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Lessons from a Flexible-Price-Model

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Abstract

This paper quantifies the size of the often discussed "internal devaluation" in the Euro-area based on a variant of the Obstfeld/Rogoff (2005) model. In contrast to most of the existing literature, this approach includes the effects of global current account adjustment and structural changes in the sense of Engler (2009). The results of the real effective exchange rate depreciation of the Eurozone-periphery are relatively constant across different simulated scenarios of global current account adjustment while the size of the internal devaluation and therefore the length of the adjustment period varies significantly. The results point to the important role which is played by Asia in the process of rebalancing the Euro-area periphery.

Introduction

The period preceding the ongoing economic crisis was characterized by the evolution of large current account imbalances among the important blocks in world economy. Low private and public savings in the US, a "savings glut" in the rest of the world (Bernanke (2005)), the "export-led-growth" strategy in Asia and the attractiveness of US financial assets provided the base for a constant inflow of capital into the US and the resulting current account deficit of up to 800 billion US - Dollar in 2006 (for details see e.g. Oberpriller (2009), p.22 - 33). As Figure 1 in Appendix A illustrates, global imbalances nearly tripled from 2% of world GDP in the beginning of the 90s to 6% in their peak in 2006.

The potential threats arising from large global imbalances and the necessity to reduce them were widely recognized after the start of the economic crisis (see Blanchard/Milesi-Ferretti (2011) for a discussion). The G-20 launched an incentive to reduce global imbalances which is part of the "Mutual Assessment Process" (MAP), a "roadmap" designed to promote a sustained recovery from the current economic crisis (for details see e.g. Faruqee/Srinivasan (2012)). The MAP recognizes that global current account adjustment majorly requires a rebalancing in relative demand between deficit and surplus regions, as pointed out by Obstfeld and Rogoff in several publication (see Obstfeld/Rogoff (2000/2005/2007)). Deficit countries need to reduce domestic demand while surplus countries need a proportionate increase in order to keep aggregate demand constant at the global level. In a perfectly integrated world this would wipe out global imbalances and leave total demand for the goods of each region unchanged. Once considering trade costs and other trade frictions, global rebalancing needs to be accompanied by appropriate exchange rate movements as the shift in relative demand causes a disproportionate high increase in the demand for the goods of surplus regions while deficit regions suffer from a shortfall in demand which affects output and employment.

Global imbalances are mainly driven by the giant US - deficit and its counterparts in Asia and the oil - exporting countries (compare Oberpriller (2009), p. 4), while Europe and the Euro-area as a whole had a nearly balanced current account over the last decade (see figure 2). This global point of view hides the emergence of substantial current account imbalances within the Eurozone which basically follow a north - south divide, where Greece, Italy, Portugal and Spain (GIPS/periphery-countries) play the deficit part (compare figure 2/3). Chen *et.al* (2012) argue that the increasing competition from cheap Chinese goods, fast rising wages in the periphery, a nominal appreciation of the Euro and the ongoing financial integration following the establishment of the monetary union caused a massive deterioration of current account-to-GDP ratios in Greece, Italy, Portugal and Spain after the introduction of the common currency. The large deficits lead to a severe increase in external liabilities in this region. According to the IMF International Investment Position Database, Portugal

(-108%), Greece (-92.5%) and Spain (-87.1%) had a negative net international investment position (NIIP) of close to 100% of their GDPs in 2010. Only the Italian NIIP (-24.3%) was significantly lower. Figure 3 shows some (questionable) progress in the reduction of current account deficits, as they contracted sharply after 2007 leading to roughly balanced values in 2013 estimates. As discussed in Lane/Milesi-Ferretti (2011), most of the current account adjustment was achieved by a compression of domestic demand induced by lower incomes while the additionally required expenditure switching resulting from a real effective depreciation hardly occurred so far (see figure 4). The preceding lack of demand in the periphery countries dampens economic growth and employment.

Reducing the intra-EMU-imbalances and bringing NIIPs back to a sustainable path is an often discussed issue in current economic debate. A recent EEAG report argues that the stabilization of the Eurozone requires current account adjustment via a real depreciation to substitute the shortfall in domestic demand from which the periphery suffers by an "import" of foreign demand (compare EEAG (2013)). Darvas (2012) points to the serious risks to external solvency if the large external debts are not reduced. Finally, Sinn/Wollmershäuser (2011) point to the risks for Germany and other core countries to suffer severe losses resulting from the "Target2" - payment-transaction-system , if a deficit country would leave the Eurozone. Achieving the required real devaluation such that these countries can start to repay their foreign debts while recovering from the crisis is therefore an indispensable issue for future economic stability and growth in the Eurozone.

Any implementation of appropriate political measures to reduce the imbalances and any discussion about the length of the adjustment period requires a viable estimate of the size of the required real exchange rate movements. Different attempts can be found in literature which provide such an estimate. Probably the most influential one, which is used in the mentioned EEAG-report and also in Sinn (2013) can be found in Goldman-Sachs (2012). This study uses the Obstfeld/Rogoff (2005/2007) model to calculate the required depreciation for each of the periphery countries in an approach which solely concentrates on intra-EMU price movements. A reduction in the current account deficit of one of the periphery countries has therefore to be matched by a proportionate reduction in the surplus of one of the core countries, especially Germany. This relationship is less direct in a global framework as this could allow the Eurozone-core to maintain or increase some of its surpluses or, in contrast, to run substantial deficits while the GIPS current accounts reverse. Considering global issues for Eurozone rebalancing is also argued in Darvas (2012) who points to the importance of extra-Euro trade, as a considerable part of the current account deficits results from trade with EMU-external countries. This view is also supported by the results of Obstfeld/Rogoff (2005), who show that rebalancing the US current account which has its counterpart in surpluses in Asia could induce a large depreciation of the Euro against the US-Dollar, thus potentially affecting Eurozone adjustment.

In this paper, I provide an estimate of the required real effective exchange rate depreciation and the EMU-internal devaluation in a global framework building on Obstfeld/Rogoff (2005). The analysis is conducted in a comparative-static way. I start by calculating equilibrium prices in a status with given current account imbalances and then calculate the changes in equilibrium prices if all or parts of the imbalances are wiped out[1]. Relative outputs of the various regions are fixed such that the current account adjustment is achieved without harming economic growth. I simulate different scenarios of global current account behavior to study its effects on the size and the directions of required price movements which are necessary to wipe out the deficits of the periphery. I therefore develop a four-country-version of the Obstfeld/Rogoff (2005) model to execute the simulations. The model includes a Eurozone-core- and a Eurozone-periphery-region besides Asia and the United States. Based on Engler (2009), my model additionally allows to study the changes in the required depreciation that occur once labor can move freely between the tradable- and non-tradable sector within an economy. Rebalancing the periphery countries will presumably require a long period of adjustment. Allowing production factors to shift between tradable and non-tradable sectors is therefore a necessary feature of the model. This is already argued in Obstfeld/Rogoff (2005), although they did not include this feature in their analysis, as they mainly discuss the short-run implications of global rebalancing on the US-Dollar. Adding supply-side adjustment lowers the need for depreciation.

In section 1, I develop the model. In section 2, I provide the calibration. In section 3, I discuss the results of the different simulations and outline potential ways to expand the model to get a more sophisticated view on the subject. In section 4, I conclude.

1. The Model

The model presented in this section is an extension of the Obstfeld/Rogoff (2005/2007) model. It takes a general equilibrium approach. Obstfeld/Rogoff´s analysis requires the appropriate shifts in relative demand as a pre-condition to the exchange rate movements. While the current economic crisis was guided by a major contraction of demand in deficit regions, the increase in domestic demand in surplus regions and the appropriate movements in exchange rates lack far behind the required levels. The consequence is an underutilization of production factors in the periphery. The analysis here refers to the medium- or long-run and assumes that major economies escape the current economic downturn. It furthermore assumes perfectly flexible prices such that the required movements in real exchange rates can happen instantly. With sticky prices, the adjustment would become a long lasting process which is guided by a continuous shortfall in demand in the periphery

[1] The current account of the periphery is always set to zero in the second period while the current accounts of the other regions are set according to the respective scenario of global current account adjustment

until the required depreciation is achieved. In the basic model, the relative supply of tradable and non-tradable goods is held constant. It calculates the price movements which have to accompany a demand-driven reversal of the GIPS current accounts to substitute the lack in domestic demand by an import of foreign demand if significant effects on output and employment shall be avoided.

I study the effects of global rebalancing on the required real effective depreciation, as well as on the required Eurozone-internal devaluation by developing a version of the model which includes the United States and Asia besides a Eurozone-core and -periphery region. I do not model each single country in the Eurozone in order to limit the size of the model. Following Engler (2009), I model the relative supply of tradable and non-tradable goods flexible and verify the effects on the required depreciation of the periphery region. I start this section by outlining the demand side, followed by the supply side and finish by combining both to a general equilibrium. Finally, I give a more detailed overview of how the model works.

Demand Side

I closely follow Obstfeld/Rogoff (2005), Engler (2009) and Oberpriller (2009) on the demand side. The regions considered are: United States (U), Eurozone-core-countries (E1), Asia (A) and Euro - Zone deficit/GIPS countries (E2). There are ten goods in the model, each region producing a representative tradable- and a representative non - tradable good. The model abstracts from intertemporal decisions and focuses on the distribution of expenditures within the period[2]. Aggregate consumption is divided into consumption of traded goods $\left({C_T}^i\right)$ and non - traded goods $({C_N}^i)$ where *i* indexes the region. These consumption levels are weighted with their respective shares in total consumption C^i, where γ gives the share of tradable goods in consumption. θ is the (constant) elasticity of substitution between traded and non - traded goods. It determines the impact of changing relative prices between these goods on the consumed quantities.

$$C^i = \left[\gamma^{\frac{1}{\theta}} \left({C_T}^i\right)^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} \left({C_N}^i\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, for\ i = U, E1, A, E2$$

Consumption of tradables comprises the consumption of the good which is produced at home and goods which are produced abroad. This brings international trade into the model. For the US the consumption basket of tradables is given by:

$${C_T}^U = \left[{a_1}^{\frac{1}{\varphi}} (C_U^U)^{\frac{\varphi-1}{\varphi}} + {a_2}^{\frac{1}{\varphi}} (C_{E1}^U)^{\frac{\varphi-1}{\varphi}} + {a_3}^{\frac{1}{\varphi}} (C_A^U)^{\frac{\varphi-1}{\varphi}} + {a_4}^{\frac{1}{\varphi}} (C_{E2}^U)^{\frac{\varphi-1}{\varphi}}\right]^{\frac{\varphi-1}{\varphi}},$$

[2] For details see Mejean et. al. (2011)

C_j^i gives the consumption of the tradable good from region *j* in region *i*. φ gives the elasticity of substitution between traded goods, which is also taken as constant. It reflects the impact of changing relative prices between tradable goods from different regions on the consumed quantities. The model assumes heterogeneous preferences in the different regions. Obstfeld/Rogoff (2005) introduce a preference in consumption for domestically produced tradable goods ($a_1$in the case of the US) to account for the empirically documented "home bias" in consumption (compare Obstfeld/Rogoff, 2005, p.26). Consequently, also consumption preferences towards tradable goods from other regions are included ($a_2 - a_5$in the case of the US). These preferences are constant over time. Another possible approach to include the effects of a "home bias" would be to incorporate trade costs in the model (see Obstfeld/Rogoff, 2005, p.26). The next step outlines the price indexes which are derived from the given consumption indexes[3]. As the analysis in this paper is in real prices, all prices shall be thought in terms of a common "numeraire". Consumer price index (CPI) in region *i* is given by:

$$P_C^i = \left[\gamma \left(P_T^i\right)^{1-\theta} + (1-\gamma)\left(P_N^i\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}, for\ i = U, E1, A, E2.$$

P_T^i and P_N^i give country *i´s* price index for consumed tradable goods and the price index for the non - tradable good. The price index for tradable goods is given by:

$$P_T^U = \left[a_1 P_U^{1-\varphi} + a_2 P_{E1}^{1-\varphi} + a_3 P_A^{1-\varphi} + a_4 P_{E2}^{1-\varphi}\right]^{\frac{1}{1-\varphi}}$$

for the United States, where P_i represents the price of the tradable good produced in region *i*. The price index for region *i´s* tradable goods consumption depends on the price of each region´s tradable good weighted with *i´s* preference towards this region and the constant elasticity of substitution between tradable goods. The other tradable - goods price indexes are calculated in the same way. The "law of one price" is assumed to hold for each tradable good. Despite this, the tradable price indexes differ across regions due to the different consumption weights.

The bilateral terms of trade (TOT) $t_{i,j}$ are defined as the price ratio of the tradable goods P_i and P_j of the two considered regions. They are analytically defined as:

$$t_{U,E1} = \frac{P_{E1}}{P_U} \qquad t_{U,A} = \frac{P_A}{P_U} \qquad t_{U,E2} = \frac{P_{E2}}{P_U} \qquad t_{E1,A} = \frac{P_A}{P_{E1}} \qquad (1)$$

$$t_{E1,E2} = \frac{P_{E2}}{P_{E1}} \qquad t_{A,E2} = \frac{P_{E2}}{P_A}$$

[3] for details of the derivation compare Obstfeld/Rogoff (1996, chapter 4)

A rise in $t_{U,E1}$, for example, reflects an increase in the in the price of E1´s tradable good relative to the US-tradable good, thus representing a deterioration of the US - terms of trade vis-a-vis the Eurozone-core region.

Bilateral real exchange rates are given by relative CPIs. For the United States they are:

$$q_{U,E1} = \frac{P_C^{E1}}{P_C^U} \qquad q_{U,A} = \frac{P_C^A}{P_C^U} \qquad q_{U,E2} = \frac{P_C^{E2}}{P_C^U} \tag{2}$$

All the other bilateral real exchange rates can be derived from these four. For example:

$$q_{E1,A} = \frac{P_C^A}{P_C^{E1}} = \frac{P_C^A * P_C^U}{P_C^{E1} * P_C^U} = \frac{\frac{P_C^A}{P_C^U}}{\frac{P_C^{E1}}{P_C^U}} = \frac{q_{U,A}}{q_{U,E1}} \tag{3a}$$

Real exchange rates are functions of relative prices of tradable *and* non - tradable goods. To show this, the bilateral real exchange rate e.g. of the US and E1 can be expressed as (compare Oberpriller 2009, p.55):

$$q_{U,E1} = \frac{P_T^{E1}}{P_T^U} * \left[\frac{\gamma + (1-\gamma)(\frac{P_N^{E1}}{P_T^{E1}})^{1-\theta}}{\gamma + (1-\gamma)(\frac{P_N^U}{P_T^U})^{1-\theta}} \right]^{\frac{1}{1-\theta}} \tag{3b}$$

The other bilateral real exchange rates are calculated accordingly. Real effective exchange rates (REER) are expressed as the trade-weighted average of bilateral real exchange rates of region *i* against all other regions. I weight the different bilateral real exchange rates according to the share of exports and imports with the specific partner region *j* in total exports and imports of the considered region *i*. These weights ($w_{i,j}$) are assumed to be constant over the period of the analysis. For example:

$$REER^U = {q_{U,E1}}^{w_{U,E1}} * {q_{U,A}}^{w_{U,A}} * {q_{U,E2}}^{w_{U,E2}} \tag{3c}$$

In equilibrium, all non - tradable goods have to be consumed in the region in which they are produced. All tradable goods have to be consumed in the producing region or in one of the other regions. I outline the demand side equations, while the supply side is shown in the next part. For now, consumers in each of the four regions are endowed with a fixed amount of the tradable- and non-tradable good. One gets four market clearing conditions for non - tradable goods and three for

tradable goods. Walrasian law implies that if all the other markets clear, then also the fourth tradable market clears. For US - non - tradables one gets the market clearing condition[4]:

$$Y_N^U = (1-\gamma)\left(\frac{P_N^U}{P_C^U}\right)^{-\theta} C^U \tag{4}$$

and for US - tradables:

$$Y_T^U = \gamma a_1 \left(\frac{P_U}{P_T^U}\right)^{-\varphi}\left(\frac{P_T^U}{P_C^U}\right)^{-\theta} C^U + \gamma b_1 \left(\frac{P_U}{P_T^{E1}}\right)^{-\varphi}\left(\frac{P_T^{E1}}{P_C^{E1}}\right)^{-\theta} C^{E1} + \gamma c_1 \left(\frac{P_U}{P_T^A}\right)^{-\varphi}\left(\frac{P_T^A}{P_C^A}\right)^{-\theta} C^A \tag{5}$$

$$+ \gamma d_1 \left(\frac{P_U}{P_T^{E2}}\right)^{-\varphi}\left(\frac{P_T^{E2}}{P_C^{E2}}\right)^{-\theta} C^{E2}$$

Each region´s current account is calculated by subtracting the nominal consumption of tradable goods $P_T^i C_T^i$ in this specific region from the nominal output of its tradable good $P_i Y_T^i$. To this, interest payment on its net international investment position (=rF^i) is added. All current accounts sum up to zero. US current account e.g. is given by:

$$CA^U = P_U Y_T^U + rF^U - P_T^U C_T^U \tag{6}$$

In order to keep equations short, I define:

$$ca_U = \frac{CA^U}{P_U Y_T^U} \qquad ca_{E1} = \frac{CA^{E1}}{P_U Y_T^U} \qquad ca_A = \frac{CA^A}{P_U Y_T^U} \qquad ca_{E2} = \frac{CA^{E2}}{P_U Y_T^U}$$

$$f^U = \frac{F^U}{P_U Y_T^U} \qquad f^{E1} = \frac{F^{E1}}{P_U Y_T^U} \qquad f^A = \frac{F^A}{P_U Y_T^U} \qquad f^{E2} = \frac{F^{E2}}{P_U Y_T^U}$$

$$\sigma_{U,E1} = \frac{Y_T^U}{Y_T^{E1}} \qquad \sigma_{U,A} = \frac{Y_T^U}{Y_T^A} \qquad \sigma_{U,E2} = \frac{Y_T^U}{Y_T^{E2}}$$

$$\sigma_{N,U} = \frac{Y_N^U}{Y_T^U} \qquad \sigma_{N,E1} = \frac{Y_N^{E1}}{Y_T^{E1}} \qquad \sigma_{N,A} = \frac{Y_N^A}{Y_T^A} \qquad \sigma_{N,E2} = \frac{Y_N^{E2}}{Y_T^{E2}}$$

$\sigma_{U,i}$ represents US-tradable output relative to country *i´s* tradable output. $\sigma_{N,i}$ stands for country *i´s* non - tradable output relative to its own tradable output. Market clearing conditions for tradable and non-tradable goods are rearranged by implementing $C^i = \frac{1}{\gamma}\left(\frac{P_T^i}{P_C^i}\right)^{\theta} * C_T^i, for\ i = U, E1, A, E2$ and expressed in nominal terms[5]. Then the current account equations are substituted into the

[4] All demand functions are derived from maximizing C subject to an expenditure constraint (for further details see Engler (2009) and Mejean et. al. (2011)

[5] The consumption of traded goods in each region follows: $C_T^i = \frac{1}{\gamma}\left(\frac{P_T^i}{P_C^i}\right)^{-\theta} * C^i$ (compare Oberpriller 2009, p. 157).

transformed market clearing conditions. Finally the equations are normalized over nominal output of the tradable good in the US (for a comparison see e.g. Oberpriller (2009), p.162 and Engler (2009), p.21). For the market clearing condition of the US tradable good this yields:

$$1 = a_1 \frac{1}{a_1 + a_2 {t_{U,E1}}^{1-\varphi} + a_3 {t_{U,A}}^{1-\varphi} + a_4 {t_{U,E2}}^{1-\varphi}} \ (1 + rf_U - ca_U) \tag{7}$$

$$+ b_1 \frac{1}{b_1 + b_2 {t_{U,E1}}^{1-\varphi} + b_3 {t_{U,A}}^{1-\varphi} + b_4 {t_{U,E2}}^{1-\varphi}} \left(\frac{t_{U,E1}}{\sigma_{U,E1}} + \ rf_{E1} - \ ca_{E1} \right)$$

$$+ c_1 \frac{1}{c_1 + c_2 {t_{U,E1}}^{1-\varphi} + c_3 {t_{U,A}}^{1-\varphi} + c_4 {t_{U,E2}}^{1-\varphi}} \left(\frac{t_{U,A}}{\sigma_{U,A}} + \ rf_A - \ ca_A \right)$$

$$+ d_1 \frac{1}{d_1 + d_2 {t_{U,E1}}^{1-\varphi} + d_3 {t_{U,A}}^{1-\varphi} + d_4 {t_{U,E2}}^{1-\varphi}}$$

$$* \left(\frac{t_{U,E2}}{\sigma_{U,E2}} - \ rf_U - \ rf_{E1} - \ rf_A + \ ca_U + ca_{E1} + ca_A \right).$$

Using the same procedure for the market clearing equation of the US non-tradable good yields[6]:

$$\frac{P_N^U Y_N^U}{P_U Y_T^U} = \left(\frac{1-\gamma}{\gamma} \right) \left[(a_1 + a_2 {t_{U,E1}}^{1-\varphi} + a_3 {t_{U,A}}^{1-\varphi} + a_4 {t_{U,E2}}^{1-\varphi})^{\frac{1-\theta}{\varphi-1}} \right] \tag{8}$$

$$* {z_U}^{1-\theta} * \ (1 + rf_U - ca_U)$$

The others are calculated in the same way.

<u>Supply Side</u>

Obstfeld/Rogoff (2005) consider only changes affecting the demand side of the economy, while relative supply of tradable- and non - tradable goods is fixed. By introducing a supply side to the model, current account adjustment can also be achieved by shifting labor (the only production factor considered) between the traded and the non - traded goods sector, thereby changing (real) tradable- and non - tradable output. When introducing the supply side of the model, I closely follow Engler (2009) and extend his three - country model to a four - country model. A version of a four - country model can also be found in Oberpriller (2009).

The production of tradable (T)- and non - tradable (N) goods is described by:

$$Y_k^j = A_i^j \ (L_i^j)^v \tag{9}$$

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[6] Following Engler (2009), I define the "internal terms of trade" as $z_i = \frac{P_N^i}{P_i}$, $for \ i = \ U, E1, A, E2$

L_k^j is the total labor input in the production of good *k* ($k = T, N$) in region *j*, while A_k^j is total factor productivity. *v* is marginal product of labor[7]. Firms working in the non - tradable/tradable sector maximize their profits:

$$\max_{L_T^j} P_j\, A_T^j\, (L_T^j)^v - \omega L_T^j\ ;\ \max_{L_N^j} P_N^j A_N^j\, (L_N^j)^v - \omega L_N^j$$

Profits are given by nominal output $P_j\, A_T^j\, (L_T^j)^v$ or $P_N^j A_N^j\, (L_N^j)^v$ minus wages paid for labor ωL_T^j or ωL_N^j, where ω denotes the nominal wage rate.[8] The first order conditions state:

$$vP_j\, A_T^j (L_T^j)^{v-1} = \omega^j = \ vP_N^j A_N^j (L_N^j)^{v-1}. \tag{10}$$

In equilibrium, nominal wages are equalized across different sectors within a region since the model assumes perfect integration of intra - region labor markets. In contrast, labor is assume to be immobile between regions, allowing wages to differ between regions. From (10), I derive relative labor inputs between the tradable and non - tradable sector of region j:

$$\frac{L_N^j}{L_T^j} = \left(\frac{P_j\, A_T^j}{P_N^j A_N^j}\right)^{\frac{1}{v-1}} \tag{11}$$

From the production function, relative output of non-tradable to tradable goods in region j is given by:

$$\frac{Y_N^j}{Y_T^j} = \frac{A_N^j {L_N^j}^v}{A_T^j {L_T^j}^v}$$

Plugging (11) into the relative output yields:

$$\frac{Y_N^j}{Y_T^j} = \left(\frac{P_N^j}{P_j}\right)^{\frac{v}{1-v}} \left(\frac{A_N^j}{A_T^j}\right)^{\frac{1}{1-v}}$$

and further:

$$\frac{Y_N^j}{Y_T^j} = \left(\frac{P_N^j}{P_j}\right)^{\frac{v}{v-1}} \left(\frac{A_T^j}{A_N^j}\right)^{\frac{1}{v-1}} = \frac{P_j}{P_N^j}\left(\frac{P_j\, A_T^j}{P_N\, A_N^j}\right)^{\frac{1}{v-1}} \tag{12}$$

Rearranging and substituting the "internal terms of trade" (z) into (12) gives:

[7] see Engler (2009) for further details on the production function

[8] Remember the definition of the price of the tradable good from each region. P_j therefore gives the price of the tradable good produced in region j!

$$\frac{P_N^j Y_N^j}{P_j Y_T^j} = \left(z_j \frac{A_N^j}{A_T^j} \right)^{\frac{1}{1-v}}$$

From firms´ profit maximization one gets four market clearing conditions for non - tradable goods. For the US this gives:

$$\frac{P_N^U Y_N^U}{P_U Y_T^U} = \left(\frac{A_N^U}{A_T^U} \, z_U \right)^{\frac{1}{1-v}} \tag{13}$$

The same procedure is used to calculate the relative supply of tradable goods between countries. It is shown for the US - E1 relationship. From firms´ profit maximization it follows that:

$$vP_U A_T^U (L_T^U)^{v-1} = \; vP_U Y_T^U (L_T^U)^{-1} = \omega_U$$

and

$$vP_{E1} A_T^{E1} (L_T^{E1})^{v-1} = \; vP_{E1} Y_T^{E1} (L_T^{E1})^{-1} = \omega_{E1}$$

Therefore:

$$\frac{\omega_{E1}}{\omega_U} = \frac{vP_{E1} A_T^{E1} (L_T^{E1})^{v-1}}{vP_U A_T^U (L_T^U)^{v-1}}$$

By combining:

$$\frac{L_T^{E1}}{L_T^U} = \frac{P_{E1} Y_T^{E1}}{P_U Y_T^U} \left(\frac{\omega_{E1}}{\omega_U} \right)^{-1} .$$

Substitution of labor inputs and rearranging the result finally gives:

$$\frac{P_{E1} Y_T^{E1}}{P_U Y_T^U} = \frac{t_{U,E1}}{\sigma_{U,E1}} = \left[\left(\frac{\omega_{E1}}{\omega_U} \right)^{-v} t_{U,E1} \; \frac{A_T^{E1}}{A_T^U} \right]^{\frac{1}{1-v}}, ^{9} \tag{14}$$

for the US-E1 relationship. The others are calculated in the same way:

In this form, it is easy to equate the market clearing conditions for the supply side of the economy with the conditions for the demand side in order to combine both to a general equilibrium. For the specification of a general equilibrium, relative wage rates and relative total factor productivities must also be calculated. Rearranging of (10) gives:

[9] For the definition of $\sigma_{U,E1}$ and $t_{U,E1}$ see page.6/8

$$L_T^j = \left(\frac{\omega_j}{vP_jA_T^j}\right)^{\frac{1}{v-1}},\ L_N^j = \left(\frac{\omega_j}{vP_NA_N^j}\right)^{\frac{1}{v-1}}$$

Combining them gives the total labor supply L^j in country j:

$$L^j = L_T^j + L_N^j = \left(\frac{\omega_j}{vP_jA_T^j}\right)^{\frac{1}{v-1}} + \left(\frac{\omega_j}{vP_NA_N^j}\right)^{\frac{1}{v-1}}$$

This is rearranged to:

$$\frac{\omega_j}{P_jA_T^j} = v\left[\frac{1+\left(z_j\frac{A_N^j}{A_T^j}\right)^{\frac{1}{v-1}}}{L^j}\right]^{1-v}$$

For relative wages between the US and E1, I therefore get:

$$\frac{\omega_{E1}}{\omega_U} = \left(\frac{L^U}{L^{E1}}\right)^{1-v}\left[\frac{1+\left(z_{E1}\frac{A_N^{E1}}{A_T^{E1}}\right)^{\frac{1}{1-v}}}{1+\left(z_U\frac{A_N^U}{A_T^U}\right)^{\frac{1}{1-v}}}\right]^{1-v} t_{U,E1}\frac{A_T^{E1}}{A_T^U} \quad (15)$$

Relative productivities are calculated only for the initial allocation and are constant then as the model abstracts from endogenous productivity changes between sectors and regions over time. Relative total factor productivities between tradable and non - tradable sectors within one region are calculated from (12) as:

$$\frac{A_N^U}{A_T^U} = \left(\frac{Y_N^U}{Y_T^U}\right)^{v-1} * (z_U)^v = {\sigma_{N,U}}^{v-1} * (z_U)^v \quad (16)$$

For relative total factor productivities of tradable sectors between regions one gets:

$$\frac{A_T^{E1}}{A_T^U} = \left(\frac{Y_T^{E1}}{Y_T^U}\right)^{v-1} * \left(t_{U,E1}\right)^{-v} * \frac{\omega_{E1}}{\omega_U} = {\sigma_{U,E1}}^{v-1} * \left(t_{U,E1}\right)^{-v} * \frac{\omega_{E1}}{\omega_U} \quad (17)$$

General Equilibrium

By implementing the equations which were calculated in the same fashion as (14) into (7) one gets the market clearing condition for US tradable goods. By implementing (13) into (8) one gets the market clearing condition for the US non-tradable good. Using the same procedures to calculate market clearing conditions for goods of the other regions finally gives 3 market clearing conditions for tradable goods and 4 for non-tradable goods (see Appendix B). Together with 3 relative wage

equations which are calculated like (15), 4 equations for relative productivities between tradable and non-tradable sectors (calculated like (16)), 3 equations for relative productivities between the US tradable sector and other tradable sectors (calculated like (17)) and 9 additional terms-of-trade equations[10] this gives 26 equations for 26 unknowns ($t_{U,E1}, t_{U,A}, t_{U,E2}, t_{E1,U}, t_{E1,A}, t_{E1,E2}, t_{A,U}, t_{A,E1}$, $t_{A,E2}$, $t_{E2,U}, t_{E2,A}, t_{E2,E1}$ $z_U, z_{E1}, z_A, z_{E2}, \frac{\omega_{E1}}{\omega_U}, \frac{\omega_A}{\omega_U}, \frac{\omega_{E2}}{\omega_U}, \frac{A_N^U}{A_T^U}, \frac{A_N^{E1}}{A_T^{E1}}, \frac{A_N^A}{A_T^A}, \frac{A_N^{E2}}{A_T^{E2}}, \frac{A_T^{E1}}{A_T^U}, \frac{A_T^A}{A_T^U}, \frac{A_T^{E2}}{A_T^U}$). Real exchange rates and real effective exchange rates for the initial allocation are then calculated according to (3). In period 2, values of relative productivities ($\frac{A_N^U}{A_T^U}, \frac{A_N^{E1}}{A_T^{E1}}, \frac{A_N^A}{A_T^A}, \frac{A_N^{E2}}{A_T^{E2}}, \frac{A_T^{E1}}{A_T^U}, \frac{A_T^A}{A_T^U}, \frac{A_T^{E2}}{A_T^U}$) are taken from period 1, allowing the relative sector sizes ($\sigma_{N,U}$, $\sigma_{N,E1}$, $\sigma_{N,A}$, $\sigma_{N,E2}$, $\sigma_{U,E1}$, $\sigma_{U,A}$, $\sigma_{U,E2}$) to be determined endogenously.

How the model Works

I start by explaining a purely demand-side driven adjustment as can be found in Obstfeld/Rogoff (2000/2005/2007). Current account adjustment basically requires aggregate demand in deficit regions to fall relative to surplus regions. This shift in relative demand causes the relative price of a deficit regions´ tradable good to fall (in the case of perfectly flexible prices) as individuals are assumed to have a preference in consumption towards domestically produced tradable goods. This causes a real depreciation of the currency as domestically produced tradables have a higher importance for domestic CPI while foreign tradables have a higher importance for the foreign CPI.

This terms-of-trade effect is reinforced by changes in the relative prices of non-tradable to tradable goods which reflects the fact that current account adjustment requires to shift within-country-demand away from tradables in deficit regions and towards tradables in surplus regions. Thus tradables become more expensive relative to non-tradables in the deficit region and cheaper in the surplus region. Relative demand shocks and price adjustments together bring the current accounts of the regions to their exogenously chosen target value while sustaining full employment. Any reduction in domestic demand is compensated by an "import" of foreign demand or by an appropriate switch of domestic demand between sectors within one economy. Deficit regions suffer in contrast from a shortfall in demand, i.e. unemployed resources, as long as the shifts in relative demand are not accompanied by the required price movements (e.g. due to price rigidities). These dynamic considerations are not included in the model as prices are assumed to be fully flexible and the relative total outputs of the various regions are set exogenously. I use 2007- (i.e. pre-crisis)- values for relative outputs presuming that production was at, or close to, potential output before the crisis.

[10] $t_{E1,U} = 1/t_{U,E1}, t_{E1,A} = t_{U,A}/t_{U,E1}, t_{E1,E2} = t_{U,E2}/t_{U,E1}$
$t_{A,U} = 1/t_{U,A}, t_{A,E1} = t_{U,E1}/t_{U,A}, t_{A,E2} = t_{U,E2}/t_{U,A}$
$t_{E2,U} = 1/t_{U,E2}, t_{E2,A} = t_{U,A}/t_{U,E2}, t_{E2,E1} = t_{U,E1}/t_{U,E2}$

I consider this to be a useful reference value. Taking later years would calculate an adjustment with consistently underemployed factors of production in the periphery countries.

The validity of a purely demand-driven adjustment relies on the assumption that production factors cannot move freely between the tradable and non-tradable sector, which is basically true in the short run. Once labor (capital is excluded in the model) can move between sectors, the lower prices of non-tradables in deficit regions will induce a shift of labor towards the more lucrative tradable sector. The increased supply of tradable goods creates a larger terms-of-trade deterioration compared to the purely demand-driven adjustment. This magnifying effect on the size of the real exchange rate movement stands in contrast to the dampening impact of a smaller decrease in the relative prices of non-tradables against tradables. Simulations prove the dominance of the second effect in the overall real exchange rate movements which reflects the large amount of non-tradables in the CPI.

The model is solved by using "Dynare". I use a MatLab file that starts two "Dynare" files - the first one calculates the variables like TOT and RER for the initial allocation with the given current account imbalance, the second one calculates them for the adjusted current accounts. MatLab then calculates the percentage changes in terms of RER, TOT, REER and the relative sector sizes between these two allocations. Small deviations arise compared to the actual values as "Dynare" linearizes the equations. Comparisons with results of Obstfeld/Rogoff (2005) and Engler (2009) prove these deviations to be rather small which reflects the fact that the discussed effects appear to be roughly linear (see Forbes 2005, p.4).

2. Calibration

Table 1 lists the countries which are considered in the different regions. Ireland is taken as part of the surplus - region as its current account has already reversed and as the Goldman/Sachs study finds no further need for real depreciation.

Table 2 summarizes the parameter values for the elasticities of substitution, the relative outputs of tradable goods between regions and the relative output of the non-tradable to the tradable sector within the respective economy. The values are taken from Obstfeld/Rogoff (2005) as far as possible. The elasticities of substitution (θ and ϕ) are set to $\theta=1$ and $\phi=2$. Real non-tradable to real tradable output is set to 3 across all regions. Obstfeld/Rogoff argue this high number with the huge amount of non-tradable services which are required in the production of tradable goods. The share of traded goods in consumption is set to 0.25. Relative tradable output of E1 is taken as 55% of US tradable

output. E2´s tradable output relative to the US´s is assumed to be 28,3%. These calculations are approximations based on data from the IMF World Economic Outlook database of 2007.

Region	Countries
U	United States
E1	Austria, Belgium, Germany, Finland, France, Ireland, Netherlands
A	China, Japan, Hong Kong, India, South Korea, Singapore, Malaysia, Taiwan
E2	Greece, Italy, Portugal, Spain

Table 1: Considered countries in each region

Parameter	Value	Description
ϕ	2	Elasticity of substitution between traded goods
θ	1	Elasticity of substitution between traded and non - traded goods
γ	0.25	share of traded goods in consumption
$\sigma(U,E1)$	1.8	US real tradable output relative to E(1) real tradable output
$\sigma(U,A)$	1	US real tradable output relative to A real tradable output
$\sigma(U,E2)$	3.53	US real tradable output relative to E2 real tradable output
$\sigma(N,U)$	3	US real non - tradable output relative to real tradable output
$\sigma(N,E1)$	3	E(1) real non - tradable output relative to real tradable output
$\sigma(N,A)$	3	A real non - tradable output relative to real tradable output
$\sigma(N,E2)$	3	E2 real non - tradable output relative to real tradable output

Table 2: Parameter values

Table 3 summarizes the calibration of initial current account- and international investment positions. International investment positions are calculated from the IMF Balance of Payments Statistics. Interest rate *r* is set to 5%.

The consumption preferences of the different regions are shown in table 4. E1´s and E2´s home-bias is assumed to equal the home-bias of whole "Europe" which was taken as 0.7 in Obstfeld/Rogoff (2005). Consumption preferences for the other regions were calculated from the OECD - STAN bilateral trade statistics. These consumption preferences shall mainly incur the effects of trade costs and other trade frictions. I therefore calculate the preferences such that the model roughly matches the observed global trade patterns over the last decade. Roughly 70% of all imports of the GIPS region result for example from trade with the core countries[11]. This value varies only between 74% and 70% over the period from 2000 to 2007. The high share reflects the high importance of trade frictions in international trade. This trade pattern would not occur in the model without a very high "preference" (0,2427) for E1´s tradable good compared to other region´s tradable goods. Exchange

[11] This is based on my own calculations from the STAN database where I only included the countries considered in the paper

rate movements affect the share of imports coming from each region, but the consumption preferences limit these effects to match empirically observed facts.

Relative labor inputs $\frac{L^i}{L^j}$ reflect relative urban populations[12] in the considered regions. For E1 and E2 populations are calculated from the IMF World Economic Outlook database: $\frac{L^U}{L^{E1}} = 1.6$, $\frac{L^U}{L^A} = 0.22$, $\frac{L^U}{L^{E2}} = 2.4$.

Country	ca	rf
U	-0,23	-0,035
E1	0,07	0,0102
A	0,23	0,04
E2	-0,07	-0,0177

Table 3: Current Accounts and NIIP

Scenarios

I calculate the required real depreciation of the Eurozone-periphery to balance its current account in several scenarios of global current account adjustment. The analysis relies on a viable fixation of the target current account value for the periphery. Different attempts to identify this value can be found in literature. Goldman-Sachs (2012) shows the results for a target value of 0, a target value which stabilizes the net foreign asset position and a value in which the net foreign asset position is stabilized within -25% of GDP over an adjustment period of 20 years. I abstract from all these difficulties and set the target value to 0 for the periphery countries (i.e. $ca_A = 0$ in all simulations), recognizing the fact that achieving current account surpluses requires even larger price movements. This brings the periphery countries to a point from which they can start to repay their foreign debts and lower the risk of an external insolvency. The current accounts of the other regions are set according to the respective scenario, while accounting for the fact that all deficits and surpluses sum up to zero. Table 5 lists the target current account values of the different regions.

Global Rebalancing

The scenario in which all deficits and surpluses are globally wiped out. This is the baseline scenario in Obstfeld/Rogoff (2005) and other papers dealing with the issue. It brings the global economy to a point from which deficit countries start to repay their external debts.

[12] Taking only urban population under consideration follows the approach of Engler (2009).

Region	Parameter	Value	Preference towards traded goods from:
U	a1	0,7000	U
U	a2	0,0889	E(1)
U	a3	0,1656	A
U	a5	0,0455	E2
E(1)	b2	0,7	E(1)
E(1)	b1	0,0309	U
E(1)	b3	0,0780	A
E(1)	b5	0,1910	E2
A	c3	0,7	A
A	c1	0,0952	U
A	c2	0,1415	E(1)
A	c5	0,0633	E2
E2	d4	0,7000	E2
E2	d1	0,0108	U
E2	d2	0,2427	E1
E2	d3	0,0465	A

Table 4: Consumption preferences

Europe Trade Places

The US deficit is wiped out such that the US can start to lower their external liabilities. In addition, Asia is defending its surplus. The reason might be that Asia continues with its strategy of export-led-growth and its plan to build up foreign exchange rate reserves. This scenario corresponds to a failure of the Mutual Assessment Process. The lower US - demand is offset by increases in demand in the Eurozone-core.

Asia Trade Places

This is the opposite scenario to the previous, implying that the Eurozone-core, particularly Germany is defending its surplus while the US deficit contracts. A potential reason might be that Germany tries to limit wage growth to further improve its "competitiveness", while Asia follows the MAP and boosts domestic demand.

European Export Boost

In this scenario, the Eurozone-core does not only defend its surplus, but increases it to the Asian level of 2007. The US and Asia run deficits half the size of the US deficit in 2007. This scenario is not really

likely to happen in this extreme fashion, but shows how such a way of global adjustment influences the results.

Purely Intra-European-Rebalancing

The MAP fails at the global level and the US deficit as well as the Asian surplus does not contract. The Eurozone reduces internal imbalances implying that the reduction in the deficits of the periphery is matched by proportionate reductions in the surpluses of the core. From a 2013-perspective this would even imply an expansion of global imbalances back to 2007 levels, as they contracted following the economic crisis (see figure 1).

Global Rebalancing		**Europe Trade Places**		**Asia Trade Places**		**European Export Boost**		**Purely Intra-European-Rebalancing**	
Region	ca	Region	ca	Region	ca	Region	ca	Region	ca
U	0	U	0	U	0	U	-0.115	U	-0,23
E1	0	E1	-0,23	E1	0,07	E1	0,23	E1	0
A	0	A	0,23	A	-0,07	A	-0,115	A	0,23
E2	0	E2	0	E2	0	E2	0	E2	0

Table 5: Current Accounts target values for the different scenarios

3. Results

Figures 5, 6 and 7 summarize graphically the results of the different simulations. They show the required real effective exchange rate depreciation for the periphery countries to balance its current account as well as the EMU-internal devaluation across the different scenarios. I additionally added the predicted changes in the real effective exchange rate of the core countries to provide a feeling for a possible nominal depreciation of the Euro. The following discussion is divided into two parts - one in which the current accounts of the United States and Asia behave symmetrically and one in which they do not.

Symmetric Behavior

Scenario: "Global Rebalancing"/"Purely Intra-European-Adjustment"

In both scenarios, the current accounts of the United States and Asia show a proportionate change. "Global Rebalancing" implies that the US - deficit contracts by from 23% of US-tradable GDP and Asian surpluses contract by the same number. In "Purely intra-European-Rebalancing", the US and

Asian current accounts remain at the initial level. The current account deficit of the periphery countries is reduced to zero, the current account surpluses of the core contract by the same amount.

The results suggest a required real effective depreciation of 16% - 24% for the periphery region in "Global Rebalancing". The actual point in this range depends on the mobility of production factors between sectors. "Purely Intra-European-Adjustment" suggests a similar range of 15% to 22%. In both scenarios, the required internal devaluation roughly equals the overall REER depreciation. Both scenarios suggest that no major nominal depreciation of the Euro could support the adjustment.[13]

These numbers correspond to a simulation which was conducted in a simple 2-country- version of the model in which rebalancing only happens between the Eurozone-core and-periphery. Any changes in global demand patterns that cause a symmetric behavior of the US and Asian current account have no significant effect on the Eurozone-internal devaluation and the overall REER depreciation of the periphery.

Asymmetric Behavior

Scenario: "European Trade Places"/" Asian Trade Places"/"European Export Boost"

The difference between an analysis which only includes intra-European price movements (like Goldman-Sachs (2012)) and the one given here is that the reduction in the deficit of the periphery countries can theoretically happen in a global environment in which the core maintains/increases its surplus or in an environment in which the changes in global demand patterns switch the surplus into a deficit. All three scenarios of asymmetric behavior are extreme ones, but illustrate nicely how asymmetric global current account behavior affects the results.

Figure 5 shows that the REER depreciation of the periphery countries is between 15% and 26%, except for the very unlikely case in which the rebalancing in global demand results in a significant increase in the surpluses of the core countries ("European Export Boost"). Results show therefore no major changes to symmetric behavior in terms of REER adjustment. What effectively changes is the size of the required Eurozone-internal devaluation which varies considerably across different scenarios. "Europe trade Places" implies a large need for internal devaluation between 28% and 43%, again depending on the within-country mobility of labor. On the contrary, "Asian Trade Places" suggests only an internal devaluation between 11% and 17%. The extreme case of "European Export Boost" even allows for a further appreciation of the periphery against the core, while the current account deficit is still wiped out.

[13] The REER of the core countries appreciates considerably such that a significant depreciation of the common currency is unlikely when considering that the influence of the core countries on the aggregate REER of the Eurozone is twice as large due to its economic size.

The Length of the Adjustment Period

The main difference between an adjustment which relies more on internal devaluation than on real depreciation against Asia is that nominal changes are ruled out within a currency union. Any real depreciation against the Eurozone-core countries relies on movements in relative prices which can be subject to diverse rigidities. Additionally, the 2% inflation goal of the Euro-area rules out any quick adjustment if deflation is to be avoided in the periphery.

Figure 8 shows graphically the number of years which are required to achieve the required internal devaluation with an inflation differential of 1.5% between core and periphery. Calculations are based on an inflation rate of 2% for the whole currency union. I assume an average inflation rate of 1% in the periphery to account for the differences across various periphery countries. Following Goldman-Sachs (2012), Italy needs a depreciation which is less than that of Greece. With a 1% inflation in the whole periphery, Greek inflation can be a significantly below this value while still avoiding deflation. Consequently, the inflation rate of the core countries is assumed to be 2.5% to match the 2% goal in the Euro-area while accounting for the economic size of both blocks. "European Export Boost" is not included in the figure. In this scenario virtually all REER depreciation could result from a nominal depreciation against Asian currencies which could be conducted relatively fast. In all other scenarios, it is effectively the 2% goal which constrains a quicker adjustment. With symmetric global current account adjustment the period lasts 10 to 15 years, depending on the ability to shift production factors between sectors. "Europe Trade Places" suggests a potential adjustment period of up to 24 years while "Asian Trade Places" suggests only 7 years in the most optimistic case. This period is characterized by a shortfall in domestic demand in the periphery countries and a sustainable recovery from the "import" of foreign demand. A "lost decade" in the sense of Eichengreen *et.al.* (2013) appears hardly to avoid without a major expansion in Asian domestic demand and a nominal depreciation of the Euro against Asian currencies[14]. In the most pessimistic case, it could be a "lost quarter of a century".

Additional Remarks

The underlying Obstfeld/Rogoff (2005) model was not constructed to calculate very precise values. It was mainly used to warn of a large nominal depreciation of the US Dollar which might accompany global rebalancing. This conclusion remains the same independent of whether the depreciation is 30% or 35%. The more exact calculation of the various consumption preferences in this paper is

[14] "Asian Trade Places" and "European Export Boost" allow for a substantial nominal depreciation of the Euro against Asian currencies as the real exchange rate of the Eurozone-core against Asia also depreciates considerably. Giving a more precise value would require to include nominal exchange rates and monetary policies in the model.

already an attempt to fit the model closer to reality. Various attempts prove the sensitivity of the model with respect to most parameters ("home-bias", γ, the different relative outputs σ and the interest payment on the NIIP) to be within a negligible range. Some additional points merit attention:

Choice of the Elasticities of Substitution

Obstfeld/Rogoff underline the sensitivity of the model with respect to the elasticities of substitution (θ and ϕ) which is consistent with my own experiences. The model assumes uniform and constant elasticities of substitution and therefore a uniform production structure across all considered regions based on average estimates for the world as a whole. These values can actually be subject to significant variation between different regions and also over time. Price movements between regions which produce close substitutes yield a stronger effect on the current account than others. Bayoumi *et. al.* (2011) point out that intra-Euro-area exports have significantly higher price elasticities than extra-Euro-area exports which lowers the effects of a nominal Euro depreciation. This reinforces the importance of intra-EMU adjustment and lowers the effects of a boost in Asian demand and a nominal depreciation of the common currency. For the following reasons, the given results are still assumed to remain valid when considering them as minimum values to achieve rebalancing:

The choice of θ=1 (the within-country elasticity of substitution) represents a relatively conservative estimate such that the actually required price movements might be even higher. According to Obstfeld/Rogoff (2005), the choice of ϕ=2 (cross-country elasticity of substitution) represents a compromise between estimates which lie above and those which lie below. A higher value here would reduce the need for price changes. Additionally, if this value varies between regions, the divergence in the results across different scenarios could be lower. The last two effects are however regarded to be relatively small as the "terms-of-trade" effect accounts only for roughly 1/4 of the overall movements in CPIs.

Valuation Effects

The last decades have seen a steady increase in gross asset flows around the globe. The importance of asset revaluation effects is therefore steadily increasing. Gourinchas/Rey (2005) point out that the positive revaluation effects resulting from a nominal depreciation of the US Dollar could substantially lower the need for external adjustment of the United States, while Obstfeld/Rogoff (2005) find only a relatively small effect. In terms of the Eurozone, asset revaluation effects, while empirically relevant in the run-up to the financial crisis, mostly resulted from changes in equity prices rather than changes in nominal exchange rates (compare European Commission 2010). Reducing the need for depreciation would require a sizeable nominal depreciation of the Euro (scenario "Asian Trade Places" and "European Export Boost") while the opposite effect appears with a significant

appreciation of the Euro ("Europe Trade Places"). The effectiveness of a depreciation against Asia would therefore be reinforced with a nominal depreciation of the Euro while the internal devaluation becomes more important in the other scenario(s). Valuation effects are therefore countervailing to some extent the loss in precision due to the assumption of a homogenous production structure as they work in the opposite direction. Including them would nevertheless allow to give a more precise estimate.

The Role of OPEC

The counterparts to the US deficit are mainly in Asia and the oil-exporting countries, including Russia. In the model, the role of OPEC is neglected and aggregate surpluses of both blocks were attributed to Asia. Giving an exact estimate would require to include the OPEC countries and Russia. This is however only useful when considering differences in the production structure as the tradable good of this region would be oil, thus implying substantial differences in the elasticities of substitution compared to other regions. The effects of this are again considered to be small due to the limited economic size of this block and the homogeneity of trade flows with the other regions.

In summary, a uniform production structure and the abstraction from valuation effects and the OPEC countries represent a simplification of the model which incorporates some errors in the analysis. These errors are however regarded to be in a justifiable range when viewing the results as minimum estimates as these effects are relatively small and would wipe out each other to some extent.

A Dynamic Approach

The approach in this paper is a static one, therefore giving no insights into the dynamics of the adjustment path. Including nominal price rigidities, a limited exchange rate pass through on import prices as well as monetary and fiscal policy instruments would give a more detailed view on the possible costs of the adjustment process and the adequate policy measures under the various scenarios. One approach in this direction can be found in Ferrero *et.al.* (2008) who deal with the optimal monetary policy of the US-FED in the case of global rebalancing.

Conclusions

My results suggest a 15% to 26% REER depreciation that is required to eliminate the current account deficits in the periphery countries while returning relative outputs to pre-crisis values. The actual value within this range, while relatively constant along different scenarios of global current account behavior, depends on the within-country-mobility of labor. The required "internal devaluation" of

the Eurozone-periphery against the core amounts to 16% - 24% if the reduction in the deficit of the periphery is matched by a proportionate reduction in the surpluses of the core. This points to an adjustment period of 10-15 years with the given inflation goal of 2%. The period is guided by a shortfall of demand and the subsequent underemployment of production factors in the periphery countries. With a disproportionate reduction, the need for internal devaluation varies significantly between 11% and 43% implying an adjustment period of 7 to 24 years if deflation is to be avoided in all periphery countries. The actual value within this range depends heavily on Asia´s willingness/ability to boost domestic demand and give up the undervaluation of its currencies. Results are supposed to represent conservative estimates with the actual values lying close to, while possibly slightly beyond, the given ones. Including differences in the production structure and valuation effects would improve the model. A dynamic approach, including sticky prices, a limited exchange rate pass-through and monetary and fiscal instruments would give a more sophisticated view on the subject.

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Appendix A

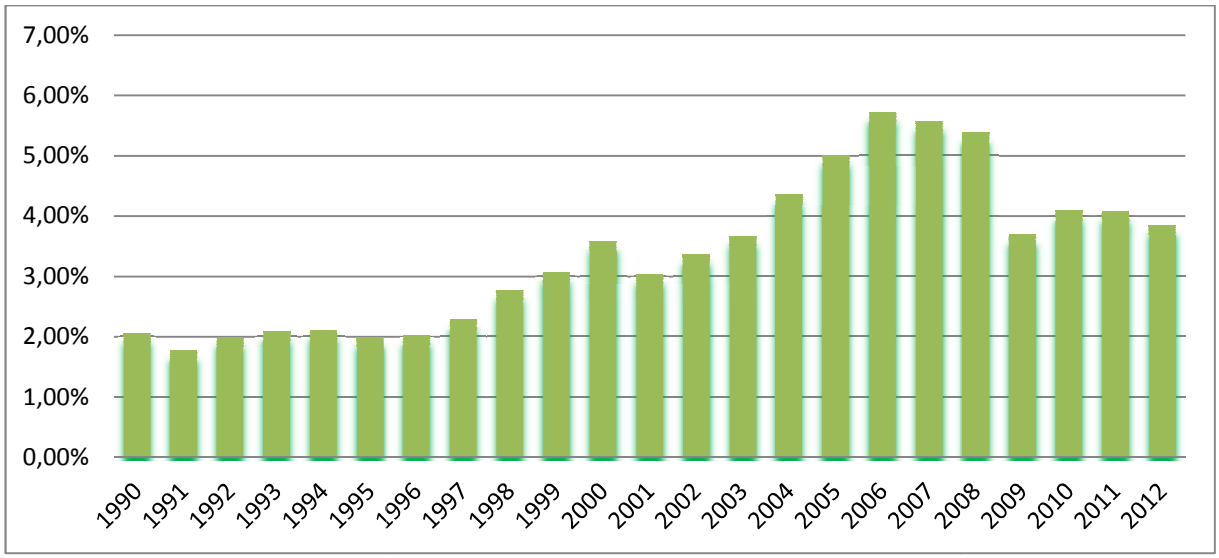

Figure 1: Global imbalances as percent of world GDP 1990-2012 (sum of absolute values of CA - deficits and surpluses)

Source: IMF World Economic Outlook Database, December 2012; (2012 values are estimates)

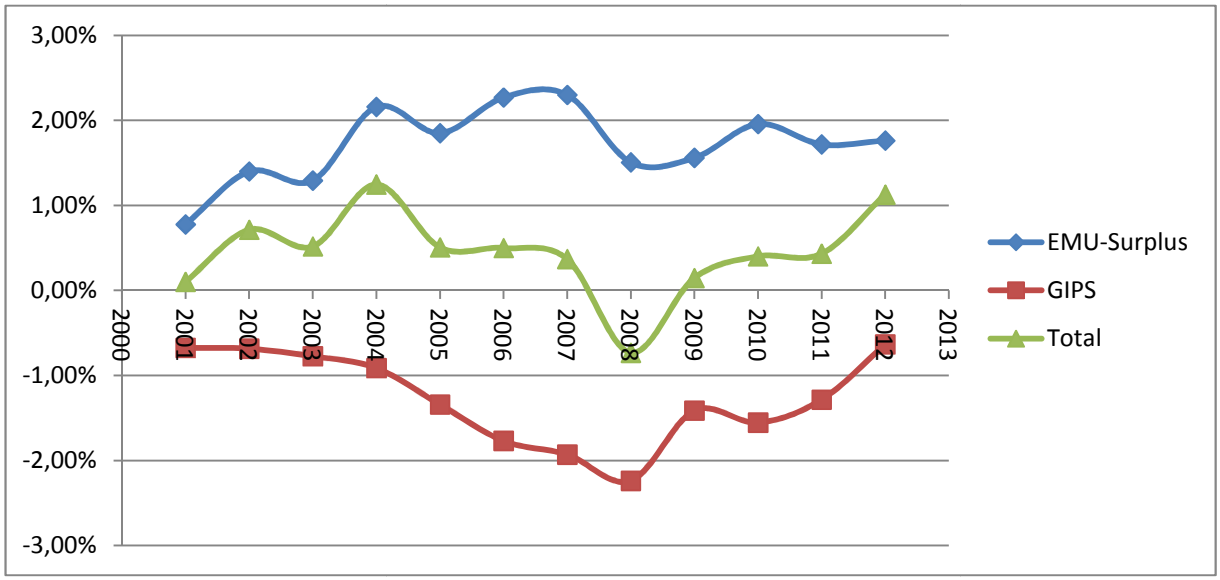

Figure 2: Current Account Imbalances as percentage of Euro - Zone GDP 2001-2012

Source: IMF World Economic Outlook Database, December 2012; (2012 values are estimates)

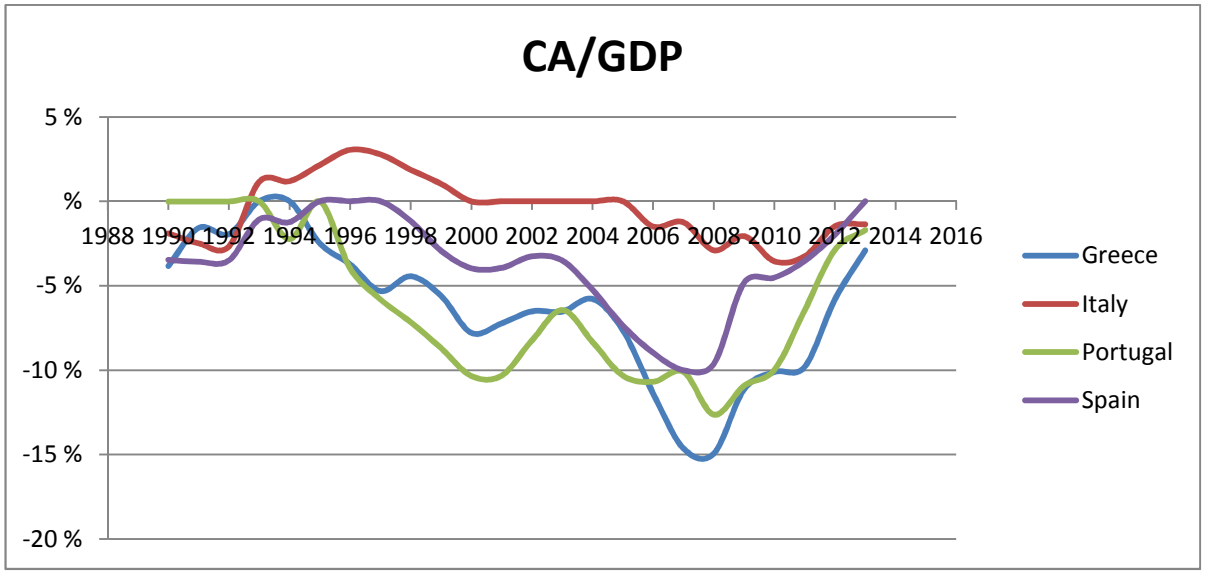

Figure 3: Current Account/GDP ratio "GIPS countries" 1990-2013

Source: IMF World Economic Outlook Database, December 2012; (2012/2013 values are estimates)

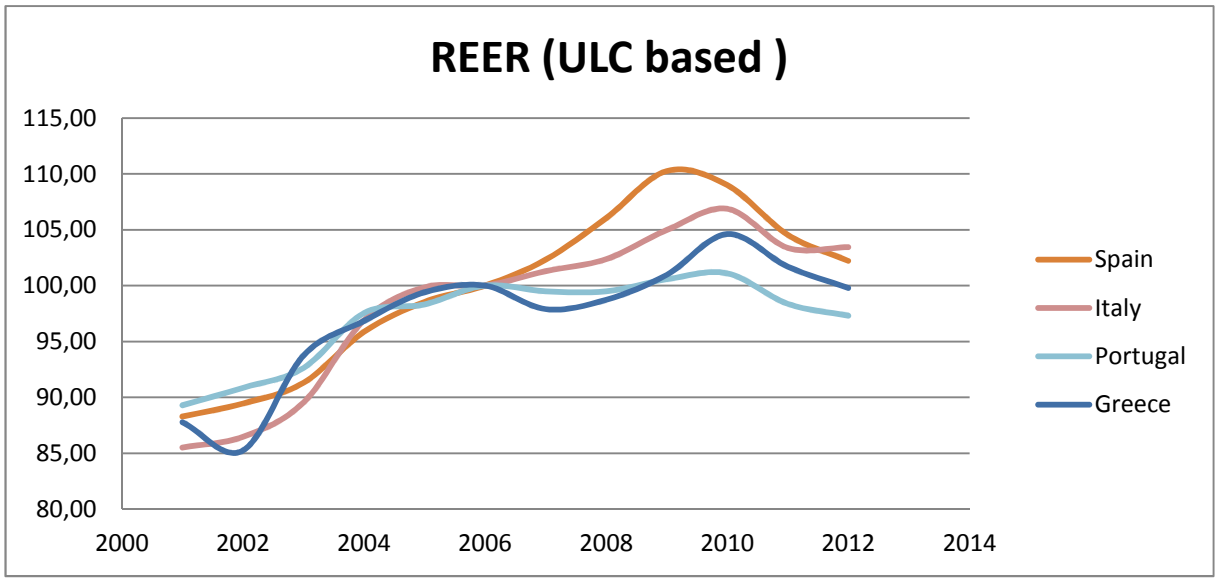

Figure 4: Real Effective Exchange Rates based on Unit Labor Costs: GIPS countries 2000 - 2012;

Source: Eurostat, December 2012;

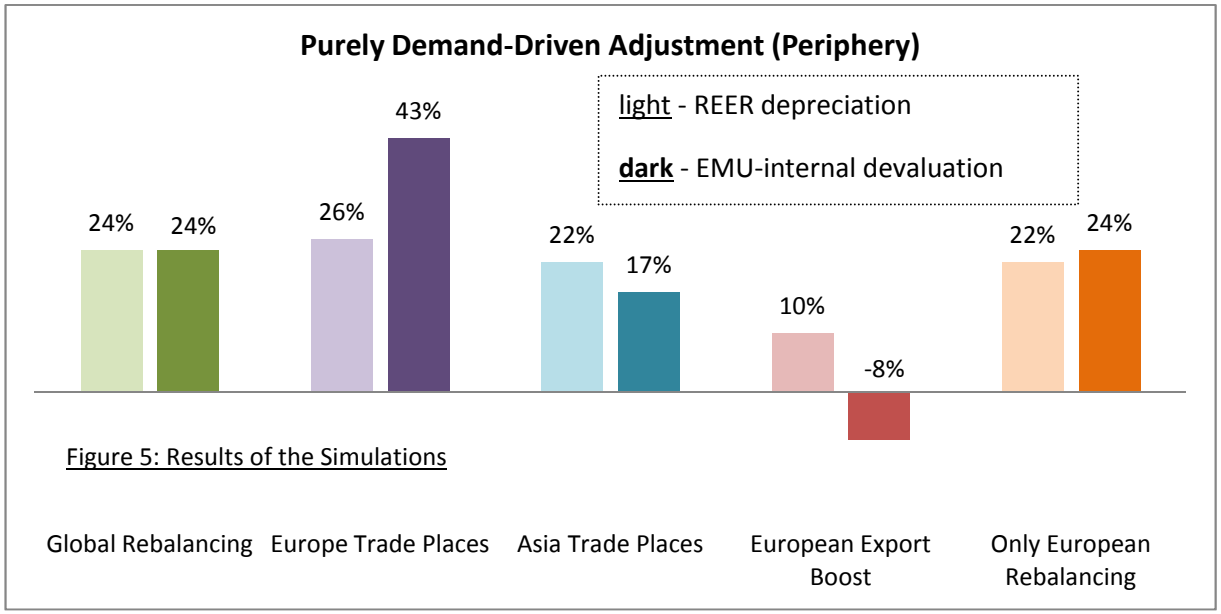

Figure 5: Results w/o supply-side adjustments for Eurozone-periphery

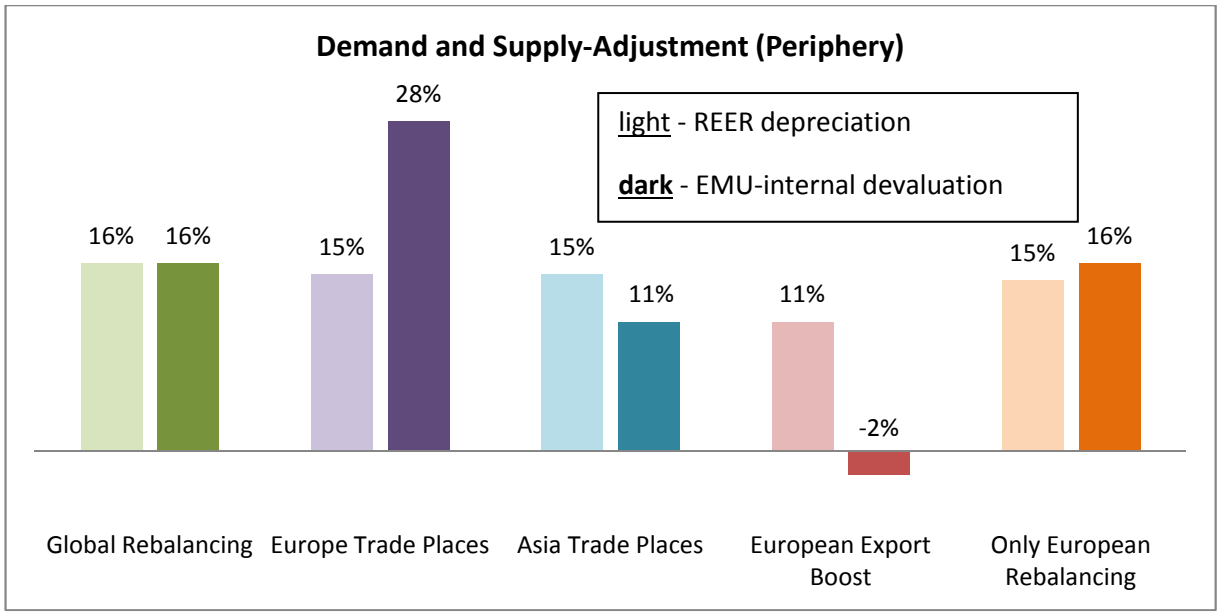

Figure 6: Results with supply-side adjustments for Eurozone-periphery

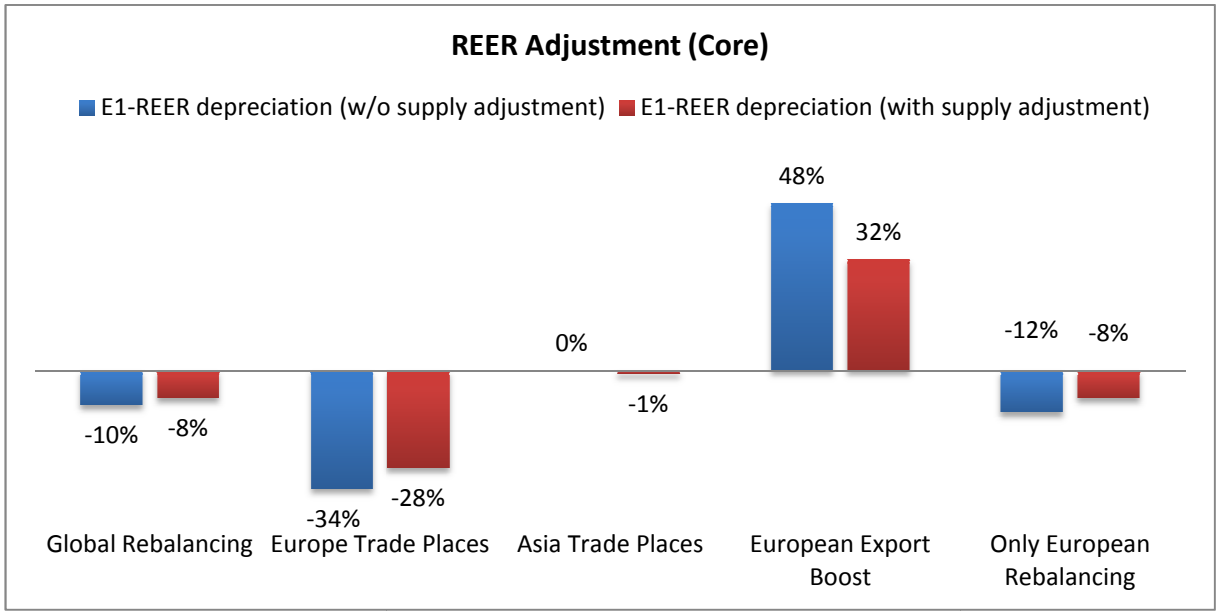

Figure 7: Results - Real effective exchange rate adjustments for Eurozone-core

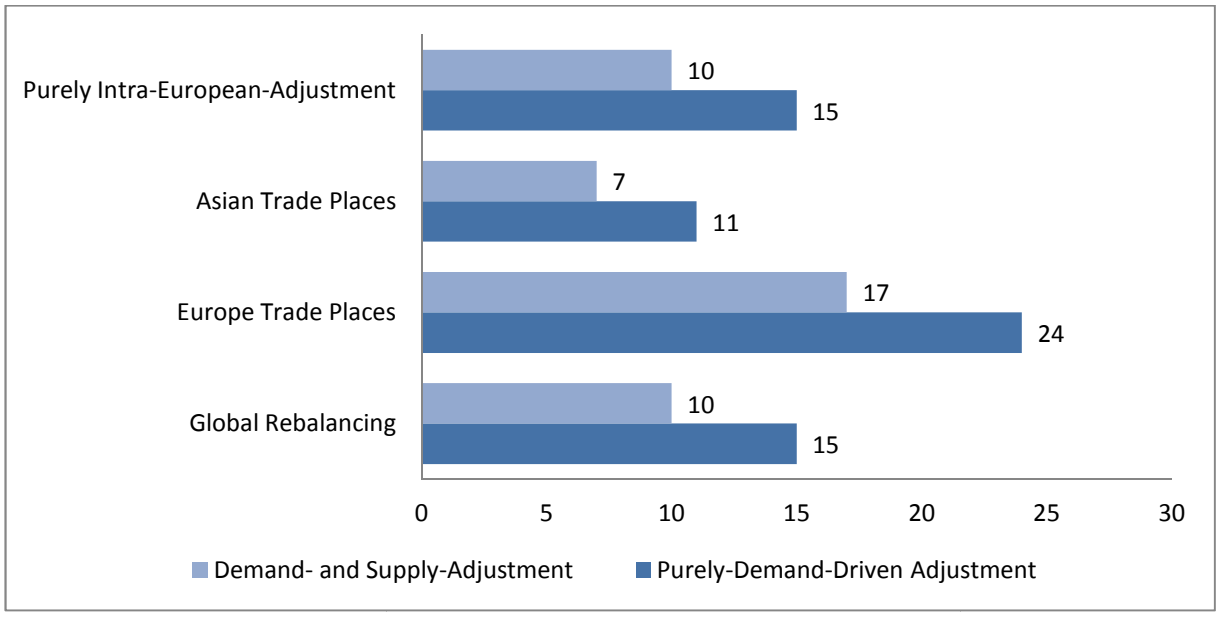

Figure 8: Length of the Adjustment Period

Appendix B

General Equilibrium

(GE1):

$$1 = a_1 \frac{1}{a_1 + a_2 {t_{U,E1}}^{1-\varphi} + a_3 {t_{U,A}}^{1-\varphi} + a_4 {t_{U,E2}}^{1-\varphi}} (1 + rf_U - ca_U)$$

$$+ b_1 \frac{1}{b_1 + b_2 {t_{U,E1}}^{1-\varphi} + b_3 {t_{U,A}}^{1-\varphi} + b_4 {t_{U,E2}}^{1-\varphi}} \left(\left[\left(\frac{\omega_{E1}}{\omega_U} \right)^{-v} t_{ue1} \frac{A_T^{E1}}{A_T^U} \right]^{\frac{1}{1-v}} + rf_{E1} - ca_{E1} \right)$$

$$+ c_1 \frac{1}{c_1 + c_2 {t_{U,E1}}^{1-\varphi} + c_3 {t_{U,A}}^{1-\varphi} + c_4 {t_{U,E2}}^{1-\varphi}} \left(\left[\left(\frac{\omega_A}{\omega_U} \right)^{-v} t_{ua} \frac{A_T^A}{A_T^U} \right]^{\frac{1}{1-v}} + rf_A - ca_A \right)$$

$$+ d_1 \frac{1}{d_1 + d_2 {t_{U,E1}}^{1-\varphi} + d_3 {t_{U,A}}^{1-\varphi} + d_5 {t_{U,E2}}^{1-\varphi}}$$

$$* \left(\left[\left(\frac{\omega_{E2}}{\omega_U} \right)^{-v} t_{ue2} \frac{A_T^{E2}}{A_T^U} \right]^{\frac{1}{1-v}} - rf_U - rf_{E1} - rf_A + ca_U + ca_{E1} + ca_A \right)$$

(GE2):

$$\left[\left(\frac{\omega_{E1}}{\omega_U} \right)^{-v} t_{ue1} \frac{A_T^{E1}}{A_T^U} \right]^{\frac{1}{1-v}} = a_2 \frac{1}{a_1 {t_{U,E1}}^{\varphi-1} + a_2 + a_3 {t_{E1,A}}^{1-\varphi} + a_4 {t_{E1,E2}}^{1-\varphi}} (1 + rf_U - ca_U)$$

$$+ b_2 \frac{1}{b_1 {t_{U,E1}}^{\varphi-1} + b_2 + b_3 {t_{E1,A}}^{1-\varphi} + b_4 {t_{E1,E2}}^{1-\varphi}} \left(\left[\left(\frac{\omega_{E1}}{\omega_U} \right)^{-v} t_{ue1} \frac{A_T^{E1}}{A_T^U} \right]^{\frac{1}{1-v}} + rf_{E1} - ca_{E1} \right)$$

$$+ c_2 \frac{1}{c_1 {t_{U,E1}}^{\varphi-1} + c_2 + c_3 {t_{E1,A}}^{1-\varphi} + c_4 {t_{E1,E2}}^{1-\varphi}} \left(\left[\left(\frac{\omega_A}{\omega_U} \right)^{-v} t_{ua} \frac{A_T^A}{A_T^U} \right]^{\frac{1}{1-v}} + rf_A - ca_A \right)$$

$$+ d_2 \frac{1}{d_1 {t_{U,E1}}^{\varphi-1} + d_2 + d_3 {t_{E1,A}}^{1-\varphi} + d_4 {t_{E1,E2}}^{1-\varphi}}$$

$$* \left(\left[\left(\frac{\omega_{E2}}{\omega_U} \right)^{-v} t_{ue2} \frac{A_T^{E2}}{A_T^U} \right]^{\frac{1}{1-v}} - rf_U - rf_{E1} - rf_A + ca_U + ca_{E1} + ca_A \right)$$

(GE3):

$$\left[\left(\frac{\omega_A}{\omega_U}\right)^{-v} t_{u,A}\ \frac{A_T^A}{A_T^U}\right]^{\frac{1}{1-v}} = a_3 \frac{1}{a_1 {t_{U,A}}^{\varphi-1} + a_2 {t_{A,E1}}^{1-\varphi} + a_3 + a_4 {t_{A,E2}}^{1-\varphi}} (1 + rf_U - ca_U)$$

$$+ b_3 \frac{1}{b_1 {t_{U,A}}^{\varphi-1} + b_2 {t_{A,E1}}^{1-\varphi} + b_3 + b_4 {t_{A,E2}}^{1-\varphi}} \left(\left[\left(\frac{\omega_{E1}}{\omega_U}\right)^{-v} t_{ue1}\ \frac{A_T^{E1}}{A_T^U}\right]^{\frac{1}{1-v}} + rf_{E1} - ca_{E1} \right)$$

$$+ c_3 \frac{1}{c_1 {t_{U,A}}^{\varphi-1} + c_2 {t_{A,E1}}^{1-\varphi} + c_3 + {t_{A,E2}}^{1-\varphi}} \left(\left[\left(\frac{\omega_A}{\omega_U}\right)^{-v} t_{ua}\ \frac{A_T^A}{A_T^U}\right]^{\frac{1}{1-v}} + rf_A - ca_A \right)$$

$$+ d_3 \frac{1}{d_1 {t_{U,A}}^{\varphi-1} + d_2 {t_{A,E1}}^{1-\varphi} + d_3 + d_4 {t_{A,E2}}^{1-\varphi}}$$

$$* \left(\left[\left(\frac{\omega_{E2}}{\omega_U}\right)^{-v} t_{ue2}\ \frac{A_T^{E2}}{A_T^U}\right]^{\frac{1}{1-v}} - rf_U - rf_{E1} - rf_A + ca_U + ca_{E1} + ca_A \right)$$

(GE4):

$$z_U = \left[\left(\frac{1-\gamma}{\gamma}\right) \left[(a_1 + a_2 {t_{U,E1}}^{1-\varphi} + a_3 {t_{U,A}}^{1-\varphi} + a_4 {t_{U,E2}}^{1-\varphi})^{\frac{1-\theta}{\varphi-1}} \right] (1 + rf_U - ca_U) \left(\frac{A_N^U}{A_T^U}\right)^{\frac{1}{v-1}} \right]^{\%}$$

(GE5):

$$z_{E1} = \left[\begin{array}{l} \left(\frac{1-\gamma}{\gamma}\right) \left[(b_1 {t_{U,E1}}^{\varphi-1} + b_2 + b_3 {t_{E1,A}}^{1-\varphi} + b_4 {t_{E1,E2}}^{1-\varphi})^{\frac{1-\theta}{\varphi-1}} \right] \\ * \left(1 + \left[\left(\frac{\omega_{E1}}{\omega_U}\right)^{-v} t_{U,E1}\ \frac{A_T^{E1}}{A_T^U}\right]^{\frac{-1}{1-v}} (rf_{E1} - ca_{E1}) \right) \left(\frac{A_N^{E1}}{A_T^{E1}}\right)^{\frac{1}{v-1}} \end{array} \right]^{\%}, \qquad \% = \frac{1-v}{v+(1-v)\theta}$$

(GE6):

$$z_A = \left[\begin{array}{c} \left(\frac{1-\gamma}{\gamma}\right) \left[(c_1 {t_{U,A}}^{\varphi-1} + c_2 {t_{A,E1}}^{1-\varphi} + c_3 + c_4 {t_{A,E2}}^{1-\varphi})^{\frac{1-\theta}{\varphi-1}} \right] \\ * \left(1 + \left[\left(\frac{\omega_A}{\omega_U}\right)^{-v} t_{U,A} \frac{A_T^A}{A_T^U} \right]^{\frac{-1}{1-v}} (rf_A - ca_A) \right) \left(\frac{A_N^A}{A_T^A}\right)^{\frac{1}{v-1}} \end{array} \right]^{\%}$$

(GE7):

$$z_{E2} = \left[\begin{array}{c} \left(\frac{1-\gamma}{\gamma}\right) \left[(d_1 {t_{U,E2}}^{\varphi-1} + d_2 {t_{E2,E1}}^{1-\varphi} + d_3 {t_{E2,A}}^{1-\varphi} + e_4)^{\frac{1-\theta}{\varphi-1}} \right] \\ * \left(1 + \left[\left(\frac{\omega_{E2}}{\omega_U}\right)^{-v} t_{U,E2} \frac{A_T^{E2}}{A_T^{E2}} \right]^{\frac{-1}{1-v}} (-rf_U - rf_{E1} - rf_A + ca_U + ca_{E1} + ca_A) \right) \left(\frac{A_N^{E2}}{A_T^{E2}}\right)^{\frac{1}{v-1}} \end{array} \right]^{\%}$$

List of Symbols

Symbol	Description
C^i	Consumption in region *i*
C_T^i	Consumption of tradable goods in region *i*
C_N^i	Consumption of non-tradable goods in region *i*
γ	Share of tradable goods in consumption
C_j^i	Consumption of the tradable good from region *j* in region *i*
$a_i, i = 1-5$	Consumption preferences of U towards tradable goods from region *i*
$b_i, i = 1-5$	Consumption preferences of E1 towards tradable goods from region *i*
$c_i, i = 1-5$	Consumption preferences of A towards tradable goods from region *i*
$d_i, i = 1-5$	Consumption preferences of E2 towards tradable goods from region *i*
P_C^i	Consumer price index region *i*
P_T^i	Tradable goods price index region *i*
P_N^i	Non-tradable goods price index region *i*
θ	Elasticity of substitution between tradable and non-tradable goods
φ	Elasticity of substitution between tradable goods
P_i	Price of the tradable good from region *i*
$t_{i,j}$	Terms of trade region *i,j*
$q_{i,j}$	Bilateral real exchange rate region *i,j*
REER	Real effective exchange rate
RER	Real exchange rate
Y_N^i	Non-tradable output region *i*
Y_T^i	Tradable output region *i*
CA^i	Current account region *i*
ca^i	Current account region i normalized over US tradable GDP
F^i, NIIP	International investment position region *i*
f^i	International investment position region *i* normalized over US tradable GDP
r	Nominal interest rate
z_i	Relative price of the non-tradable to the tradable good in region *i*
A_T^i	Total factor productivity tradable output region *i*
A_N^i	Total factor productivity non-tradable output region *i*
L_i	Labor input region *i*

v	Marginal productivity of labor
w_i	Wage rate region *i*
$\sigma_{i,j}$	Relative tradable output region *i,j*
$\sigma_{N,i}$	Relative non-tradable to tradable output region *i*

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