (and so the lower is the unemployment level), the higher is the producer power to set prices[10]

The wage's behaviour, as described in equation (18), requires little explanation. Nominal wage adjusts to its desired level with the adjustment speed defined as c_7 . The desired level, described in equation (19), depends on the parameter Γ_8 (which can be assumed to represent the minimum

[10]We know that the effect on prices of an increased level of activity is generally very low (see Layard, Nickell and Jackman, 1999, pag. 25) and is probably negligible in those countries starting from very low aggregate demand. But we don't want to exclude it on a priori ground and in any case, neglecting the unemployment level does not change the qualitative results of our model.

wage), on the price level and, inversely, on the unemployment level.

As shown by equation (20), employment adjusts to its desired level with a speed of adjustment equal to c_8. The desired level given by equation (21), contains elements of both Keynesian and neoclassical theories. Indeed, it depends on the output as well as on the real wage. Furthermore, there are two other variables influencing the demand for labour: the stock of capital K(t) and the transfers from the government to the enterprises through the Active Labour Market Policies, ALMPs(t). The reason for including the stock of capital is due to the fact that in the transition countries the accumulation process has often restarted after the fall of the planned systems, given that the industrial structures and the infrastructures present at the end of the eighties were either obsolete or specific to production of goods and services mainly for exports within the CMEA area[11]. This means that the production possibilities and the employment level are now constrained by the level reached in the rebuilding process of the physical capital. In brief, we can say that employment is *capital constrained*. The other component, ALMPs(t), has a doubly positive effect on demand for labour; Firstly, it contributes directly to the reduction of labour cost to the firm[12]. Secondly, by increasing workers' productivity[13], it is more

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[11]CMEA (Council of Mutual Economic Assistance), the supranational organization that grouped together all countries under the Soviet Union influence.

[12]For example, this is the case of ALMPs that take the form of reduction of the payroll taxes payed by the employer if he employs workers belonging to certain groups (long-term unemployed, young, etc.).

[13]This is the case of ALMPs that take the form of training programs. For a detailed surveys on the various forms of ALMPs and their effects on the labour market, see L. Calmfors, 1994.

convenient for entrepreneurs to switch towards more labour intensive production technologies.

The unemployment level can then be obtained by applying the unemployment rate (described in equation 10) to the labour force. For the sake of simplicity, we assume that the labour force coincides with the population. This last variable to grow at an exogenous rate, δ_1 .

Regarding equation (23), because of the country's intention to became a full member of the Union, it is assumed that the national monetary authority decides to peg the currency to the Union's currency even before to acquire full membership. This means that with perfect free movement of capital the national interest rate is not free to change, and has to be pegged to the one set by the Union Central Bank, thus reducing even more the policy instruments in the hands of the authorities.

The last three equations are descriptive: the dynamic of the capital formation is given by the dynamic of the two types of investment, public and private (equation (24)); the tax system is assumed to be proportional (equation (26)); the real profits are obtained as a difference between real income and the total real salaries (equation (25)).

3. Numerical simulation and equilibrium analysis

Before solving the system to find the equilibrium paths and to analyze its properties, we need to linearize some of the equations around their steady state values. The linearization process being a very long and technical matter we refer the interested readers to the appendix, where the determination of the steady state of the system has also been described, while the steady state growth rates of all the endogenous variables are reported in Table 1.

TABLE 1

$\rho_1, \rho_2, \rho_3, \rho_4, \rho_5, \rho_6, \rho_7, \rho_{11}, \rho_{13}, \rho_{15}$	$= \beta_8\delta_2 - \beta_9\delta_3 - \frac{\beta_9}{1-\beta_{13}\beta_{16}}[\beta_{13}\beta_{17}\delta_1 - \beta_{14}\delta_3]$
ρ_8	$= \frac{\beta_{14}\delta_3 - \beta_{13}\beta_{17}\delta_1}{1-\beta_{13}\beta_{16}}$
ρ_9	$= \frac{\beta_{16}\beta_{14}\delta_3 - \beta_{17}\delta_1}{1-\beta_{13}\beta_{16}}$
ρ_{10}	$= \delta_1$
ρ_{14}	$= \frac{(1-\beta_{13})\beta_{17}\delta_1 + (1-\beta_{16})\beta_{14}\delta_3}{1-\beta_{13}\beta_{16}}$

3.1. Steady state analysis

Let's now analyze the economic meaning of the steady state growth rate values obtained. We can see that in equilibrium, all the real variables grow at the same rate. The analysis of the composition of that rate of growth shows the strong *demand-driven* nature of the economy under consideration.

The first element ($\beta_8\delta_2$) says that the domestic economy growth strongly depends on the export elasticity to foreign income and on the rate of growth of the partner economy. The nature of the economy is stressed also by the second and third term of the real variables growth rate: $-\beta_9\delta_3 - \frac{\beta_9}{1-\beta_{13}\beta_{16}}[\beta_{13}\beta_{17}\delta_1 - \beta_{14}\delta_3]$. Indeed, it depends positively on the export elasticity to the terms of trade (in absolute value) and on the rate of growth of foreign price. It also depends on the domestic price elasticity to the cost of imported raw material ($\beta_{14}\delta_3$) and on the price elasticity to unemployment ($\beta_{13}\beta_{17}$). These relations all underline the fact that, given the importance of exports for the domestic economy, the better is their competitive power the faster the economy grows. Finally, the indexation effect ($\beta_{13}\beta_{16}$)[14] has an impact on the growth of the economy because of the indirect effect on consumption through real wage. The rate of growth of this last variable is given by the difference between nominal wage growth rate and the price rate of growth.

The indexation effect also influences the rate of growth of the nominal variables (price as well as wage) as we would have expected. Moreover domestic prices are obviously influenced by the cost of imported goods (being the raw material ($\beta_{14}\delta_3$) and by the price elasticity to unemployment ($\beta_{13}\beta_{17}$). While the nominal wage growth rate is influenced by the wage elasticity to unemployment (β_{17}) and by the component ($\beta_{14}\beta_{16}$) that we can define as nominal wage elasticity to foreign price. In as far as the rate of growth of unemployment benefits is concerned, it is by construction equal to the real wage one.

Lastly, in steady state the employment growth rate as to be the same as the labour force one, in order to keep constant the unemployment rate at

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[14]Being β_{13} the elasticity of price to wage and β_{16} the elasticity of wage to price, we can consider their product as the grade of the economy's indexation.

its equilibrium value.

3.2. Comparative dynamics

We can now proceed to a comparative dynamic analysis of the steady state results. Referring to the values shown in Table 1, we can see that the first element of the rate of growth of the real variables ($\beta_8\delta_2$) indicates that the domestic economy will grow at a higher[15] rate the higher is the export elasticity to foreign income for a given value of the foreign income growth rate. The same is valid for higher growth rate of foreign income. Very simply, the real side of the domestic economy will grow at a faster rate, making it possible to devote larger amounts of resources to the public expenditure (in all its components) and easing the restructuring process, the more they can export to the rest of the world. Moreover, given the demand driven nature of the economy, real variables growth rates will be higher the higher is (in absolute term) the export elasticity to the terms of trade and the higher is the rate of growth of foreign prices ($-\beta_9\delta_3$). Finally, the lower is the value of domestic price elasticity to the cost of imported raw materials ($\beta_{14}\delta_3$), and the higher is the value of the price elasticity to unemployment ($\beta_{13}\beta_{17}$) the stronger will be the growth of the acceding country's economy. This shows that the more the domestic firms are able to contain internal price increases due to the increase in the costs of

[15]The expression a higher value of .... corresponds to a higher (or smaller) value of..., means that we are comparing two different steady states: the first one in which the parameter under consideration has a certain value and the second one in which the same parameter has a different value.

production (wage and row material cost) the more competitive they are on the international market.

This result is in line with the reality of the EU acceding countries; given the limited amount of internal resources, a push to the growth process has to come from foreign countries through exports demand.

The indexation effect ($\beta_{13}\beta_{16}$) has a positive impact on the real variables given that it prevents a real wage fall that would reduce consumption restraining the growth of the economy.

The indexation effect obviously influences in the same direction the rate of growth of the nominal variables (price as well as wage). Moreover, while the growth of domestic price is lower the lower is its elasticity to imported goods and the higher is its indirect elasticity to the level of economic activity ($\beta_{13}\beta_{17}$), the nominal wage rate of growth is smaller the lower is its indirect elasticity to foreign price ($\beta_{14}\beta_{16}$) and the higher is its elasticity to unemployment (β_{17}).

3.3. Equilibrium analysis

Given the numbers of the equations involved in the model it is not possible to say anything on the nature of the equilibrium if we do not attribute values to the parameters. As we said earlier, in developing this model our interest was principally on the possible effect of EU accession on the entering countries and for this reason we decided to attribute to the parameters the values that have been obtained from those estimated by

Merlvede B. et al. (2003)[16]. More precisely, we used the average values of the parameters estimated for the three most representative CEECs: Czech Republic, Hungary and Poland[17].

The solution obtained shows that the linearized system is locally stable. The values of the characteristic roots (table 2) tell us the qualitative property of the equilibria: it is a stable node. Starting from sufficiently near the steady state, all the endogenous variables converge towards their long run equilibrium growth paths.

TABLE 2

λ_1	-1.15129
λ_2	-1.0031
λ_3	-0.927
λ_4	-0.89999
λ_5	-0.86899
λ_6	-0.611014
λ_7	-0.264986
λ_8	-0.02581
λ_9	-0.0177967

[16]The model of Merlvede B. et al., differs from our model under several aspects, the most important being its static property. But, considering that there are few empirical studies that estimate parameters for the CEECs, we decided to use their estimates. The values chosen can be found in the appendix.
In another work that is being carried out, we are estimating the parameter values for some of the CEECs. But given the difficulties in collecting all the necessary data and the complexity of the non-linear dynamic estimation process, the estimates are not yet available.

[17]The relevance of these countries has been determined in terms of the size of populations and in terms of the percentage of their GDP with respect to the EU-15. Slovenia has the highest ratio of its GDP to the EU-15, but its population is very small. See Boeri et al., 2002.

We obtain very interesting results if we slightly change the values of some of the most relevant parameters. For example, by slightly increasing the value of Γ_{11} (the ratio of state investment to GDP from 0.2 to 0.25) we observe an increase in the values, in absolute terms, of some of the characteristic roots (table 3). Analogously, the same happens if we increase the value of Γ_6 (the ratio of government spending on Active Labour Market Policies to GDP from 0.005 to 0.0075, table 4) Technically, this means that a change in these parameters does not change the qualitative nature of the equilibria and only increases the velocity at which the equilibrium growth path is approached.

TABLE 3

λ_1	-1.15164
λ_2	-1.0031
λ_3	-0.927
λ_4	-0.900002
λ_5	-0.86899
λ_6	-0.611014
λ_7	-0.264986
λ_8	-0.0752268
λ_9	-0.021642

TABLE 4

λ_1	-1.1514
λ_2	-1.0031
λ_3	-0.927
λ_4	-0.900003
λ_5	-0.86899
λ_6	-0.611014
λ_7	-0.264986
λ_8	-0.09851
λ_9	-0.01772

As we know, these parameters are the ones that represent the expenditure policy of the government. But having to respect the budget constraints imposed on the acceding countries by having to respect the

Copenhagen Criteria, the policy authority cannot choose the amount of public expenditure that would best satisfy their needs. This clearly shows that if the government of the applicant countries could use their fiscal policy more freely, the transition process could be faster. This aspect is even more important if we remember that entering the Union means the loss of the other tools that the policy authority can use to stimulate their economy. Indeed, they lose both the use of the exchange rate to stimulate exports and the interest rate to stimulate investment.

There is one aspect of the enlargement which can have a positive effect in the short term for the new entrant country. It is the possibility to access the Structural and Cohesion funds. These funds would allow the government of the interested country to increase state investment in infrastructures (or in welfare programs, or in labour market policies, and so on), without worsening the public deficit[18]. However, if in the redistribution process of these funds, the incumbent countries are not prepared to give up a big share of their transfer from the Union, then the amount of money the CEECs receive might not be enough to counterbalance the constraining effect of having to respect the Maastricht Criteria.

We can therefore conclude that adoption of European Union Membership is not necessary the best move for the CEECs, at least in the short term. The results strongly depend on the Social Policy and on the

[18]Structural Fund and Cohesion Fund support always involves part-financing. That means that if prior to acquiring EU membership the government of one of the CEECs can make an investment for 100 million , becoming a member of EU will make possible for the same government to make an investment for 200 million , the difference being supplied by the European Union.

Cohesion Policy that will be adopted by the Union.

4. Conclusion

We built a dynamic continuous time model to analyze the effects on the CEECs of the enlargement of the European Union towards the east. The model is characterized by many Keynesian features. It is a demand driven economy in which employment depends on the level of the aggregate demand but also on the existence of capital. A large role is played by the public expenditure which directly helps the capital accumulation process by spending in public investment and by the transfers to firms through Active Labour Market Policies. But it also influences indirectly the accumulation process through welfare programs. Sustaining the consumption level with unemployment benefits, it increases the aggregate demand and given how expectations are formed, it also influences the desired rate of capital accumulation.

Having to respect the Maastricht criteria constrains public expenditure and the taxation burden is also quite heavy. The different components of public expenditure (welfare and investment) influence each other. In the short term, the more the governments spend on welfare (unemployment benefits and ALMPs) the less they can spend for investment and vice versa. Moreover they cannot reduce taxation because the employed population is not large enough and therefore the tax base is small. The choice is not only between the different components of public expenditure, but also between lower taxes but a smaller welfare system or a larger welfare system with consequently higher taxation. The different effects on the income multiplier of these policies have to be considered when making a choice but without neglecting the internal social conditions.

In conclusion, even if it is true that becoming a member of the EU will give the CEECs the opportunity of receiving Structural and Cohesion Funds, these might not be enough to overcome the reduction in the accumulation process caused by the obligatory respecting of the Maastricht Criteria, and therefore in the short run the costs of becoming EU members might outweigh the benefits.

APPENDIX

A. Derivation of the Steady State

In order to linearize equations (9) and (15) we have to find the steady state value of the variables. To this end we apply the *undetermined coefficients method*[19]. In as far as the exogenous variables are concerned we assume that:

$$LF = LF_0 e^{\delta_1 t}, \quad Y_f = Y_{f0} e^{\delta_2 t}, \quad P_f = P_{f0} e^{\delta_3 t}, \quad \text{and}$$

$$i = i_f = i_{f0} = i_0,$$

[19]See Gandolfo G., 1998, pp. 158 and 266-68.

$$S = S_0.$$

For the endogenous variables, we let

$$\begin{aligned}
&C = C_0 e^{\rho_1 t}, && Inv_p = Inv_{p0} e^{\rho_2 t}, && Inv_g = Inv_{g0} e^{\rho_3 t}, \\
&X = X_0 e^{\rho_4 t}, && M = M_0 e^{\rho_5 t}, && G = G_0 e^{\rho_6 t}, \\
&Y = Y_0 e^{\rho_7 t}, && P = P_0 e^{\rho_8 t}, && W = W_0 e^{\rho_9 t}, \\
&L = L_0 e^{\rho_{10} t}, && K = K_0 e^{\rho_{11} t}, && \varkappa = \varkappa_0, \\
&ALMP = ALMP_0 e^{\rho_{13} t}, && UB = UB_0 e^{\rho_{14} t}, && PR = PR_0 e^{\rho_{15} t}.
\end{aligned}$$

where the $\rho' s$ and variables with 0 as a subscript are the undetermined coefficients. By substituting in equations (1) and (25) and using the lowercase variables to indicate the natural logarithm of the correspondent uppercase variable, we have

$$\begin{aligned}
\rho_1 = c_1\{&\gamma_1 + \beta_1[(\rho_9 - \rho_8 + \rho_{10})t + \log(1-\Gamma_2) + (w_0 - p_0 + l_0)] \\
&+ \beta_2[(ub_{10} + lf_0 + \varkappa_0) + (\rho_{14} + \delta_1)t] \\
&+\beta_3[pr_0 + \rho_{15}t + \log(1-\Gamma_2)] - c_0 - \rho_1 t\};
\end{aligned} \tag{27}$$

$$\rho_2 = c_2[\gamma_3 - \beta_5 i_0 + \beta_6 \rho_7 t + \beta_7 almp_0 + \beta_7 \rho_{13} t - inv_{p0} - \rho_2 t]; \tag{28}$$

$$Inv_{g0}e^{\rho_3 t} = \Gamma_{11} Y_0 e^{\rho_7 t};$$

(29)

$$\rho_4 = c_3\{\gamma_4 + \beta_8(y_{f0} + \delta_2 t) + \beta_9[(\rho_8 - \delta_3)t + p_0 - p_{f0} - s_0] - x_0 - \rho_4 t\};$$

(30)

$$\rho_5 = c_4\{\gamma_5 + \beta_{10}(y_0 + \rho_7 t) + \beta_{11}[(\rho_8 - \delta_3)t + p_0 - p_{f0} - s_0] - m_0 - \rho_5 t\};$$

(31)

$$G_0 e^{\rho_6 t} = UB_0 e^{\rho_{14} t}(LF_0 e^{\delta_1 t} - Le^{\rho_{10} t}) + ALMP_0 e^{\rho_{13} t} + Inv_{g0} e^{\rho_3 t};$$

(32)

$$\rho_7 = c_5[\log(C_0 e^{\rho_1 t} + Inv_{p0} e^{\rho_2 t} + X_0 e^{\rho_4 t} - M_0 e^{\rho_5 t} + G_0 e^{\rho_6 t}) - y_0 - \rho_7 t];$$

(33)

$$\rho_8 = c_6[\gamma_7 + \beta_{13} w_0 + \beta_{13}\rho_9 t + \beta_{14}(p_{f0} + s_0) - \beta_{15}(lf_0 + \delta_1 t + \varkappa_0) + \beta_{14}\delta_3 t - p_0 - \rho_8 t];$$

(34)

$$\rho_9 = c_7[\gamma_8 + \beta_{16} p_0 + \beta_{16}\rho_8 t - \beta_{17}(lf_0 + \delta_1 t + \varkappa_0) - w_0 - \rho_9 t];$$

(35)

$$\rho_{10} = c_8[\gamma_9 + \beta_{18} y_0 + \beta_{18}\rho_7 t - \beta_{19}(w_0 - p_0) - \beta_{19}(\rho_9 - \rho_8)t + \beta_{20} k_o + \beta_{20}\rho_{11} t + \beta_{21} almp_0 + \beta_{21}\rho_{13} t - l_0 - \rho_{10} t];$$

(36)

$$\rho_{11} = \frac{(Inv_{p0}e^{\rho_2 t} + Inv_{g0}e^{\rho_3 t})}{K_0 e^{\rho_{11} t}};$$

(37)

$$\varkappa_0 = \frac{(LF_0 e^{\delta_1 t} - L_0 e^{\rho_{10} t})}{LF_0 e^{\delta_1 t}};$$

(38)

$$ALMP_0 e^{\rho_{13} t} = \Gamma_6 Y_0 e^{\rho_7 t};$$

(39)

$$UB_0 e^{\rho_{14} t} = \Gamma_{10} \frac{W_0}{P_0} e^{(\rho_9 - \rho_8) t};$$

(40)

$$PR_0 e^{\rho_{15} t} = Y_0 e^{\rho_7 t} - \frac{W_0}{P_0} L_0 e^{(\rho_9 - \rho_8 + \rho_{10}) t};$$

(41)

Equations (27)-(41) are identically satisfied if, and only if the following two sets of equations are satisfied:

Set 1

$$\beta_1(\rho_9 - \rho_8 + \rho_{10}) + \beta_2(\rho_{14} + \delta_1) + \beta_3\rho_{15} - \rho_1 = 0$$

(42)

$$\beta_6\rho_7 + \beta_7\rho_{13} - \rho_2 = 0$$

(43)

$$\rho_7 - \rho_3 = 0$$

(44)

$$\beta_8\delta_2 + \beta_9(\rho_8 - \delta_3) - \rho_4 = 0$$

(45)

$$\beta_{10}\rho_7 + \beta_{11}(\rho_8 - \delta_3) - \rho_5 = 0$$

(46)

$$\rho_6 = \rho_{14}\rho_{10} = \rho_{14}\delta_1 = \rho_{13} = \rho_3$$

(47)

$$\rho_1 = \rho_2 = \rho_4 = \rho_5 = \rho_6 = \rho_7$$

(48)

$$\beta_{13}\rho_9 + \beta_{14}\delta_3 - \beta_{15}\delta_1 - \rho_8 = 0$$

(49)

$$\beta_{16}\rho_8 - \beta_{17}\delta_1 - \rho_9 = 0$$

(50)

$$\beta_{18}\rho_7 - \beta_{19}(\rho_9 - \rho_8) + \beta_{20}\rho_{11} + \beta_{12}\rho_{13} - \rho_{10} = 0$$

(51)

$$\rho_{11} = \rho_2 = \rho_3$$

(52)

$$\delta_1 - \rho_{10} = 0$$

(53)

$$\rho_{13} = \rho_7$$

(54)

$$\rho_{14} = \rho_9 - \rho_8$$

(55)

$$\rho_{15} = \rho_7 = \rho_{10}$$

(56)

Set 2

$$\log C_0 = c_0 = \gamma_1 + \beta_1[\log(1-\Gamma_2) + (w_0 - p_0 + l_0)] + \beta_2(ub_0 + lf_0 + \varkappa_0) + \beta_3[pr_0 + \log(1-\Gamma_2)]$$

(57)

$$\log Inv_{p0} = inv_{p0} = \gamma_3 - \beta_5 i_0 + \beta_7 almp_0$$

(58)

$$Inv_{g0} = \Gamma_{11} Y_0$$

(59)

$$\log X_0 = x_0 = \gamma_4 + \beta_8 y_{f0} + \beta_9(p_0 - p_{f0} - s_0)$$

(60)

$$\log M_o = m_0 = \gamma_5 + \beta_{10} y_0 + \beta_{11}(p_0 - p_{f0} - s_0)$$

(61)

$$G_0 = UB_0(LF_0 - L_0) + ALMP_0 + Inv_{g0}$$

(62)

$$\log Y_0 = y_0 = \log(C_0 + Inv_{p0} + X_0 - M_0 + G_0)$$

(63)

$$\log P_0 = p_0 = \gamma_7 + \beta_{13} w_0 + \beta_{14}(p_{f0} + s_0) - \beta_{15}(lf_0 + \varkappa_0)$$

(64)

$$\log W_0 = w_0 = \gamma_8 + \beta_{16} p_0 - \beta_{17}(lf_0 + \varkappa_0)$$

(65)

$$\log L_0 = l_0 = \gamma_9 + \beta_{18} y_0 - \beta_{19}(w_0 - p_0) + \beta_{20} k_0 + \beta_{21} almp_0$$

(66)

$$K_0 = Inv_{p0} + Inv_{g0}$$

(67)

$$\varkappa_0 = 1 - \frac{L_0}{LF_0}$$

(68)

$$ALMP_0 = \Gamma_6 Y_0$$

(69)

$$UB_0 = \Gamma_{10} \frac{W_0}{P_0}$$

(70)

$$PR_0 = Y_0 - L_0 \frac{W_0}{P_0}$$

(71)

By solving Set 1 we obtain the values of the steady state growth rates of the endogenous variables, while the solution of Set 2 gives us the initial values of the steady state paths of the endogenous variables. For our purposes the relevant values are the steady state growth rates, hence we shall concentrate on these.

From equations (44) and (48) we demonstrate that the growth rate of income, real consumption, public investment, private investment, export, import and public expenditure (all in real terms), has to be the same in steady state.

From equation (45) and (46) we can see that in order to be identically verified the rate of growth of domestic price has to be the same as its foreign correspondent. Moreover, exports (and hence all the other variables), grow at a rate that, given the value of elasticity β_8, depends on the rate of growth of world output.

Obviously, the rate of growth of the physical capital is equal to the sum of public and private investment growth rates as confirmed by equation (52). Similarly, as equation (53) shows, in steady state the employment rate of growth has to be equal to the labour force rate of growth, so that unemployment rate of growth is null. Equations (54) and (55) tell us that in the steady state, the rate of growth of the different categories of public expenditures (Active Labour Market Policy and Unemployment Benefit) has to be equal to the rate of growth of real income. Finally, given the division of the gross national income into two categories, real salaries and real profits, equation (56) states that the three variables have to grow at the same rate. The growth rate values so obtained are reported in Table 1 in the text.

B. Linearization about the steady state

At this point we build new variables as logarithmic deviations of the original variables from their steady state values. We obtain a system of non-linear *autonomous* differential equations. This makes possible to study the *local* stability of the original system trough the study of its linearized counterpart[20]. The new variables are:

$$x_1 = \log \frac{C}{C_0 e^{\rho_1 t}}$$

$$x_2 = \log \frac{Inv_p}{Inv_{p0} e^{\rho_2 t}}$$

$$x_3 = \log \frac{Inv_g}{Inv_{g0} e^{\rho_3 t}}$$

$$x_4 = \log \frac{X}{X_0 e^{\rho_4 t}}$$

$$x_5 = \log \frac{M}{M_0 e^{\rho_5 t}}$$

[20]See G. Gandolfo, 1981, pp. 25 -29, 1997, Chap. 21, pp. 333-335 and pp. 360-363.

$$x_6 = \log \frac{G}{G_0 e^{\rho_6 t}}$$

$$x_7 = \log \frac{Y}{Y_0 e^{\rho_{71} t}}$$

$$x_8 = \log \frac{P}{P_0 e^{\rho_8 t}}$$

$$x_9 = \log \frac{W}{W_0 e^{\rho_9 t}}$$

$$x_{10} = \log \frac{L}{L_0 e^{\rho_{10} t}}$$

$$x_{11} = \log \frac{K}{K_0 e^{\rho_{11} t}}$$

$$x_{12} = \chi - \chi_0$$

$$x_{13} = \log \frac{ALMP}{ALMP_0 e^{\rho_{13} t}}$$

$$x_{14} = \log \frac{UB}{UB_0 e^{\rho_{14} t}}$$

$$x_{15} = \log \frac{PR}{PR_0 e^{\rho_{15} t}}$$

At this point we can rewrite the original system in terms of the new variables:

$$Dx_1 = c_1[\beta_1(x_9 - x_8 + x_{10}) + \beta_2(x_{14} + x_{12}) + \beta_3 x_{15} - x_1] \tag{72}$$

$$Dx_2 = c_2(\beta_6 Dx_6 + \beta_7 x_{13} - x_2) \tag{73}$$

$$x_3 = x_7 \tag{74}$$

$$Dx_4 = c_3 \beta_9 x_8 - x_4 \tag{75}$$

$$Dx_5 = c_4(\beta_{10} x_6 + \beta_{11} x_8 - x_5) \tag{76}$$

$$x_6 = \frac{ALMP_0}{G_0} x_{13} + \frac{Inv_{g0}}{G_0} x_3 \tag{77}$$

$$Dx_7 = c_5\left[\frac{C_0}{Y_0}(x_1 - x_7) + \frac{Inv_{p0}}{Y_0}(x_2 - x_7) + \frac{X_0}{Y_0}(x_4 - x_7) - \frac{M_0}{Y_0}(x_5 - x_7) + \frac{G_0}{Y_0}(x_6 - x_7) \right] \tag{78}$$

$$Dx_8 = c_6(\beta_{13} x_9 - x_8) \tag{79}$$

$$Dx_9 = c_7(\beta_{16}x_8 - x_9)$$

(80)

$$Dx_{10} = c_8(\beta_{18}x_6 - \beta_{19}x_9 + \beta_{19}x_8 + \beta_{20}x_{11} + \beta_{21}x_{13} - x_{10})$$

(81)

$$Dx_{11} = \frac{1}{1+\rho_{11}}\left[\frac{Inv_{p0}}{K_0}x_2 + \frac{Inv_{g0}}{K_0}x_3 - \frac{Inv_{p0} + Inv_{g0}}{K_0}x_{11}\right]$$

(82)

$$x_{12} = 0$$

(83)

$$x_{13} = x_7$$

(84)

$$x_{14} = x_9 - x_8$$

(85)

$$x_{15} = \frac{Y_0}{Y_0 - \frac{W_0}{P_0}L_0}x_7 - \frac{\frac{W_0}{P_0}L_0}{Y_0 - \frac{W_0}{P_0}L_0}(x_9 - x_8 + x_{10})$$

(86)

The equations (77), (78), (82) and (86), are obtained after applying the following log- linearization process:

Consider equation (9) of the text. Consider then the log deviations of $G(t)$ from its equilibrium growth path

$$x_6 = \log \frac{UB(t)\varkappa LF(t) + ALMP(t) + Inv_{g0}(t)}{G_0 e^{\rho_6 t}}$$

It can be re-written as

$$= \log \frac{\frac{UB(t)}{UB_0 e^{\rho_{14} t}} UB_0 e^{\rho_{14} t} (\varkappa - \varkappa_0) \frac{LF(t)}{LF_0 e^{\delta_1 t}} LF_0 e^{\delta_1 t}}{G_0 e^{\rho_6 t}} +$$

$$\log \frac{\frac{ALMP(t)}{ALMP_0 e^{\rho_{13} t}} ALMP_0 e^{\rho_{13} t} + \frac{Inv_g(t)}{Inv_{g0} e^{\rho_3 t}} Inv_{g0} e^{\rho_3 t}}{G_0 e^{\rho_6 t}}.$$

Recalling from the solution for the steady state growth rate that

$$\rho_6 = \rho_{13} = \rho_{14} = \rho_3 \text{ and } \varkappa = \varkappa_0,$$

we can rewrite the last equation as

$$x_6 = \log \frac{e^{x_{13}} ALMP_0 + e^{x_3} Inv_{g0}}{G_0}$$

By applying the linearization formula given in Gandolfo (1981, p. 98) we obtain equation (77).

Consider now equation (14) of the text and rewrite it as

$$D \log Y(t) = c_5 \left(\frac{C(t)}{Y(t)} + \frac{Inv_p(t)}{Y(t)} + \frac{X(t)}{Y(t)} - \frac{M(t)}{Y(t)} + \frac{G}{Y(t)} \right)$$

By performing the same operation on the corresponding steady state value and subtracting it from the former we obtain

$$Dx_7 = \left\{ \frac{C_0 e^{\rho_1 t}}{Y_0 e^{\rho_7 t}} \left[\frac{C(t)/C_0 e^{\rho_1 t}}{Y(t)/Y_0 e^{\rho_7 t}} - 1 \right] + \frac{Inv_{p0} e^{\rho_2 t}}{Y_0 e^{\rho_7 t}} \left[\frac{Inv_p(t)/Inv_{p0} e^{\rho_2 t}}{Y(t)/Y_0 e^{\rho_7 t}} - 1 \right] \right.$$
$$+ \frac{X_0 e^{\rho_4 t}}{Y_0 e^{\rho_7 t}} \left[\frac{X(t)/X_0 e^{\rho_4 t}}{Y(t)/Y_0 e^{\rho_7 t}} - 1 \right] - \frac{M_0 e^{\rho_5 t}}{Y_0 e^{\rho_7 t}} \left[\frac{M(t)/M_0 e^{\rho_5 t}}{Y(t)/Y_0 e^{\rho_7 t}} - 1 \right] +$$
$$\left. \frac{G_0 e^{\rho_6 t}}{Y_0 e^{\rho_7 t}} \left[\frac{G(t)/G_0 e^{\rho_6 t}}{Y(t)/Y_0 e^{\rho_7 t}} - 1 \right] \right\}.$$

Recalling from (48) that $\rho_1 = \rho_2 = \rho_4 = \rho_5 = \rho_6 = \rho_7$,

$$Dx_7 = c_5 \left(\frac{C_0}{Y_0} e^{x_1 - x_7} + \frac{Inv_{p0}}{Y_0} e^{x_2 - x_7} + \frac{X_0}{Y_0} e^{x_4 - x_7} - \frac{M_0}{Y_0} e^{x_5 - x_7} + \frac{G_0}{Y_0} e^{x_6 - x_7} \right)$$

which gives us equation (78)

$$Dx_7 = c_5 \left[\frac{C_0}{Y_0}(x_1 - x_7) + \frac{Inv_{p0}}{Y_0}(x_2 - x_7) + \frac{X_0}{Y_0}(x_4 - x_7) - \frac{M_0}{Y_0}(x_5 - x_7) \right.$$
$$\left. + \frac{G_0}{Y_0}(x_6 - x_7) \right].$$

We now apply the same procedure to equation (24) of the text to obtain equation (82). Taking the original equation (24) and its corresponding steady state value and subtracting the later from the former, we obtain

$$Dx_{11} = \frac{Inv_g}{K} + \frac{Inv_p}{K} - \left(\frac{Inv_{g0} e^{\rho_3 t}}{K_0 e^{\rho_{11} t}} + \frac{Inv_{p0} e^{\rho_2 t}}{K_0 e^{\rho_{11} t}}\right)$$

which after some manipulation can be written

$$Dx_{11} = \frac{Inv_{g0}e^{\rho_3 t}}{K_0 e^{\rho_{11} t}}\left(\frac{\frac{Inv_g(t)}{Inv_{g0}e^{\rho_3 t}}}{\frac{K(t)}{K_0 e^{\rho_{11} t}}} - 1\right) + \frac{Inv_{p0}e^{\rho_2 t}}{K_0 e^{\rho_{11} t}}\left(\frac{\frac{Inv_p(t)}{Inv_{p0}e^{\rho_2 t}}}{\frac{K(t)}{K_0 e^{\rho_{11} t}}} - 1\right).$$

Remembering that

$$\rho_{11} = \rho_2 + \rho_3$$

we have

$$Dx_{11} = e^{-(\rho_2+\rho_3)}\left[\frac{Inv_{g0}}{K_0}(e^{x_3-x_{11}} - 1) + \frac{Inv_{p0}}{K_0}(e^{x_2-x_{11}} - 1)\right].$$

Given that

$$e^{x_i \pm x_j} \approx 1 + x_i \pm x_j$$

we can rewrite the last equation as

$$Dx_{11} = \frac{1}{1+\rho_2+\rho_3}\left[\frac{Inv_{g0}}{K_0}(x_3 - x_{11}) + \frac{Inv_{p0}}{K_0}(x_2 - x_{11})\right]$$

from which we obtain equation (82).

Finally equation (86) is obtained applying a similar procedure to the equation (25). Taking the logarithm of equation (25) and of its correspondent steady state value (equation 41). Subtract the later from the former and obtain

$$x_{15} = \log\frac{Y(t) - \frac{W(t)}{P(t)}L(t)}{Y_0 e^{\rho_7 t} - \frac{W_0}{P_0}L_0 e^{(\rho_9-\rho_8+\rho_{10})t}},$$

which can be rewritten as

$$x_{15} = \log \frac{Y_0 e^{\rho_7 t} \frac{Y(t)}{Y_0 e^{\rho_7 t}} - \frac{W_0 e^{\rho_9 t}}{P_0 e^{\rho_8 t}} \frac{W(t)/W_0 e^{\rho_9 t}}{P(t)/P_0 e^{\rho_8 t}} L_0 e^{\rho_{10} t} \frac{L(t)}{L_0 e^{\rho_{10} t}}}{Y_0 e^{\rho_7 t} - \frac{W_0}{P_0} L_0 e^{(\rho_9 - \rho_8 + \rho_{10})t}}.$$

Given that

$$\rho_7 = \rho_9 - \rho_8 + \rho_{10}$$

we can write

$$x_{15} = \log \frac{Y_0 e^{x_7} - \frac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}}{Y_0 - \frac{W_0}{P_0} L_0} =$$
$$\log(Y_0 e^{x_7} - \frac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}) - \log(Y_0 - \frac{W_0}{P_0} L_0). \tag{87}$$

Assuming $Y_0 e^{x_7}$ as a single variable, say x and $\frac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}$ as another single variable, say y, we can apply formula (I.1) given in Gandolfo (1981, p. 98) to the first logarithm and obtain

$$\log(Y_0 e^{x_7} - \frac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}) \simeq$$

$$\log(Y_0 e^{x_7^0} - \frac{W_0}{P_0} L_0 e^{(x_9^0 - x_8^0 + x_{10}^0)}) + \frac{1}{(Y_0 e^{x_7^0} - \frac{W_0}{P_0} L_0 e^{(x_9^0 - x_8^0 + x_{10}^0)})}$$

$$\left[(Y_0 e^{x_7^0} \log \frac{Y_0 e^{x_7}}{Y_0 e^{x_7^0}}) - (\frac{W_0}{P_0} L_0 e^{(x_9^0 - x_8^0 + x_{10}^0)} \log \frac{\frac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}}{\frac{W_0}{P_0} L_0 e^{(x_9^0 - x_8^0 + x_{10}^0)}}) \right].$$

Because by definition

$$x_7^0 = x_9^0 = x_8^0 = x_{10}^0 = 0,$$

it follows that

$$\log(Y_0 e^{x_7} - \tfrac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}) \simeq$$

$$\log(Y_0 - \tfrac{W_0}{P_0} L_0) + \frac{1}{(Y_0 - \frac{W_0}{P_0} L_0)}$$

$$(Y_0 x_7 - \tfrac{W_0}{P_0} L_0 (x_9 - x_8 + x_{10}).$$

By substituting this last equation into equation (87), we obtain

$$x_{15} = \log \frac{Y_0 e^{x_7} - \frac{W_0}{P_0} L_0 e^{(x_9 - x_8 + x_{10})}}{Y_0 - \frac{W_0}{P_0} L_0} \simeq$$

$$\frac{Y_0}{Y_0 - \frac{W_0}{P_0} L_0} x_7 - \frac{\frac{W_0}{P_0} L_0}{Y_0 - \frac{W_0}{P_0} L_0} (x_9 - x_8 + x_{10}),$$

which corresponds to equation (86).

C. Parameter's values

Elasticity	Constants	Speed of adjustment
$\beta_1 = 0.4$	$\gamma_1 = 0.8$	$c_1 = 1.150$
$\beta_2 = 0.6$	$\gamma_2 = 0.3$	$c_2 = 1.003$
$\beta_3 = 0.3$	$\gamma_3 = 0.4$	$c_3 = 0.927$
$\beta_4 = 0$	$\gamma_4 = 1.9$	$c_4 = 0.869$
$\beta_5 = -0.1125$	$\gamma_5 = 0.2$	$c_5 = 0.08$
$\beta_6 = 1.2$	$\gamma_6 = 0.005$	$c_6 = 0.493$
$\beta_7 = 0.1$	$\gamma_7 = 1.2$	$c_7 = 0.383$
$\beta_8 = 0.2536$	$\gamma_8 = 0.7$	$c_8 = 0.9$
$\beta_9 = -0.401$	$\gamma_9 = 0.7$	
$\beta_{10} = 0.1668$	$\gamma_{10} = 0.5$	Rate of growth of the
$\beta_{11} = 0.3093$	$\gamma_{11} = 0.2$	exogenous variables
$\beta_{12} = 0$	$\Gamma_2 = 0.35$	$\delta_1 = 0.01$
$\beta_{13} = 0.1411$		$\delta_2 = 0.025$
$\beta_{14} = 0.1289$		$\delta_3 = 0.02$
$\beta_{15} = 0$		
$\beta_{16} = 0.4402$		
$\beta_{17} = 0.00015$		
$\beta_{18} = 0.0509$		

$$\beta_{19} = 0.0291$$

$$\beta_{20} = 0.002$$

$$\beta_{21} = 0.002$$

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