European Integration , Monetary Policy and Exchange Rate Behaviour

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Chapter 6

The Timing of EU Expansion and the Real Exchange Rate

Summary

This chapter analyses the impact of the timing of EU expansion on the real exchange rate between the accession countries' currencies and the euro. I find that the real exchange rate response to EU accession is smaller in the case of a postponed accession, as postponement gives the accession countries more time to converge in terms of productivity. By contrast, early EU accession (and the ensuing decline in bilateral trade costs) would contribute to reducing the real exchange rate response to productivity shocks in the candidate member states. Thus, there is a tradeoff between the size of the change in the real exchange rate at the moment of accession (which argues for postponement) and the size of the real exchange rate response to productivity shocks (which argues for quick accession).

6.1 Introduction

The timing of the accession of the candidate member states to the European Union (EU)[1] is an issue where considerations of international security and political stability play an important role. From an economic point of view, a case can be made for quick accession: if economic integration is expected to yield benefits to all participating countries, why

[1]Twelve countries are currently involved in accession negotiations with the EU: Hungary, Poland, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Romania, Bulgaria, Malta, Cyprus. The EU governments have agreed that ten of the candidate countries can become member states in 2004. The analysis in this paper can be applied to these and other future accessions.

lose time in reaping those benefits? On the other hand, the productivity gap between the candidate member countries and the current member states is quite large. The German re-unification of 1990-91 shows that quick accession may have adverse consequences in the new member states, such as high unemployment or a loss of competitiveness. Therefore, it can be argued that a substantial amount of real convergence (in the sense of bridging the productivity gap) should preferably have taken place before the moment of EU accession.

The average price level in the accession countries is currently less than 50% of the EU level. The accession process may involve economic changes which call for an adjustment of the relative price level. In other words, the real exchange rate between the candidate member states and the current EU member states may need to change. This adjustment should preferably be smooth, i.e. without large shocks. The currencies of the new member states will most likely be tightly pegged to the euro shortly after accession. In case the nominal exchange rate is effectively fixed shortly after EU accession – either because candidate member states try to fulfill the Maastricht criterion for exchange rate stability against the euro,[2] or because they adopt the single currency shortly after accession – any adjustment in relative prices between the accession countries and the existing member states needs to take place via domestic prices. This may give rise to temporary (or persistent) inflation differentials between both groups of countries. If the accession countries immediately join the monetary union, the European Central Bank would be required to set its policy so that price stability in the extended euro area is achieved, but this policy might be inappropriate from the viewpoint of the current member states (and possibly also for the new member states).

Upon EU accession, the new member states will join the Single Market. Formal trade barriers will be abolished, at least for industry products. In addition, EU accession will promote the harmonisation of product standards, which will further reduce the cost of cross-border transactions between current and new member states. Therefore, in this paper, EU accession will be modeled as a reduction in trade costs between the EU and the candidate member states.

This chapter studies how the behaviour of the real exchange rate may be affected by the timing of EU accession. More specifically, the following policy-relevant questions related to the expansion of the EU are analysed. First, I study whether the impact of EU accession on the real exchange rate depends on the extent to which productivity levels have converged. This is relevant for the question when the candidate member

[2] The criterion is that a member state has respected the normal fluctuation margins of the exchange rate mechanism of the European Monetary System without severe tensions and without devaluation for at least two years.

states should be admitted (assuming that there is a convergence of their productivity levels towards that of the existing EU member states). Next, I analyse whether the response of the real exchange rate to productivity shocks is different before and after EU accession. Another important question, whether EU membership itself affects the convergence in terms of productivity will not be addressed here. Productivity shocks are assumed to be exogenous throughout the paper.

I employ the Ricardian model developed by Dornbusch, Fischer and Samuelson (1977), hereafter: 'DFS'.[3] The DFS model contains many goods. The character of each good (tradable or non-tradable) is endogenously determined. The dynamic version of the model is due to Obstfeld and Rogoff (1996, chapter 4). The DFS model is a two-country model. I treat the European Union and the group of candidate member states each as one country. This can be justified by the similarity of the countries in each region compared to the dissimilarities between both regions. I introduce some extensions to the Obstfeld and Rogoff (1996) analysis. First, I allow for asymmetries in country size and the initial level of productivity between regions. Second, I analyse the impact of a reduction in trade costs.

I obtain the following results. First, the timing of EU accession affects the exchange rate response to accession. The real exchange rate of the candidate member states is predicted to appreciate by one to two percent upon accession. This seems large, given that this prediction is based on a decline in trade costs by only three percentage points and given that it does not take into account confidence effects. The real exchange rate appreciation is smaller in the case of postponed accession. Intuitively, the more productivity levels (and wages) of the current and new member states have converged before accession, the more price levels have converged and therefore the smaller the marginal impact of reducing trade costs on relative prices.

Second, productivity shocks are likely to be an important source of real exchange rate fluctuations during the convergence process. I find that the response of the real exchange rate to productivity shocks declines as a result of EU accession. Intuitively, the decline in trade costs stimulates bilateral trade between the existing and new member states. Productivity shocks only affect the real exchange rate to the extent that they influence the relative price of non-traded goods. Therefore, the reduced share of non-traded goods in total output means that the real exchange rate becomes less sensitive to unanticipated productivity changes. Thus, EU accession itself will contribute to stabilising the real exchange rate between the accession countries and the existing EU member states.

[3]The DFS model is Ricardian in the sense that it stresses the role of comparative advantage in determining the pattern of international trade in a flex-price environment.

The remainder of this chapter is organised as follows. Section 6.2 presents the basic model and derives the equilibrium conditions. In section 6.3, I use comparative statics to study how the timing of the accession affects the exchange rate response to accession. Section 6.4 presents a dynamic version of the model, which is then used to study the response of the real exchange rate to productivity shocks and how this response changes after EU accession. Section 6.5 concludes.

6.2 The model

6.2.1 Technologies and preferences

The world consists of two countries, Home and Foreign, of population size n and $1-n$ respectively (the world population is normalised at 1). The world economy produces a continuum of goods, indexed by $z \in [0,1]$. The only factor of production, labour, is available in fixed quantities nL in the Home and $(1-n)L^*$ in the Foreign country, where L and L^* are labour effort per individual in the Home and Foreign country.[4] The asymmetry in country size is an extension of the model in Obstfeld and Rogoff (1996, chapter 4).

The countries have different technologies for producing goods out of labour. Initially, let $v\alpha(z)$ [$v^*\alpha^*(z)$] be the number of goods z which can be produced by one unit of labour in the Home (Foreign) country, where $\alpha(z)$ [$\alpha^*(z)$] are commodity-specific technologies and v [v^*] are economy-wide technologies. Obstfeld and Rogoff assume that, initially, $v = v^*$. By contrast, I allow for asymmetry in productivity ($v \neq v^*$) at any time. This is required in order to capture an important asymmetry between the EU and the accession countries in Central and Eastern Europe. The goods are indexed so that they are ranked in order of diminishing Home country comparative advantage, i.e.:

$$\frac{v\alpha(z_i)}{v^*\alpha^*(z_i)} > \frac{v\alpha(z_j)}{v^*\alpha^*(z_j)}, \quad \text{for each } 0 < z_i < z_j < 1,$$

where an asterisk denotes the Foreign country. Note that the ranking of goods is not affected by the economy-wide technologies.

[4]As in the basic DFS model, there is no capital in the model in this paper. It is not directly clear whether the inclusion of capital would affect the outcome of the model. Excluding the role of capital is supported by some earlier research, which suggests that the increase in labour productivity achieved in the more successful Central and Eastern European countries (CEECs) reflects increases in total factor productivity, rather than increases in the capital stock. See Doyle, Kuijs and Jiang (2001).

In the remainder of this paper, Foreign variables have an asterisk (*). Apart from that, the mathematical expressions for Foreign variables are identical to those found for the Home country, unless explicitly stated otherwise.

Household preferences are defined by a simple intertemporal utility function:

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \log C_s, \tag{6.1}$$

where U is the lifetime utility of a representative household in the Home country, C is the real composite consumption index, β is the discount factor and s and t are time subscripts. Time subscripts will be suppressed whenever possible.

The consumption index of the composite good is defined by

$$C = \exp\left[\int_0^1 \log c(z)dz\right]. \tag{6.2}$$

The consumption-based price index (defined as the lowest cost of purchasing one unit of composite real consumption, C) is:

$$P = \exp\left[\int_0^1 \log p(z)dz\right], \tag{6.3}$$

where $p(z)$ is the price of good z expressed in units of good 1 [the numeraire good, so that $p(1) = 1$].

Demand for good z is given by

$$c(z) = \frac{P}{p(z)}C. \tag{6.4}$$

This functional form of the demand function implies that the elasticity of substitution between all pairs of goods is unity. Each good has a constant share in total expenditure, i.e. $\int_{z_i}^{z_j} p(z)c(z)dz = (z_j - z_i)PC$, for all $0 < z_i < z_j < 1$.

The individual budget constraint for the representative Home individual (in nominal terms) is:

$$B_t = (1 + i_{t-1})B_{t-1} + W_t L_t - P_t C_t, \tag{6.5}$$

where W is the nominal wage rate, which is uniform across different industries in the same country, as labour is mobile within each country (but not internationally, so that W^* can differ from W), L is labour effort per individual, B_t is the stock of nominal bonds held by the representative household on date t and i_{t-1} is the nominal interest rate on bonds between $t-1$ and t.

Maximising utility function (6.1) subject to budget constraint (6.5) yields the Euler condition for intertemporal consumption smoothing:

$$C_{t+1} = \beta(1 + r_t)C_t, \tag{6.6}$$

where r_t is the real interest rate on bonds between t and $t + 1$.[5]

6.2.2 Trade costs and market equilibrium

For any internationally traded good z, a fraction τ melts away in transit, so that only a fraction $1 - \tau$ arrives at the destination. Intuitively, the 'melting loss' can be interpreted as any kind of trade barrier which makes cross-border transactions more costly than domestic transactions.[6]

Goods are produced only in Home if importing them would be more expensive, i.e. if $p(z) < p^*(z)/(1 - \tau)$. Similarly, goods are produced in Foreign if it is more expensive to import these goods, i.e. if $p(z)/(1 - \tau) > p^*(z)$. Figure 1 shows the pattern of international specialisation [where the curve labeled A is $W/W^* = (1-\tau)v\alpha/(v^*\alpha^*)$ and curve B is $W/W^* = \frac{1}{1-\tau}v\alpha/(v^*\alpha^*)$].

Home produces all goods to the left of z^H and Foreign produces all goods to the right of z^F.[7] For given wages (W, W^*) and trade costs (τ), the cut-off points z^H and z^F are defined by

$$p(z^H) = \frac{p^*(z^H)}{1 - \tau}, \tag{6.7}$$

$$\frac{p(z^F)}{1 - \tau} = p^*(z^F). \tag{6.8}$$

Each good is produced under perfect competition. Therefore, firms price at marginal cost: $p(z) = W/[v\alpha(z)]$. Now, equations (6.7)-(6.8) can be rewritten as

$$\frac{W}{W^*} = \frac{v\alpha(z^H)}{(1 - \tau)v^*\alpha^*(z^H)}, \tag{6.9}$$

$$\frac{W}{W^*} = \frac{(1 - \tau)v\alpha(z^F)}{v^*\alpha^*(z^F)}. \tag{6.10}$$

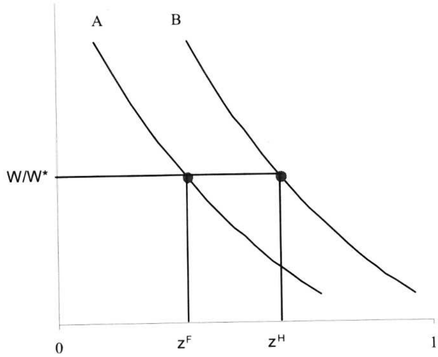
Goods in $[0, z^F]$ are produced exclusively in Home and exported to Foreign, since the comparative advantage in producing these goods is sufficiently high to overcome

[5] Maximising the utility function (6.1) subject to budget constraint (6.5) yields $P_{j+1}C_{j+1} = \beta(1 + i_j)P_jC_j$, which can be rewritten as $C_{j+1} = \beta\frac{P_j}{P_{j+1}}(1 + i_j)C_j = \beta(1 + r_j)C_j$.

[6] See Lejour, De Mooij and Nahuis (2001) for an estimate of barriers to trade in different industries in the EU and the candidate member states.

[7] See DFS (1977, pp. 829-830) for a more detailed discussion of Figure 1.

Figure 6.1: Pattern of international specialisation



the costs of international trade. Similarly, goods in $[z^H, 1]$ are produced exclusively in Foreign and exported to Home. Goods in $[z^F, z^H]$ are produced in both countries, but not traded internationally.

The market equilibrium conditions for Home-produced and Foreign-produced goods are:[8,9]

$$
\begin{aligned}
nWL &= z^H nPC + z^F(1-n)P^*C^*, &(6.11)\\
(1-n)W^*L^* &= (1-z^H)nPC + (1-z^F)(1-n)P^*C^*. &(6.12)
\end{aligned}
$$

The international wage ratio and industry location are determined jointly by equations (6.9)-(6.10) and (6.11)-(6.12).

[8]This can be seen as follows: Market equilibrium requires that Home output equals world spending on Home-produced goods, whereas Foreign output equals world spending on Foreign-produced goods. Firms make zero profits, so Home output is equal to labour income in the Home country (nWL) and Foreign output is equal to labour income in the Foreign country $[(1-n)W^*L^*]$. Home consumption is equal to nPC. As Home produces the goods in $[0, z^H]$, it follows from equation (6.4) that Home consumption of domestically produced goods is $z^H nPC$. Home imports the goods in $[z^H, 1]$, so Home consumption of Foreign-produced goods is $(1-z^H)nPC$. Similarly, Foreign consumption equals $(1-n)P^*C^*$. As Foreign produces the goods in $[z^F, 1]$, Foreign consumption of domestically produced goods is $(1-z^F)(1-n)P^*C^*$. Foreign imports the goods in $[0, z^F]$, so Foreign consumption of Home-produced goods is $z^F(1-n)P^*C^*$.

[9]The losses from trading (melting costs) are precisely offset by the higher price of exported goods. As a result of this, melting costs do not show up in the equations for market equilibrium.

The law of one price fails to hold for any good. It holds neither for non-traded goods (since there is no arbitrage) nor for traded goods (since the price is $1/(1-\tau)$ times higher in the importing country than in the exporting country). The Home and Foreign price indices are

$$P = \exp\{\int_0^{z^H} \log[\frac{W}{v\alpha(z)}]dz + \int_{z^H}^1 \log[\frac{W^*}{(1-\tau)v^*\alpha^*(z)}]dz\}, \tag{6.13}$$

$$P^* = \exp\{\int_0^{z^F} \log[\frac{W}{(1-\tau)v\alpha(z)}]dz + \int_{z^F}^1 \log[\frac{W^*}{v^*\alpha^*(z)}]dz\}. \tag{6.14}$$

6.3 EU accession and the real exchange rate

This section studies the timing of the accession and its implications for the real exchange rate. I use comparative statics to do so. I first solve the model for a steady state with a balanced trade account. Since the functional form of the model precludes the derivation of a reduced-form solution, I use a numerical approach in order to assess the impact of the timing of EU accession. The decision on the timing of accession is exogenous in this model. I compare two scenarios: immediate and postponed accession. In the first scenario. EU accession (modeled as a reduction in trade costs) occurs when productivity in the candidate member states is at the current low level. In the second case, by contrast. EU accession occurs when productivity in the candidate member states has reached a higher level.

6.3.1 Steady state

In a steady state, all exogenous variables are constant. Steady-state values will be represented by overbars. Imposing the steady state restriction on the equations in the previous subsection, we obtain a system of 10 independent equations in 11 endogenous variables (see Appendix A). Given that the model contains more endogenous variables than independent equations, the steady state is not uniquely determined. Therefore, I impose the initial condition of zero net foreign assets in order to close the model:

$$\overline{B} = 0. \tag{6.15}$$

This amounts to assuming that not only the current account, but also the trade account is balanced in the initial steady state.

For notational simplicity, I impose that the production technologies have the following functional form (see Obstfeld and Rogoff, 1996, chapter 4):

$$\alpha(z) = \exp(-z), \tag{6.16}$$
$$\alpha^*(z) = \exp(z-1), \tag{6.17}$$

I also assume that labour effort per individual is equal to one ($L = L^* = 1$), so that labour input is fully captured by population size: n vs $1-n$. Then, from equations (6.5), (6.11) and (6.15):

$$\frac{\overline{W}}{\overline{W}^*} = \frac{\overline{z}^F}{1-\overline{z}^H}\frac{(1-n)}{n}. \tag{6.18}$$

Substitute (6.16)-(6.17) into equations (6.9)-(6.10), take logarithms on both sides and combine:

$$\log\frac{\overline{W}}{\overline{W}^*} - \log\frac{\overline{v}}{\overline{v}^*} = 1-\overline{z}^F-\overline{z}^H, \tag{6.19}$$
$$\overline{z}^H - \overline{z}^F = -\log(1-\tau). \tag{6.20}$$

Equations (6.18)-(6.20) jointly determine the relative wage ($\overline{W}/\overline{W}^*$) and the pattern of international specialisation ($\overline{z}^H$, $\overline{z}^F$).

First we analyse how the pattern of specialisation is affected by trade costs, country size and productivity. From equation (6.20), the share of non-tradable goods in output is increasing in trade costs. Under zero trade costs ($\tau = 0$) all goods are tradable, so that the size of the non-tradable sector is zero ($\overline{z}^H - \overline{z}^F = 0$). As trade costs increase, fewer goods are traded. Trade costs above 63% are prohibitive.[10] I will henceforth assume that $\tau < .63$.

From equations (6.18) and (6.19), if the Home country is relatively large ($n > \frac{1}{2}$), it will import a smaller range of goods than Foreign ($1-\overline{z}^H < \overline{z}^F$). The large country will export a wider range of goods.[11] Intuitively, given different production technologies

[10]When trade costs are small, $-\log(1-\tau)$ may be approximated by τ, so that the size of the non-tradable sector is proportional to trade costs ($\overline{z}^H - \overline{z}^F \approx \tau$). As trade costs get larger, the size of the non-tradable sector increases more than proportionally. Trade costs of 63% are prohibitive, since -log(1-.63)$\approx -\log(1/e) = 1$. In this case, the non-tradable sector is 100% of the economy and both economies produce all goods.

[11]On the import side, $\overline{z}^F$ equals the range of goods imported by Foreign and also the share of Foreign income spent on imports in the steady state. However, on the export side, there is a distinction between the range of exported goods and the share of exports in output: $\overline{z}^F$ is the range of goods exported by Home, but since some exportable goods are consumed domestically, it is not equal to exports as a share of Home output. Given that the trade balance is in equilibrium in steady state, the share of exports in Home output equals the share of imports in Home output ($1-\overline{z}^H$).

for different goods, it is optimal for a country to specialise in the production of a few goods in which it is highly efficient. However, for a large country, a strong degree of specialisation is incompatible with equilibrium in the world market. A large country must be self-sufficient in a large range of goods.[12] Similarly, if the Home country is more productive ($\overline{v} > \overline{v}^*$), it will, ceteris paribus, import a smaller range of goods than Foreign ($1 - \overline{z}^H < \overline{z}^F$). The more productive country will export a larger range of products. Intuitively, a low level of productivity reduces a country's economic size in terms of output. Therefore, analogously to the discussion of differences in country size, the less productive country will specialise in the production of a few goods. Thus, the model predicts that the production structure of large and highly productive countries will be relatively well-diversified.

Next, consider how the relative wage rate is affected by country size, productivity and trade costs. From equations (6.18)-(6.20), the Home relative wage ($\overline{W}/\overline{W}^*$) is decreasing in Home's relative country size ($\frac{n}{1-n}$). Large countries must produce a larger range of goods (see above) and are therefore less able to exploit their comparative advantage in the production of specific goods. An economy-wide productivity increase in Foreign (a decline in $\overline{v}/\overline{v}^*$) leads to a decline in Home's relative wage rate. However, productivity differences are less than fully reflected in wages. The intuition for the latter is that a more productive country must produce a larger range of goods in equilibrium, so it is less able to exploit its comparative advantage in the production of specific goods. The impact of a decline in trade costs ($\tau \downarrow$) on the relative wage rate is ambiguous.[13]

The steady state real exchange rate ($\overline{P}/\overline{P}^*$) is given by (see appendix A for the derivation):

$$\log \frac{\overline{P}}{\overline{P}^*} = (\overline{z}^H - \overline{z}^F)[\log \frac{\overline{W}}{\overline{W}^*} - \log \frac{\overline{v}}{\overline{v}^*}]. \tag{6.21}$$

In the absence of trade costs ($\tau = 0$), all goods are tradable ($\overline{z}^H - \overline{z}^F = 0$) and goods arbitrage implies that the law of one price must hold. The Home and Foreign price levels are equalised and the real exchange rate is equal to unity ($\overline{P}/\overline{P}^* = 1$). With positive trade costs, some goods are non-tradable and the real exchange rate is determined by relative unit labour costs $[\overline{W}/\overline{v}]/[\overline{W}^*/\overline{v}^*]$ times the size of the non-tradable goods sector $[\overline{z}^H - \overline{z}^F]$.

[12] Note that this pattern of international specialisation has nothing to do with economies of scale in production.

[13] It is not possible to derive a reduced-form solution for the relative wage rate. However, eliminating $\overline{z}^F$ and $\overline{z}^H$ from equations (6.18)-(6.20) yields $\frac{\overline{W}}{\overline{W}^*} = (\frac{1-n}{n})\frac{1-\log(\overline{W}/\overline{W}^*)+\log(\overline{v}/\overline{v}^*)+\log(1-\tau)}{1+\log(\overline{W}/\overline{W}^*)-\log(\overline{v}/\overline{v}^*)+\log(1-\tau)}$, which helps to check the statements in the main text.

An economy-wide productivity increase in Foreign (a decline in $\overline{v}/\overline{v}^*$) causes a decline in unit labour costs in the Foreign non-tradable sector, despite that $\overline{W}/\overline{W}^*$ falls as well. The decrease in unit labour costs results in a depreciation of the Foreign real exchange rate.[14] A decline in trade costs has an ambiguous impact on the exchange rate. On the one hand, it reduces the size of the non-tradables sector $(\overline{z}^H - \overline{z}^F)$, thus limiting the scope for price differences. On the other hand, its impact on the relative wage rate $[\log(\overline{W}/\overline{W}^*)]$ is ambiguous, as pointed out above.

Combining the steady-state version of equation (6.5) and its Foreign counterpart with equations (6.15) and (6.21) yields

$$\log\frac{\overline{C}}{\overline{C}^*} = (\overline{z}^H - \overline{z}^F)\log\frac{\overline{v}}{\overline{v}^*} + [1 - (\overline{z}^H - \overline{z}^F)]\log\frac{\overline{W}}{\overline{W}^*}. \tag{6.22}$$

Equation (6.22) shows that the relative consumption level $(\overline{C}/\overline{C}^*)$ is a weighted average of relative productivity levels (weighted by the size of the non-tradable goods sector) and relative wage rates (weighted by the size of the tradable goods sector).[15] Intuitively, in autarky (no trade), relative consumption per capita is determined by relative productivity, whereas in a fully open economy, relative consumption per capita is determined by relative wages (purchasing power).

Equations (6.18)-(6.22) form a system of five independent equations in five endogenous variables: $\overline{z}^H$, $\overline{z}^F$, $\overline{C}/\overline{C}^*$, $\overline{P}/\overline{P}^*$ and $\overline{W}/\overline{W}^*$. The functional form of these equations precludes the presentation of a reduced-form solution.

6.3.2 Immediate versus postponed accession

Next, I make some tentative calculations on the impact of the timing of EU accession on the real exchange rate between the EU and the accession countries. Quick or postponed accession: what does it mean for the exchange rate effects of EU accession? The goal is to draw qualitative conclusions from this exercise. As the model is relatively simple, the

[14] Obstfeld and Rogoff (1996, p. 255) argue that '*a proportional fall in Foreign's unit labour requirement for all goods*' implies that '*P^* rises relative to P, so that Foreign's relative productivity gain leads to a rise* [i.e. appreciation] *in its real exchange rate*' (comment in square brackets added by me). This statement is incorrect. To the contrary, an economy-wide increase in Foreign productivity causes P^* to decline relative to P. In other words, the Foreign real exchange rate depreciates. This prediction is opposite to the well-known Balassa-Samuelson effect. The reason for this difference is that the current model presumes that productivity catch-up is economy-wide, rather than concentrated in the tradable goods sector.

[15] Note that $\overline{z}^H - \overline{z}^F$ (the size of the non-tradable sector) and $1 - (\overline{z}^H - \overline{z}^F)$, i.e. the size of the tradable sector, are both between zero and one for all admissible parameter values.

quantitative results serve no more than an illustrative purpose. In the remainder of the paper, the Home country will be the EU, whereas the Foreign country will represent the group of accession countries.

I impose that EU accession has the following stylised form: upon accession, trade costs are reduced from 50% to 47%.[16] I compare two scenarios: immediate accession versus postponed accession. Under both scenarios, I simply compare the steady-state equilibrium before and after accession. The scenarios differ in the extent to which real convergence has taken place before accession. I assume that the productivity gap between the candidate member states and the current member states is reduced over time. For simplicity, the timing of accession is assumed to have no impact on the pace of productivity growth in either region.[17] Thus, the productivity ratio $\overline{v}^*/\overline{v}$ increases exogenously over time. Currently, productivity in the candidate member states is measured at only 13% of productivity in the EU.[18] Therefore, under immediate accession, a reduction in trade costs takes place at the moment that real convergence has not yet taken place: $\overline{v}^*/\overline{v} = 0.13$. Under postponed accession, by contrast, productivity in the candidate member states has reached a higher level relative to the current EU member states. In this case, I use $\overline{v}^*/\overline{v} = 0.34$. This value for the productivity ratio corresponds to the current productivity gap between the most advanced candidate member states (Slovenia and Cyprus) and the EU average. Accidentally, this number is also roughly equal to the current productivity gap between the poorest EU member states (Portugal and Greece) and the EU average. See appendix B.

First consider the case of early accession. The impact of accession on the main variables is shown in Table 1. Wages converge ($\overline{W}^*/\overline{W}$ moves closer to one). The bilateral trade share increases by six percentage points in the candidate member states

[16]The value for τ is exogenous. Trade costs (which include all kinds of trade barriers, including a lack of harmonisation in product standards) are not directly observable. Calibration of the model (appendix B) suggests that the current level of trade costs between the EU and the candidate member states is 50%. I use 40% as the long-run level for trade costs between EU and accession countries, in line with the value for the current intra-EU level of trade costs reported in chapter 4 of this dissertation. I assume that almost one third of this reduction (from 50% to 47%) takes place upon accession, when the remaining formal trade barriers are abolished. The remainder of the reduction in trade costs (from 47% to 40%) happens gradually over the decades following EU accession, mainly as a result of the harmonisation of standards. The assumption that one-third of the reduction in trade costs is related to the abolition of formal trade barriers, whereas two-thirds is related to the harmonisation of standards is in line with the findings of Lejour, De Mooij and Nahuis (2001, Tables 4.1 and 4.3).

[17]This assumption can be defended on the grounds that productivity growth is stimulated by a country taking part in the accession process, rather than by the exact moment of EU accession.

[18]Output per capita has been converted to euro based on actual exchange rates. When taking into account differences in price level, the productivity ratio rises to roughly 40%.

and 0.3 percentage points in the EU.[19] There is a relative increase in the price level in the accession countries, which means that their real exchange rate $(\overline{P}^*/\overline{P})$ appreciates by 1.6%.[20]

Table 1 Timing of EU accession

	$\overline{W}^*/\overline{W}$	$\overline{z}^F$	$1-\overline{z}^H$	$\widehat{\overline{P}^*/\overline{P}}$
Early accession				
$(v^*/v = 0.13)$:				
$\tau = 0.50$	0.17	0.292	0.015	- -
$\tau = 0.47$	0.18	0.347	0.018	1.6%
$\tau = 0.40$	0.20	0.462	0.027	3.0%
Late accession				
$(v^*/v = 0.34)$:				
$\tau = 0.50$	0.44	0.271	0.036	- -
$\tau = 0.47$	0.45	0.321	0.044	1.2%
$\tau = 0.40$	0.50	0.426	0.063	2.2%

In the case of late accession, the average level of productivity of the candidate member states has extra time to increase relative to the EU average. The productivity increase in the accession countries causes industry migration from the EU to the candidate member states. The EU sheds its least efficient industries. The candidate member states expand the range of domestically-produced goods. This leads to a decline in the accession countries' import share $(\overline{z}^F)$ and an increase in the EU's import share $(1-\overline{z}^H)$ before the moment of accession.[21] As a result of the reduction in trade costs at the moment of accession, wages converge and the bilateral trade share increases by roughly 20%. The real exchange rate of the accession countries appreciates, but the exchange rate appreciation is smaller than in the case of early accession. Intuitively, the more that

[19] Accession countries' imports (z^F) and EU imports $(1-z^H)$ increase by 20% (from 29% to 35% of output and from 1.5% to 1.8% of output, respectively).

[20] This estimate does not take into account that EU accession affects the expectations of private agents with respect to the economic performance of the candidate member states, reducing the risk premium on the accession countries' currencies, which may cause a (much) larger real exchange rate appreciation.

[21] Recall that the EU is the Home country, whereas the group of accession countries are the Foreign country.

productivity levels and wages have converged before accession. the smaller the difference in the price level and the smaller the price impact of reducing trade costs.[22,23]

6.4 Productivity shocks and the real exchange rate

This section studies the response of the real exchange rate between the euro and the currencies of the candidate member states to productivity shocks and how this response changes after EU accession.[24] I first discuss the nature of productivity shocks in the candidate member states, then I present the dynamic version of the model and finally I compare the real exchange rate response to productivity shocks under different regimes (early/late EU accession). Under the early accession scenario, trade costs are assumed to be reduced before productivity shocks occur. Under the late accession scenario, trade costs are still at the current (higher) level when productivity shocks occur.

6.4.1 Productivity shocks

The Central and Eastern European countries (CEECs) are likely to experience a relatively quick rise in productivity. Such a productivity catch-up can be expected based on the current level of productivity in the CEECs, which is relatively low. See Barro and Sala-i-Martin (1992).

The accession process is likely to accelerate this process of real convergence. It does so in several ways. First, (the prospect of) EU membership improves the creditworthiness of the new member states and thus gives them better access to international capital markets. This will make it possible, for instance, to further upgrade the physical infrastructure in the countries involved. Second, the screening conducted by the European Commission will contribute to an improvement of institutions. One example is enhanced banking supervision, which will promote a more efficient allocation of financial resources in the economy. Third, new management techniques and business strategies can be transfered,

[22] In the extreme case of fully symmetric countries, reducing trade costs would have no impact on the real exchange rate at all.

[23] There is no simple answer to the question whether immediate accession is to be preferred over postponed accession or not. From a welfare point of view, the current model will surely generate the result that EU accession produces welfare benefits for all countries, which would lead to the conclusion that sooner accession is always better. However, a welfare analysis of immediate versus postponed accession falls outside the scope of this paper.

[24] Of course, the euro is not the currency of the European Union, but only of those countries participating in the monetary union. However, this distinction is neglected here.

possibly through partnerships with foreign companies.[25] Fourth, capital accumulation will be promoted directly by the EU structural funds and the investment of foreign firms. Capital accumulation can be expected to make a substantial contribution to productivity increases, as the marginal product of capital is likely to be relatively high in the candidate member states. The accelerated productivity rise in the new member states can be regarded as a positive side-effect of the accession process.

Productivity increases may be concentrated in the tradable goods sector. This is the standard assumption underlying the Balassa-Samuelson effect. The latter could manifest itself as a relatively high level of inflation, as an appreciation of the nominal exchange rate, or a combination of both. Another possibility, however, is that productivity increases occur economy-wide, rather than mainly in the tradable sector. For instance, Kopits (1999) points out that major reforms in education, health care, pension systems, public administration, as well as infrastructure investment in transportation, communications, create the conditions for balanced productivity improvements across all the sectors. The possibility of economy-wide productivity increases is also underlined by Jakab and Kovács (1999).[26] Because of the limitations of the model used in this paper, I restrict myself to economy-wide productivity increases.[27]

The productivity catch-up is likely to happen in a bumpy manner, rather than smoothly. Temporary positive and negative deviations from the upward productivity trend in the new member states will occur. Temporary productivity shocks are likely to be an important source of real exchange rate fluctuations during the process of real convergence.[28] Therefore, it is important to know whether the response of the real exchange rate to such temporary productivity shocks will be affected by already being part of the EU or not.

In order to study the exchange-rate response to the productivity shocks which may occur during the transition process, I use a dynamic version of the model.

[25] For the first channel through which EU accession might stimulate productivity rises, see Baldwin, Francois and Portes (1997). The second channel is put forward by Fischer and Sahay (2000) and Pelkmans, Gros and Nunez Ferrer (2000). On the third channel, see Corker, Beaumont, Van Elkan and Iakova (2000) and Doyle, Kuijs and Jiang (2001).

[26] They argue that, in the case of Hungary, productivity increased faster in the tradable sector early in the transition, due to extensive lay-offs and foreign and domestic investments which were mainly concentrated in the tradables sector, but that Hungary has now entered a next phase, as the non-tradable sector attracts new investments, mainly in the banking and retail sector.

[27] The character of each good (tradable or non-tradable) is determined endogenously. Therefore, sector-specific productivity shocks can give rise to inconsistencies in the model.

[28] Jakab and Kovács (1999) find that productivity shocks were the main determinant of relative price adjustments between non-tradable and tradable goods in Hungary during 1991-98.

6.4.2 The loglinearised model

The DFS model is a flex-price model, which fits the purpose of this paper. The horizon for the completion of the convergence process is several decades.[29] Therefore, there is no short-run price rigidity in the dynamic version of the model and the 'short run' should be interpreted as lasting several years (i.e. beyond the normal duration of nominal rigidities).

Variables with hats denote percentage deviations from the initial steady state ($\widehat{P} = dP/\overline{P}_0$). The difference operator indicates absolute deviations from the initial steady state ($dz^H = z^H - z_0^H$). For notational simplicity, subscripts zero (denoting initial steady state values) are suppressed where possible. The full loglinearised model is derived in appendix C. The most insightful way to present the model is by rewriting it in terms of country differences. Here, the main equations are presented.

The pattern of international specialisation is determined by the difference in unit labour costs:

$$dz^H + dz^F = -(\widehat{W} - \widehat{W}^*) + (\widehat{v} - \widehat{v}^*). \tag{6.23}$$

An increase in productivity in Foreign ($\widehat{v}^* > 0$), keeping trade costs unchanged, will cause some industries to migrate from Home to Foreign (z^H and z^F move to the left in figure 1). The Foreign wage increases relative to the Home wage, but Foreign still experiences a decline in unit labour costs relative to Home [W^*/v^* declines relative to W/v; also see the discussion following equations (6.18)-(6.20)].

The relative size of the non-tradables sector ($z^H - z^F$) is increasing in trade costs (τ):

$$dz^H - dz^F = \frac{d\tau}{1-\tau}. \tag{6.24}$$

The marginal impact of a change in trade costs is larger if trade costs are high, initially (in that case, $1 - \tau$ is low).

The inflation difference (or equivalently, the change in the real exchange rate) is

$$\widehat{P} - \widehat{P}^* = (z^H - z^F)\left[\widehat{W} - \widehat{W}^* - (\widehat{v} - \widehat{v}^*)\right] + (1 - z^H - z^F)\frac{d\tau}{1-\tau}. \tag{6.25}$$

The inflation difference between both countries is partly determined by price increases in the non-tradable goods sector in both countries (which are determined by wage and productivity developments), multiplied by the size of the non-tradable goods sector. The

[29] According to recent estimates, the process of real convergence will take about thirty years to be completed. See Fischer, Sahay and Végh (1998) or Doyle, Kuijs and Jiang (2001).

inflation difference also depends on trade costs. A reduction in trade costs lowers the price of imported goods in both countries. The impact on the general price level will be larger in the country with the largest share of imports. For instance, if the import share in Foreign is larger than in Home (i.e. $z^F > 1 - z^H$), then a reduction in trade costs will lead to a positive inflation differential between Home and Foreign ($\widehat{P} - \widehat{P}^* > 0$).

Equations (6.23)-(6.25) are valid both for long-run and short-run deviations from the steady state. Henceforth, however, I will distinguish between long-run and short-run changes. Short-run deviations from the steady state will be denoted by hatted variables and long-run steady state changes are indicated by hatted overbarred variables. The short-run current account balance of the Home country is determined by the change in output (reflected in real income $\widehat{W} - \widehat{P}$) and spending ($\widehat{C}$), i.e. $d\overline{B}/(\overline{PC})_0 = \widehat{W} - \widehat{P} - \widehat{C}$, which can be rewritten in terms of country differences as (see appendix C):

$$\frac{d\overline{B}}{(\overline{PC})_0} = \frac{1 - z^H}{1 - z^H + z^F}\left[\widehat{W} - \widehat{W}^* - (\widehat{P} - \widehat{P}^*) - (\widehat{C} - \widehat{C}^*)\right], \tag{6.26}$$

where the ratio $(1 - z^H)/(1 - z^H + z^F)$ is a measure for the relative size of both countries' imports. Note that this ratio equals $\frac{1}{2}$ if the import shares are equal ($1 - z^H = z^F$). It is smaller than $\frac{1}{2}$ if Home's import share is relatively small ($1 - z^H < z^F$). Intuitively, a given current account surplus $d\overline{B}$ is less important in terms of Home income per capita $\overline{PC}$ if the Home country is large and rich. The latter is reflected in a relatively small Home import share.

Sustainability requires that Home runs a long-run trade deficit (spending in excess of output: $\widehat{\overline{C}} > \widehat{\overline{W}} - \widehat{\overline{P}}$) if, and only if, it has a net claim on Foreign ($d\overline{B} > 0$), i.e. $\widehat{\overline{C}} = \overline{r} d\overline{B}/(\overline{PC})_0 + \widehat{\overline{W}} - \widehat{\overline{P}}$. The corresponding equation in terms of country differences is:

$$\widehat{\overline{C}} - \widehat{\overline{C}}^* = \frac{1 - z^H + z^F}{1 - z^H}\frac{\overline{r} d\overline{B}}{(\overline{PC})_0} + \widehat{\overline{W}} - \widehat{\overline{W}}^* - (\widehat{\overline{P}} - \widehat{\overline{P}}^*). \tag{6.27}$$

6.4.3 Comparison of pre- and post- EU accession

I have argued that productivity shocks are likely to be an important source of real exchange rate movements between the new and existing EU member states.

The question arises whether the size of the real exchange rate movements is affected by the 'membership regime', i.e. whether the response of the real exchange rate to productivity shocks differs before and after EU accession. The answer to this question will indicate whether EU accession reduces or magnifies the volatility of the real exchange rate between the accession countries and the existing member states. In this paper, EU accession is modeled as the reduction in trade costs related to the new member states' participation in the European Union's single market. Therefore, we may rephrase the above question as: does the response of the real exchange rate to productivity shocks depend on the level of trade costs? First, I consider permanent shocks, then I turn to temporary shocks.

Permanent productivity shocks

In order to study permanent productivity shocks, set $\widehat{v} = \widehat{\overline{v}}$ and $\widehat{v}^* = \widehat{\overline{v}}^*$. Unanticipated permanent shocks have no current-account effects in the model ($d\overline{B} = 0$). The reason is that, given the presence of intertemporal consumption smoothing and given the absence of nominal rigidities, the economy immediately jumps to the new steady state equilibrium (see Obstfeld and Rogoff, 1996, p. 244).[30] Thus, short-run changes are equal to long-run changes for each variable. A permanent increase in relative Foreign productivity ($\widehat{\overline{v}} - \widehat{\overline{v}}^* < 0$) causes a real depreciation of the Foreign currency ($\widehat{\overline{P}} - \widehat{\overline{P}}^* > 0$):

$$\widehat{\overline{P}} - \widehat{\overline{P}}^* = \widehat{P} - \widehat{P}^* = -(z^H - z^F)(\widehat{\overline{v}} - \widehat{\overline{v}}^*). \tag{6.28}$$

Intuitively, the change in the real exchange rate is equal to the change in the price of non-tradable goods, multiplied by the size of the non-tradables sector.[31] An economy-wide permanent increase in Foreign productivity leads to a decline in the relative price of Foreign non-tradable goods.[32] The real exchange rate response is higher if the size of the non-tradable sector ($z^H - z^F$) is larger.[33] Recall that the size of the non-tradable sector is increasing in trade costs [equation (6.20)]. Therefore, the smaller trade costs, the smaller (the absolute level of) the real exchange-rate movement in response to a productivity increase in Foreign.

Table 2 illustrates the size of the real exchange rate response to a permanent increase in Foreign productivity, holding Home productivity constant.

[30] By contrast, the presence of short-run nominal wage rigidities in chapters 4 and 5 implies that permanent shocks have non-trivial current account effects there.

[31] The relative price of tradable goods does not change, since trade costs are assumed to be constant here.

[32] In this model, an increase in Foreign productivity causes a real *depreciation* of the Foreign currency, as the productivity increase is assumed to be economy-wide. If the productivity increase would be concentrated in the tradables sector only, the real exchange rate response would be dominated by the nominal wage increase in Foreign, which would cause an *increase* in relative prices in the Foreign non-tradable goods sector and therefore a real *appreciation* of the Foreign currency, in line with the Balassa-Samuelson effect.

[33] Note that I consider small shocks. Therefore, even in the case of a permanent shock, the new steady state value of all variables are (approximately) equal to their value in the initial steady state.

Table 2 Real exchange rate and permanent productivity shock

trade costs	size of non-tradable goods sector	exchange rate response to productivity increase
τ	$z^H - z^F$	$d(\widehat{P} - \widehat{P}^*)/d\widehat{v}^*$
0	0.000	0.00
.1	0.105	0.11
.2	0.223	0.22
.3	0.357	0.36
.4	0.511	0.51
.5	0.693	0.69
.6	0.916	0.92

Temporary productivity shocks

When studying the response of the real exchange rate to temporary productivity shocks, set $\widehat{\overline{v}} = \widehat{\overline{v}}^* = 0$. Unanticipated temporary productivity shocks give rise to current-account changes. Hence, I need to distinguish between the short-run and long-run effect of a temporary productivity shock.

A temporary increase in relative Foreign productivity ($\widehat{v} - \widehat{v}^* < 0$) leads to a short-run current account surplus for Foreign, so that Foreign accumulates net foreign assets ($d\overline{B} < 0$). The interest rate receipts on the net foreign assets enable Foreign to run a long-run trade balance deficit, while satisfying the condition of a balanced long-run current account. The size of the short-run current-account effect is increasing in the size of the non-tradable goods sector ($z^H - z^F$) [see appendix C for the derivation]:

$$\frac{d\overline{B}}{(\overline{PC})_0} = \frac{(1 - z^H)(z^H - z^F)}{(1 + \overline{r})[1 - (z^H - z^F)^2]}(\widehat{v} - \widehat{v}^*).$$

The short-run exchange-rate effect is that a temporary increase in relative Foreign productivity causes a real depreciation of the Foreign currency:

$$\widehat{P} - \widehat{P}^* = -\frac{1}{(1 + \overline{r})}\left[\frac{1}{1 - (z^H - z^F)^2} + \overline{r}\right](z^H - z^F)(\widehat{v} - \widehat{v}^*). \tag{6.29}$$

Intuitively, the change in the real exchange rate is equal to the change in the price of non-tradable goods, corrected for the size of the non-tradable goods sector.[34] An economy-wide increase in Foreign productivity leads to a less than proportional increase in the Foreign wage rate, so that the relative price of Foreign non-tradable goods declines. As before, the real exchange rate response is higher if the size of the non-tradable sector $(z^H - z^F)$ is larger.

A temporary increase in Foreign relative productivity leads to a real long-run appreciation of the Foreign currency:

$$\widehat{\overline{P}} - \widehat{\overline{P}}^* = \frac{\overline{r}}{1+\overline{r}}\left[\frac{(z^H - z^F)^3}{1-(z^H - z^F)^2}\right](\widehat{v} - \widehat{v}^*). \tag{6.30}$$

Note that the long-run change in the relative price has the opposite sign of the short-run change. The intuition is that a positive productivity shock in Foreign leads to a short run surplus on the Foreign current account. The productivity shock is assumed to be temporary, so the only long-run effect is that Foreign can afford to produce less than it requires for consumption (due to its ownership of net foreign assets). The excess demand for goods in Foreign in the long run causes a real appreciation of the Foreign exchange rate. Again, the larger the size of the non-tradable sector $(z^H - z^F)$, the larger the long-run real exchange rate response to a productivity increase in Foreign.

Table 3 illustrates the size of the real exchange rate response to an increase in Foreign productivity, which is reversed in the next period. In Table 3, I have assumed $\overline{r} = .03$. The short-run response is much larger than the long-run response, as might be expected in case of a temporary shock.[35] Also, comparing Tables 2 and 3 shows that the short-run response of the real exchange rate to temporary productivity shocks is larger (and more sensitive to trade costs!) than its response to permanent shocks.[36]

To summarise this section: EU accession (and the ensuing decline in trade costs) implies that the real exchange rate between new and existing EU member states will become less responsive to productivity shocks. Intuitively, the decline in trade costs stimulates bilateral trade between the existing and new member states. Productivity shocks only affect the real exchange rate to the extent that they influence the relative price of non-traded goods. Therefore, the reduced share of non-traded goods in total

[34] The relative price of tradable goods does not change, since trade costs are assumed to be constant (see footnote 30).

[35] It can easily be shown from equations (6.29)-(6.30) that, in absolute terms, the short-run inflation differential is at least $1/\overline{r}$ times as large as the long-run inflation differential.

[36] Compare equations (6.28) and (6.29) and note that $1/[1-(z^H - z^F)^2] > 1$. The difference between the real exchange rate response to permanent and temporary shocks is caused by the current-account effect which occurs only in the case of temporary shocks.

output means that the real exchange rate becomes less sensitive to unanticipated productivity changes. The decline in trade costs reduces the short-run exchange rate response to temporary productivity shocks in particular. Thus, EU accession itself will contribute to reducing movements in the real exchange rate between the accession countries and the existing EU member states.

Table 3 Real exchange rate and temporary productivity shock

trade costs	size of N sector	short-run XR response to productivity increase	long-run XR response to productivity increase
τ	$z^H - z^F$	$d(\widehat{P} - \widehat{P}^*)/d\widehat{v}^*$	$d(\overline{\widehat{P}} - \overline{\widehat{P}}^*)/d\widehat{v}^*$
0	0.000	0.00	-0.00
.1	0.105	0.11	-0.00
.2	0.223	0.23	-0.00
.3	0.357	0.41	-0.00
.4	0.511	0.69	-0.01
.5	0.693	1.32	-0.02
.6	0.916	5.57	-0.14

'N' refers to non-tradable goods, 'XR' stands for exchange rate.

6.5 Conclusion

The eastward enlargement of the European Union is an important issue. The new member states are less productive and have a lower price level than the current EU member states. The accession process can be expected to involve economic changes which call for an adjustment of the relative price level. In other words, the real exchange rate between the candidate member states and the current EU member states may need to change. This paper has analysed how the behaviour of the real exchange rate may be affected by the timing of EU accession.

To address this issue, I have employed the Ricardian model developed by Dornbusch, Fischer and Samuelson (1977) and the dynamic version of this model, which is due to Obstfeld and Rogoff (1996, chapter 4). I have extended the model by allowing for asymmetries in country size and the initial level of productivity between regions and by allowing for changes in trade costs.

I have obtained the following results. First, the timing of EU accession affects the real exchange rate response to accession. The real exchange rate of the candidate member states is predicted to appreciate by 1-2% upon accession (based on a three percentage points decline in trade costs and not taking into account a reduction in the currency risk premium). The real exchange rate appreciation is smaller in the case of postponed accession. Intuitively, the more productivity levels (and wages) of the current and new member states have converged before accession, the more price levels have converged and therefore the smaller the marginal impact of reducing trade costs on relative prices.

Second, I find that the response of the real exchange rate to productivity shocks declines as a result of EU accession. Intuitively, the decline in trade costs stimulates bilateral trade between the existing and new member states. Productivity shocks only affect the real exchange rate to the extent that they influence the relative price of non-traded goods. Therefore, the reduced share of non-traded goods in total output means that the real exchange rate becomes less sensitive to unanticipated productivity changes. The decline in trade costs reduces the short-run exchange rate response to temporary productivity shocks in particular. Thus, EU accession itself will contribute to stabilising the real exchange rate between the accession countries and the existing EU member states.

The above suggests that, in terms of real exchange rate stability, there is a tradeoff between the size of the change in the real exchange rate at the moment of accession (which argues for postponement) and the size of the real exchange rate response to productivity shocks (which argues for quick accession). The model in this paper is not suitable to analyse this tradeoff more in-depth. The one-off nature of EU accession and the recurrent nature of productivity shocks indicate that the latter argument - i.e. the sensitivity to productivity shocks - should carry more weight. Therefore, on balance, real exchange rate stability seems to be an argument in favour of early accession of the candidate member states to the European Union.

Appendices

A The steady state

A.1 Determinacy

In a steady state, all exogenous variables are constant. Imposing this constraint on the equations derived earlier yields the following steady state equations. From equations (6.11)-(6.12):

$$\begin{aligned} n\overline{WL} &= \overline{z}^H n\overline{PC} + \overline{z}^F(1-n)\overline{P}^*\overline{C}^*, \\ (1-n)\overline{W}^*\overline{L}^* &= (1-\overline{z}^H)n\overline{PC} + (1-\overline{z}^F)(1-n)\overline{P}^*\overline{C}^*. \end{aligned}$$

From equations (6.9)-(6.10):

$$\begin{aligned} \frac{\overline{W}}{\overline{W}^*} &= \frac{\overline{v}\overline{\alpha}(\overline{z}^H)}{(1-\overline{\tau})\overline{v}^*\overline{\alpha}^*(\overline{z}^H)}, \\ \frac{\overline{W}}{\overline{W}^*} &= \frac{(1-\overline{\tau})\overline{v}\overline{\alpha}(\overline{z}^F)}{\overline{v}^*\overline{\alpha}^*(\overline{z}^F)}. \end{aligned}$$

From equations (6.13)-(6.14):

$$\begin{aligned} \log \overline{P} &= \overline{z}^H \log\frac{\overline{W}}{\overline{v}} + (1-\overline{z}^H)\log\frac{\overline{W}^*}{\overline{v}^*(1-\overline{\tau})} + \\ &\quad - \int_0^{z^H} \log\overline{\alpha}(z)dz - \int_{z^H}^1 \log\overline{\alpha}^*(z)dz, \\ \log P^* &= \overline{z}^F \log\frac{\overline{W}}{\overline{v}(1-\overline{\tau})} + (1-\overline{z}^F)\log\frac{\overline{W}^*}{\overline{v}^*} + \\ &\quad - \int_0^{z^F} \log\overline{\alpha}(z)dz - \int_{z^F}^1 \log\overline{\alpha}^*(z)dz. \end{aligned}$$

From equation (6.5) and its Foreign counterpart:

$$\begin{aligned} \overline{PC} &= \overline{r}\overline{B} + \overline{WL}, \\ \overline{P}^*\overline{C}^* &= \overline{r}^*\overline{B}^* + \overline{W}^*\overline{L}^*. \end{aligned}$$

In steady state, the current account must be balanced, but this is not necessarily the case for the trade account. The Home country can run a trade deficit in steady state ($\overline{PC} > \overline{WL}$), but only if it owns interest-bearing net foreign assets ($\overline{B} > 0$).

World net foreign assets (NFA) must be zero:

$$n\overline{B} + (1-n)\overline{B}^* = 0.$$

It follows directly from equation (6.6) that real interest rate equality will hold across countries in the steady state. The steady state world interest rate $\overline{r}$ is

$$\overline{r} = \overline{r}^* = \frac{1-\beta}{\beta}.$$

It is easy to see that one of the above eleven equations is redundant: the global equilibrium of income and spending ($n\overline{W}\overline{L} + (1-n)\overline{W}^*\overline{L}^* = n\overline{P}\overline{C} + (1-n)\overline{P}^*\overline{C}^*$) follows both from the first two equations and from the final four equations. Therefore, we have ten independent equations.

Labour supply ($\overline{L}$, $\overline{L}^*$) and productivity [$\overline{v}\overline{\alpha}(z)$, $\overline{v}^*\overline{\alpha}^*(z)$] are exogenous. In the absence of money in the model, I choose good 1 delivered in Foreign as the numeraire [$p^*(1) = 1$]. This implies that the Foreign nominal wage is $W^* = v^*\alpha^*(1)$. Therefore, we have eleven endogenous variables ($\overline{z}^H$, $\overline{z}^F$, $\overline{C}$, $\overline{C}^*$, $\overline{P}$, $\overline{P}^*$, $\overline{W}$, $\overline{B}$, $\overline{B}^*$, $\overline{r}$, $\overline{r}^*$).

The model is closed by imposing the condition of zero net foreign assets:

$$\overline{B} = 0.$$

A.2 The expression for the real exchange rate

From the previous section of this appendix:

$$\begin{aligned}\log\frac{\overline{P}}{\overline{P}^*} &= (\overline{z}^H - \overline{z}^F)[\log\frac{\overline{W}}{\overline{W}^*} - \log\frac{\overline{v}}{\overline{v}^*}] + \\ &+[z^F - (1-z^H)]\log(1-\tau) - \int_{z^F}^{z^H}\log\frac{\overline{\alpha}(z)}{\overline{\alpha}^*(z)}dz.\end{aligned}$$

Impose that $\alpha(z) = \exp(-z)$ and $\alpha^*(z) = \exp(z-1)$, as in the main text. Then we may rewrite:

$$\begin{aligned}\int_{z^F}^{z^H}\log\frac{\overline{\alpha}(z)}{\overline{\alpha}^*(z)}dz &= \int_{z^F}^{z^H}(1-2z)dz = (z-z^2)|_{z^F}^{z^H} = \\ &= z^H(1-z^H) - z^F(1-z^F) = \\ &= z^H(1-z^H) - z^F(1-z^H) - z^F(z^H - z^F) =\end{aligned}$$

$$\begin{aligned}&= (z^H - z^F)(1-z^H) - z^F(z^H - z^F) = \\ &= (z^H - z^F)(1 - z^H - z^F) = \\ &= -[\log(1-\tau)](1 - z^H - z^F).\end{aligned}$$

Therefore, the expression for the real exchange rate simplifies to:

$$\log \frac{\overline{P}}{\overline{P}^*} = (\overline{z}^H - \overline{z}^F)[\log \frac{\overline{W}}{\overline{W}^*} - \log \frac{\overline{v}}{\overline{v}^*}].$$

B Calibration of the model

The purpose of this appendix is to derive 'reasonable' estimates for the values of τ and v/v^*, using the model consisting of equations (6.18)-(6.22). The parameter values thus found help to fill in the scenarios in the main text, where τ and v/v^* are assumed to be exogenous.

Let Home be the European Union and let Foreign represent the accession countries.[37] The model will be calibrated for the twelve countries currently engaged in accession negotiations. The joint population size of these countries is 30% of the EU countries and average income per capita in these countries is 17% of the EU level. Therefore, start from $(1-n)/n = 0.3$ and $W/W^* = 6.0$ (which is equivalent to $W^*/W = 0.17$).[38]

Exports to the EU makes up 29% of accession countries' gross domestic product ($z^F = .29$), whereas exports to the accession countries is 1.4% of EU gross domestic product ($1 - z^H \approx .014$).[39] Thus, equation (6.18) is

$$\frac{z^F}{1-z^H}\frac{n}{1-n} = \frac{0.29}{0.014} * 0.3 \approx 6.0 = \frac{W}{W^*},$$

which indicates that, given the simplicity of the model, it fits the data quite well.

[37]In the model, the world consists of the EU and the accession countries only. This choice is motivated by the fact that EU accession leads to a decline in bilateral trade costs between the EU and the accession countries, but has no effect on trade costs between any of these two blocs and the rest of the world. EU accession may have an impact on third countries via trade diversion, but such third-country effects are beyond the scope of this paper.

[38]GDP data have been converted to euro using actual exchange rates, as W and W^* reflect (labour) income expressed in units of the numeraire good. Data source: Eurostat (2001). Population data are for 2000. Wage ratios are based on GDP per capita for 2000.

[39]The EU imports all goods on the range $[z^H, 1]$, so that imports as a share of income must be $1 - z^H$. Similarly, the accession countries import all goods on the range $[0, z^F]$, so that imports as a share of income must be z^F. In order to see that the bilateral trade account is balanced, note that EU income (nW) is twenty times larger than accession country income $[(1-n)W^*]$. Therefore, a share 20/21 of all tradable goods produced by Home is consumed domestically, whereas a share 1/21 is exported. Similarly, a share 1/21 of all tradable goods produced by Foreign is consumed domestically, whereas a share 20/21 is exported. Thus, the fact that $z^F = 20(1 - z^H)$ shows that the bilateral trade balance between the EU and the accession countries is indeed in equilibrium.

Use equation (6.19) to derive v/v^*:

$$\log \frac{v}{v^*} = \log \frac{W}{W^*} - (1 - z^H - z^F) = 2.1 \Rightarrow \frac{v}{v^*} = 8.0.$$

Use equation (6.20) to derive τ:

$$-\log(1 - \tau) = z^H - z^F = 0.696 \Rightarrow \tau = 0.50.$$

Thus, the model suggests that the current level of trade costs between the EU and the group of accession countries is about 50% ($\tau = 0.5$) and that the EU is eight times more productive ($v^*/v = 0.13$). The estimate for trade costs is somewhat higher than what is found by others in the literature, who typically assume that trade costs will be zero when the accession process is completed.[40] The values $\tau = 0.5$ and $v^*/v = 0.13$ will serve as the starting level for trade costs and relative productivity in the 'immediate accession' scenario in the main text.

Similarly, from equations (6.21) and (6.22), $\frac{\overline{P}}{\overline{P}^*} = 0.82$ and $\frac{\overline{C}}{\overline{C}^*} = 7.3$. The model predicts that the price level in poor countries will be higher than in rich countries, because productivity differences are only partly reflected in wage differences. In reality, the price level tends to be lower in poor countries. A generally accepted explanation for this stylised fact is the Balassa-Samuelson view that countries differ in productivity in the tradable goods sector, whereas productivity differences in the non-tradable goods sector are negligible. The DFS model used in this paper cannot make this distinction. Therefore, the model cannot be used to study the impact of *sector-specific* productivity shocks. However, the fact that international specialisation is endogenous in this model makes it quite useful in studying the impact of a decline in trade costs. Moreover, it is possible to study the impact of *economy-wide* productivity shocks using the DFS model.

I have also calibrated the model using the data for the richest of the candidate member states (Cyprus and Slovenia), using the same procedure. The average income per head in these two countries is 47% of the average income per head in the EU, or roughly the same as the poorest current EU member states (Greece and Portugal). This corresponds to $W/W^* = 2.1$. The joint country size of Cyprus and Slovenia is quite small: only 0.7% of the EU's population: $(1-n)/n = 0.007$. In this case, the model suggests the same value

[40] Lejour, De Mooij and Nahuis (2001) report formal tariffs between 9% (EU import tariffs on agricultural products from the accession countries) and 63% (Polish import tariffs on processed food from the EU). They estimate that non-tariff barriers vary between 0% and 18% (the latter for agricultural products). They implicitly assume that trade costs are negligible when the integration of the accession countries is completed. I do not make this assumption, which might explain that I find a higher estimate for trade costs. Also, I consider a wider range of countries than they do: they look at the five most advanced candidate member states, for which non-tariff barriers are likely to be lower.

for the initial level of trade costs as before ($\tau = 0.5$), whereas productivity in the EU is almost three times as high as in Cyprus and Slovenia ($v^*/v = 0.34$). $v^*/v = 0.34$ will serve as the starting level for relative productivity in the 'postponed accession' scenario in the main text.

C The loglinearised model

This appendix derives the loglinearised model, checks whether the system of equations has a unique solution and then solves the model.

C.1 Derivation

Assume labour effort per individual is constant, so that $\widehat{L} = \widehat{L}^* = 0$. From equation (6.13) in the main text, take total differentials:

$$\begin{aligned}
\widehat{P} &= \frac{dP}{\overline{P}_0} = \left\{\log[\frac{\overline{W}}{\overline{\alpha}(z^H)\overline{v}}] - \log[\frac{\overline{W}^*}{(1-\overline{\tau})\overline{\alpha}^*(z^H)\overline{v}^*}]\right\} dz^H + \\
&+ \int_0^{z^H} [\frac{dW}{\overline{W}} - \frac{d\alpha(z)}{\overline{\alpha}(z)} - \frac{dv}{\overline{v}}]dz + \\
&+ \int_{z^H}^1 [\frac{dW^*}{\overline{W}^*} - \frac{d\alpha^*(z)}{\overline{\alpha}^*(z)} - \frac{dv^*}{\overline{v}^*} + \frac{d\tau}{1-\overline{\tau}}]dz \\
&= \left\{\log[\frac{\overline{W}(1-\overline{\tau})\overline{\alpha}^*(z^H)\overline{v}^*}{\overline{W}^*\overline{\alpha}(z^H)\overline{v}}]\right\} dz^H + \\
&+ \int_0^{z^H} [\widehat{W} - \widehat{v}]dz + \int_{z^H}^1 [\widehat{W}^* - \widehat{v}^* + \frac{d\tau}{1-\overline{\tau}}]dz \\
&= \{\log 1\}dz^H + z^H(\widehat{W} - \widehat{v}) + (1-z^H)(\widehat{W}^* - \widehat{v}^* + \frac{d\tau}{1-\tau}) = \\
&= z^H(\widehat{W} - \widehat{v}) + (1-z^H)(\widehat{W}^* - \widehat{v}^* + \frac{d\tau}{1-\tau}),
\end{aligned}$$

where I have used equation (6.9) and the fact that I consider economy-wide productivity changes only (captured by $\widehat{v}$), so that sector-specific productivity changes are zero (i.e. $d\alpha(z) = d\alpha^*(z) = 0$).

Similarly, taking total differentials from the Foreign country equivalent (6.14) yields:

$$\widehat{P}^* = z^F(\widehat{W} - \widehat{v} + \frac{d\tau}{1-\tau}) + (1-z^F)(\widehat{W}^* - \widehat{v}^*).$$

From equation (6.11), take total differentials, use equations (6.5), (6.15), (6.18) and rearrange:

$$\widehat{W} = z^H(\widehat{P} + \widehat{C}) + (1 - z^H)(\widehat{P}^* + \widehat{C}^*).$$

Similarly

$$\widehat{W}^* = z^F(\widehat{P} + \widehat{C}) + (1 - z^F)(\widehat{P}^* + \widehat{C}^*).$$

From the steady-state version of the budget constraint (6.5), take total differentials and use equations (6.5) and (6.15):

$$\widehat{C} = \frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{W} - \widehat{P}.$$

Similarly, for the Foreign country, using the fact that $nB + (1-n)B^* = 0$ and $(1 - z^H)n\overline{P}_0\overline{C}_0 = z^F(1-n)\overline{P}_0^*\overline{C}_0^*$:

$$\widehat{C}^* = -(\frac{z^F}{1 - z^H})\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{W}^* - \widehat{P}^*.$$

From the short-run version of the budget constraint (6.5), use that $\overline{B}_0 = 0$ and take total differentials. This yields:

$$\frac{d\overline{B}}{(\overline{PC})_0} = \widehat{W} - \widehat{P} - \widehat{C}.$$

Similarly, for the Foreign country, using $nB + (1-n)B^* = 0$ and $(1 - z^H)n\overline{P}_0\overline{C}_0 = z^F(1-n)\overline{P}_0^*\overline{C}_0^*$:

$$-(\frac{z^F}{1 - z^H})\frac{d\overline{B}}{(\overline{PC})_0} = \frac{d\overline{B}^*}{(\overline{P}^*\overline{C}^*)_0} = \widehat{W}^* - \widehat{P}^* - \widehat{C}^*.$$

From equation (6.6) and its Foreign counterpart:

$$\begin{aligned} \widehat{\overline{C}} - \widehat{C} &= (1-\beta)\widehat{r}, \\ \widehat{\overline{C}}^* - \widehat{C}^* &= (1-\beta)\widehat{r}. \end{aligned}$$

From equations (6.9)-(6.10), using equations (6.16)-(6.17) and taking total differentials yields:

$$\begin{aligned} \widehat{W} - \widehat{W}^* &= -\frac{d\tau}{1-\tau} + (\widehat{v} - \widehat{v}^*) - 2dz^F, \\ \widehat{W} - \widehat{W}^* &= \frac{d\tau}{1-\tau} + (\widehat{v} - \widehat{v}^*) - 2dz^H, \end{aligned}$$

which can be rewritten as:

$$\begin{aligned} dz^H &= dz^F + \frac{d\tau}{1-\tau}, \\ dz^H + dz^F &= (\widehat{v} - \widehat{v}^*) - (\widehat{W} - \widehat{W}^*). \end{aligned}$$

C.2 Determinacy

From the previous section in this appendix, I obtain the following long run equations:

$$
\begin{aligned}
\widehat{\overline{P}} &= z^H(\widehat{\overline{W}} - \widehat{\overline{v}}) + (1 - z^H)(\widehat{\overline{W}}^* - \widehat{\overline{v}}^* + \frac{d\overline{\tau}}{1-\tau}),\\
\widehat{\overline{P}}^* &= z^F(\widehat{\overline{W}} - \widehat{\overline{v}} + \frac{d\overline{\tau}}{1-\tau}) + (1 - z^F)(\widehat{\overline{W}}^* - \widehat{\overline{v}}^*),\\
\widehat{\overline{W}} &= z^H(\widehat{\overline{P}} + \widehat{\overline{C}}) + (1 - z^H)(\widehat{\overline{P}}^* + \widehat{\overline{C}}^*),\\
\widehat{\overline{W}}^* &= z^F(\widehat{\overline{P}} + \widehat{\overline{C}}) + (1 - z^F)(\widehat{\overline{P}}^* + \widehat{\overline{C}}^*),\\
\widehat{\overline{C}} &= \frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{\overline{W}} - \widehat{\overline{P}},\\
\widehat{\overline{C}}^* &= -(\frac{z^F}{1-z^H})\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{\overline{W}}^* - \widehat{\overline{P}}^*,\\
d\overline{z}^H &= d\overline{z}^F + \frac{d\overline{\tau}}{1-\tau},\\
d\overline{z}^H + d\overline{z}^F &= (\widehat{\overline{v}} - \widehat{\overline{v}}^*) - (\widehat{\overline{W}} - \widehat{\overline{W}}^*).
\end{aligned}
$$

It is easy to see that one of the above eight equations is redundant: the global equilibrium of income and spending $[z^F\widehat{\overline{W}} + (1-z^H)\widehat{\overline{W}}^* = z^F(\widehat{\overline{P}} + \widehat{\overline{C}}) + (1-z^H)(\widehat{\overline{P}}^* + \widehat{\overline{C}}^*)]$ follows both from market equilibrium for goods (the third and fourth equation) and from the individual budget constraints (the fifth and sixth equation). The variable $d\overline{B}$ is predetermined and $\widehat{\overline{v}}, \widehat{\overline{v}}^*, d\overline{\tau}$ are exogenous shocks. Thus, we have seven independent equations and eight endogenous variables ($d\overline{z}^H$, $d\overline{z}^F$, $\widehat{\overline{C}}$, $\widehat{\overline{C}}^*$, $\widehat{\overline{P}}$, $\widehat{\overline{P}}^*$, $\widehat{\overline{W}}$, $\widehat{\overline{W}}^*$). Therefore, the system is underdetermined.

The short run equations are:

$$
\begin{aligned}
\widehat{P} &= z^H(\widehat{W} - \widehat{v}) + (1 - z^H)(\widehat{W}^* - \widehat{v}^* + \frac{d\tau}{1-\tau}),\\
\widehat{P}^* &= z^F(\widehat{W} - \widehat{v} + \frac{d\tau}{1-\tau}) + (1 - z^F)(\widehat{W}^* - \widehat{v}^*),\\
\widehat{W} &= z^H(\widehat{P} + \widehat{C}) + (1 - z^H)(\widehat{P}^* + \widehat{C}^*),\\
\widehat{W}^* &= z^F(\widehat{P} + \widehat{C}) + (1 - z^F)(\widehat{P}^* + \widehat{C}^*),\\
\frac{d\overline{B}}{(\overline{PC})_0} &= \widehat{W} - \widehat{P} - \widehat{C},\\
-(\frac{z^F}{1-z^H})\frac{d\overline{B}}{(\overline{PC})_0} &= \widehat{W}^* - \widehat{P}^* - \widehat{C}^*,
\end{aligned}
$$

$$
\begin{aligned}
\widehat{\overline{C}} - \widehat{C} &= (1-\beta)\widehat{r}, \\
\widehat{\overline{C}}^* - \widehat{C}^* &= (1-\beta)\widehat{r}, \\
dz^H &= dz^F + \frac{d\tau}{1-\tau}, \\
dz^H + dz^F &= (\widehat{v} - \widehat{v}^*) - (\widehat{W} - \widehat{W}^*).
\end{aligned}
$$

One of the above ten equations is redundant, because the global equilibrium of income and spending $[z^F\widehat{W} + (1-z^H)\widehat{W}^* = z^F(\widehat{P}+\widehat{C}) + (1-z^H)(\widehat{P}^* + \widehat{C}^*)]$ follows both from market equilibrium for goods and from the individual budget constraints. Thus, we have nine independent equations and ten endogenous variables (dz^H, dz^F, $\widehat{C}$, $\widehat{C}^*$, $\widehat{P}$, $\widehat{P}^*$, $\widehat{W}$, $\widehat{W}^*$, $\widehat{r}$, $d\overline{B}$).[41] Therefore, the system is underdetermined.

The existence of multiple solutions could be solved by appropriate normalisation. One possibility would be to set $\widehat{\overline{P}} = \widehat{P} = 0$. If the Home country is the euro area, this normalisation amounts to assuming that the ECB is successful in maintaining price stability. This simplification is not necessary here, because in section 6.4 of this paper (which discusses the loglinearised model), I am interested in the Home-Foreign inflation differential, rather than the absolute inflation level in individual countries. The loglinearised model can be written in terms of country differences. This also helps to simplify the model substantially, while maintaining its intuitive results.

Writing the model in terms of country differences, there are five long-run equations. A superscript d denotes country differences, i.e. $\widehat{\overline{P}}^d = \widehat{\overline{P}} - \widehat{\overline{P}}^*$):

$$
\begin{aligned}
\widehat{\overline{P}}^d &= (z^H - z^F)(\widehat{\overline{W}}^d - \widehat{\overline{v}}^d) + (1 - z^H - z^F)\frac{d\overline{\tau}}{1-\tau}, \\
\widehat{\overline{W}}^d &= (z^H - z^F)(\widehat{\overline{P}}^d + \widehat{\overline{C}}^d), \\
\widehat{\overline{C}}^d &= \frac{1 - z^H + z^F}{1 - z^H}\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{\overline{W}}^d - \widehat{\overline{P}}^d, \\
d\overline{z}^H &= d\overline{z}^F + \frac{d\overline{\tau}}{1-\tau}, \\
d\overline{z}^H + d\overline{z}^F &= -\widehat{\overline{W}}^d + \widehat{\overline{v}}^d,
\end{aligned}
$$

and six short-run equations (more accurately: five short-run equations and one equation connecting the long and short run):

[41]The variables $\widehat{\overline{C}}$ and $\widehat{\overline{C}}^*$ are determined by the subsystem of long-run equations.

$$
\begin{aligned}
\widehat{P}^d &= (z^H - z^F)(\widehat{W}^d - \widehat{v}^d) + (1 - z^H - z^F)\frac{d\tau}{1-\tau}, \\
\widehat{W}^d &= (z^H - z^F)(\widehat{P}^d + \widehat{C}^d), \\
\frac{1 - z^H + z^F}{1 - z^H}\frac{dB}{(\overline{PC})_0} &= \widehat{W}^d - \widehat{P}^d - \widehat{C}^d, \\
dz^H &= dz^F + \frac{d\tau}{1-\tau}, \\
dz^H + dz^F &= -\widehat{W}^d + \widehat{v}^d, \\
\widehat{C}^d &= \widehat{\overline{C}}^d.
\end{aligned}
$$

In this case, we have a system of eleven independent equations in eleven endogenous variables: $\widehat{\overline{P}}^d$, $\widehat{\overline{C}}^d$, $\widehat{\overline{W}}^d$, $d\overline{z}^H$, $d\overline{z}^F$, $\widehat{P}^d$, $\widehat{C}^d$, $\widehat{W}^d$, dz^H, dz^F, $d\overline{B}$. The solution of this system is uniquely determined.

C.3 Semi-reduced form solution

Solving the subsystem of long-run equations yields:

$$
\begin{aligned}
\widehat{\overline{W}}^d &= \frac{z^H - z^F}{1 - z^H}\frac{\overline{r}d\overline{B}}{(\overline{PC})_0}, \\
d\overline{z}^H &= \frac{1}{2}[-(\frac{z^H - z^F}{1 - z^H})\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{\overline{v}}^d + \frac{d\overline{\tau}}{1-\tau}], \\
d\overline{z}^F &= \frac{1}{2}[-(\frac{z^H - z^F}{1 - z^H})\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + \widehat{\overline{v}}^d - \frac{d\overline{\tau}}{1-\tau}], \\
\widehat{\overline{C}}^d &= \frac{1 - (z^H - z^F)^2}{1 - z^H}\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + (z^H - z^F)\widehat{\overline{v}}^d + (z^H + z^F - 1)\frac{d\overline{\tau}}{1-\tau}, \\
\widehat{\overline{P}}^d &= \frac{(z^H - z^F)^2}{1 - z^H}\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} - (z^H - z^F)\widehat{\overline{v}}^d - (z^H + z^F - 1)\frac{d\overline{\tau}}{1-\tau}],
\end{aligned}
$$

where $\widehat{\overline{v}}^d$ and $d\overline{\tau}$ are exogenous shocks and $d\overline{B}$ is pre-determined.

Solving the subsystem of short-run equations yields:

$$
\widehat{W}^d = \frac{z^H - z^F}{1 - (z^H - z^F)^2}\{\widehat{\overline{C}}^d - (z^H - z^F)\widehat{v}^d - (z^H + z^F - 1)\frac{d\tau}{1-\tau}\},
$$

$$
\begin{aligned}
dz^H &= \frac{1}{2[1-(z^H-z^F)^2]}\{-(z^H-z^F)\widehat{\overline{C}}^d + \widehat{v}^d + \\
&\quad +[1+(z^H-z^F)(2z^F-1)]\frac{d\tau}{1-\tau}\}, \\
dz^F &= \frac{1}{2[1-(z^H-z^F)^2]}\{-(z^H-z^F)\widehat{\overline{C}}^d + \widehat{v}^d + \\
&\quad -[1+(z^H-z^F)(2z^H-1)]\frac{d\tau}{1-\tau}\}, \\
\widehat{C}^d &= \frac{1-(z^H-z^F)^2}{1-z^H}\frac{\overline{r}d\overline{B}}{(\overline{PC})_0} + (z^H-z^F)\widehat{\overline{v}}^d + (z^H+z^F-1)\frac{d\overline{\tau}}{1-\tau}, \\
\widehat{P}^d &= \frac{1}{1-(z^H-z^F)^2}\{(z^H-z^F)^2\widehat{\overline{C}}^d - (z^H-z^F)\widehat{v}^d + \\
&\quad -(z^H+z^F-1)\frac{d\tau}{1-\tau}\}, \\
\frac{d\overline{B}}{(\overline{PC})_0} &= \frac{1-z^H}{1-(z^H-z^F)^2}\{-\widehat{\overline{C}}^d + (z^H-z^F)\widehat{v}^d + (z^H+z^F-1)\frac{d\tau}{1-\tau}\},
\end{aligned}
$$

where $\widehat{v}^d$ and $d\tau$ are exogenous shocks and $\widehat{\overline{C}}^d$ is determined in the long run.

C.4 Reduced-form solution for permanent shocks

Set $\widehat{v}^d = \widehat{\overline{v}}^d$ and $d\tau = d\overline{\tau}$. Then solving the model yields:

$$
\begin{aligned}
\widehat{\overline{W}}^d &= \widehat{W}^d = 0, \\
\frac{d\overline{B}}{(\overline{PC})_0} &= 0, \\
d\overline{z}^H &= dz^H = \frac{1}{2}\widehat{\overline{v}}^d + \frac{1}{2}\frac{d\overline{\tau}}{1-\tau}, \\
d\overline{z}^F &= dz^F = \frac{1}{2}\widehat{\overline{v}}^d - \frac{1}{2}\frac{d\overline{\tau}}{1-\tau}, \\
\widehat{\overline{C}}^d &= \widehat{C}^d = (z^H-z^F)\widehat{\overline{v}}^d + (z^H+z^F-1)\frac{d\overline{\tau}}{1-\tau}, \\
\widehat{\overline{P}}^d &= \widehat{P}^d = -(z^H-z^F)\widehat{\overline{v}}^d - (z^H+z^F-1)\frac{d\overline{\tau}}{1-\tau}.
\end{aligned}
$$

Permanent shocks have no impact on the current account, so that short-run changes are equal to long-run changes for each variable.

C.5 Reduced-form solution for temporary shocks

Set $\widehat{\overline{v}}^d = 0$ and $d\overline{\tau} = 0$. Then solving the model yields the following steady state changes:

$$
\begin{aligned}
\widehat{\overline{W}}^d &= \frac{\overline{r}}{1+\overline{r}}\left[\frac{z^H - z^F}{1-(z^H - z^F)^2}\right]\left\{(z^H - z^F)\widehat{v}^d + (z^H + z^F - 1)\frac{d\tau}{1-\tau}\right\}, \\
d\overline{z}^H &= d\overline{z}^F = -\frac{\overline{r}}{2(1+\overline{r})}\left[\frac{z^H - z^F}{1-(z^H - z^F)^2}\right]\{(z^H - z^F)\widehat{v}^d + \\
&\quad +(z^H + z^F - 1)\frac{d\tau}{1-\tau}\}, \\
\widehat{\overline{C}}^d &= \widehat{C}^d = \frac{\overline{r}}{1+\overline{r}}\left\{(z^H - z^F)\widehat{v}^d + (z^H + z^F - 1)\frac{d\tau}{1-\tau}\right\}, \\
\widehat{\overline{P}}^d &= \frac{\overline{r}}{1+\overline{r}}\left[\frac{(z^H - z^F)^2}{1-(z^H - z^F)^2}\right]\left\{(z^H - z^F)\widehat{v}^d + (z^H + z^F - 1)\frac{d\tau}{1-\tau}\right\},
\end{aligned}
$$

and the following short-run changes

$$
\begin{aligned}
\widehat{W}^d &= -\left(\frac{1}{1+\overline{r}}\right)\frac{z^H - z^F}{1-(z^H - z^F)^2}\left\{(z^H - z^F)\widehat{v}^d + (z^H + z^F - 1)\frac{d\tau}{1-\tau}\right\}, \\
dz^H &= \frac{1}{2(1+\overline{r})}\left[\frac{1}{1-(z^H - z^F)^2} + \overline{r}\right]\widehat{v}^d + \\
&\quad + \frac{1}{2(1+\overline{r})}\left[\frac{1+(z^H - z^F)(2z^F - 1)}{1-(z^H - z^F)^2} + \overline{r}\right]\frac{d\tau}{1-\tau}, \\
dz^F &= \frac{1}{2(1+\overline{r})}\left[\frac{1}{1-(z^H - z^F)^2} + \overline{r}\right]\widehat{v}^d + \\
&\quad - \frac{1}{2(1+\overline{r})}\left[\frac{1-(z^H - z^F)(2z^H - 1)}{1-(z^H - z^F)^2} + \overline{r}\right]\frac{d\tau}{1-\tau}, \\
\widehat{P}^d &= -\frac{1}{(1+\overline{r})}\left[\frac{1}{1-(z^H - z^F)^2} + \overline{r}\right](z^H - z^F)\widehat{v}^d + \\
&\quad - \frac{1}{(1+\overline{r})}\left[\frac{1}{1-(z^H - z^F)^2} + \overline{r}\right](z^H + z^F - 1)\frac{d\tau}{1-\tau}, \\
\frac{d\overline{B}}{(\overline{PC})_0} &= \frac{1 - z^H}{(1+\overline{r})[1-(z^H - z^F)^2]}\{(z^H - z^F)\widehat{v}^d + (z^H + z^F - 1)\frac{d\tau}{1-\tau}\}.
\end{aligned}
$$

The short-run output effect is

$$
\widehat{W}^d - \widehat{P}^d = \left[1 + \frac{1}{\overline{r}}\left(\frac{1}{1+z^H - z^F}\right)\right]\widehat{C}^d,
$$

whereas the long-run output effect is

$$
\widehat{\overline{W}}^d - \widehat{\overline{P}}^d = \frac{z^H - z^F}{1+z^H - z^F}\widehat{\overline{C}}^d.
$$

Thus (recall that intertemporal consumption smoothing implies $\widehat{\overline{C}}^d = \widehat{C}^d$), the short-run output effect is larger than the long-run output effect, as one would expect in case of a temporary shock:

$$|\widehat{W}^d - \widehat{P}^d| > |\widehat{C}^d| = |\widehat{\overline{C}}^d| > |\widehat{\overline{W}}^d - \widehat{\overline{P}}^d|.$$