# Rebalancing in the Eurozone - Implications for the real exchange rate, terms of trade and welfare
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**Abstract**

The article extends the framwork used by Obstfeld and Rogoff (2000, 2004, 2005) to analyze the US current account deficit to include intertemporal optimization. Using changes to the TARGET2 balances in the beginning of the soverign debt crisis in 2011/2012 as an approximation to the current account between surplus and deficit countries in the Eurozone, the article considers the implication for relative prices between surplus and deficit countries of the current account closing. The analysis shows that if current accounts would have gone to zero over a five year period after 2012, this would imply large inflation differences between the two groups of countries.

# Introduction

Economists agree that the Eurozone's periphery countries' lack of competitiveness is one of the challenges facing the Eurozone[1]After countries in the periphery adopted the Euro, capital flowed to these countries from the core resulting in an appreciated real exchange rate and reduced competitiveness. When the sovereign debt crisis started in late 2009/early 2010 this capital flow reversed making it difficult for local enterprises to obtain credit in their banks.

As the capital flow from the core reversed, the European Central Bank (ECB) initiated extensive refinancing operations. However, these operations were insufficient in some countries. Among others, Greece and Portugal initiated emergency loans through their national central banks. According to Sinn and Wollmershäuser (2012), these extra financing operations have financed purchases of foreign produced goods and assets. Through the Target2[2] system in the ECB, the transactions resulting from these purchases have manifested as Target2 balances. Sinn and Wollmershäuser (2012) argue that a change in a country's Target2 balance represents its balance of payments with the rest of the Eurozone. Hence, Target2 balances may result from deficits/surpluses in either the current account or the financial account of a country. Under the assumption that the balance of payments is equal to the current account, the paper answers the three following questions related

[1]The Eurozone in this article is narrowed down to two regions: the core countries and the periphery countries. The *core* countries consists of Finland, Germany, Luxembourg and the Netherlands. The *periphery* countries consists of Austria, Belgium, France, Greece, Ireland, Italy, Portugal and Spain. The core countries are those with positive Target2 balances.

[2]Target2 is a payment system in the ECB and is explained in Sinn and Wollmershäuser (2012).

to the rebalancing[3] of the Eurozone:

- Can the observed current account deficits be explained by a stylized flexible price model?
- What are the consequences of a rebalancing for the real exchange rate between the core and the periphery?
- What are the possible welfare consequences of a rebalancing?

To answer these questions, an intertemporal general equilibrium model is set up. The world consists of two regions which are endowed with two goods each -one traded and one nontraded good. The model setup is similar to that of Obstfeld and Rogoff (2000, 2004, 2005). Their setup leaves out the intertemporal descision at the benefit of including home bias. The paper incorporates the intertemporal decision, although at the cost of not including home bias. Including the intertemporal decision allows for comparisons of different adjustment paths and how these affect welfare.

Contrasting the observed current accounts from the Target2 data with the predictions from the calibrated model, the calibration exercise concludes that the model can not explain observed current accounts. In particular, it suggests that consumption of traded goods in the periphery region is too high. This in turn leads to an over appreciated price level and lack of competitiveness.

Proceeding from this, the paper considers potential paths for the development of the current account (which are consistent with the observed current account) and their implications for the real exchange rate and welfare. Because the implied consumption paths are different from those implied by utility maximization, the allocations are referred to as suboptimal. Assuming that current accounts would go to zero over a five year period following 2012, the framework predicts that a significant real exchange rate adjustment would take place. The price level in core countries would rise by up to 9% more than in periphery countries annually, posing a significant challenge

[3]The Eurozone is said to be rebalanced when the Target2 balances are zero. That is, at their pre-crisis level.

to the conduct of monetary policy. This appreciation of the core countries' real exchange rate relative to the periphery is driven by increasing nontraded goods prices in the core relative to the periphery. If one considers housing as a nontraded good, this evolution of prices can help explain why Greeks bought German housing in the midst of the sovereign debt crisis. If investors expect such an evolution of nontraded good prices, one would expect to observe a shift in investment from the periphery nontraded sector to the nontraded sector in the core. This flow of capital could take the form of a "capital flight" from the periphery to the core.

The welfare consequences of this rebalancing is found to be small, although being larger for the periphery region than the core region.

## Target2 Balances

Sinn and Wollmershäuser (2012) identify three possible interpretations of the Target balances.

- TARGET stands for *Trans-European Automated Real-Time Gross Settlement Express Transfers* and is the European settlement system for transactions between commercial banks in the Euro countries.

- Target balances represent claims and liabilities a national central bank in the Eurozone has to the Eurosystem.

- Target balances measure accumulated deficits and surpluses in each Euro country's balance of payments with other Euro members. Target liabilites are the share of the original central bank money created by a national central bank, which exceeds the stock of central bank money available in this national central bank's jurisdiction. These central bank money were used for a net purchase of goods and assets from other Euro countries. Oppositely, a target claim is the surplus stock of central bank money in excess of that created by the country's own central bank. This surplus arises from the net sale of goods and assets to other Euro countries.

Central bank money is cash held by banks and the rest of the economy and money which commercial banks have in their account at the national central bank. Central bank money is equivalent to the monetary base. It is the third definition which implies that changes in Target2 balances represent the balance of payments between a Euro country and the rest of the monetary union. Auer (2012) empirically confirms this interpretation. After 2007, the correlation between the current account and changes in Target2 balances increased indicating that the current account plays a greater role in explaining Target2 changes during the crisis. However, changes in the Target2 balance of a national central bank may also be the result of deficits and surpluses in the country's financial account.

In the years before the crisis, the Target2 balances were close to zero before increasing when the financial crisis struck and the ECB initiated liquidity operations. Sinn and Wollmershäuser (2012) argue that this implies that the central banks' refinancing operations have supported the current account deficits of the periphery after the flow of capital from the core stopped. Under normal circumstances, the periphery would run up debt to the core to finance the current account deficits. Instead, this form of financing has been replaced by central bank financing.

Recognizing that interpreting changes in Target2 balances as current accounts may overstate the size of current account deficits, The article uses changes in the Target2 balances as an approximation to the current account between the two regions, recognizing that this may overstate the current account deficits. However, the Target2 balances are a good approximation for the net asset positions between Eurozone countries. Following the standard interpretation of accumulated current account deficits as debt, the theoretical analysis uses the Target2 balances as a measure of the amount borrowed by the periphery. In line with this interpretation, the core receives a bond from the periphery as promise of future repayment. The stock of bonds is then the regions' net asset position.

# Framework

To analyze the research questions, the article uses a framework similar to that of Obstfeld and Rogoff (2000, 2004, 2005). The world consists of two regions, Home (H) and Foreign (F), which are endowed with two goods each. One of the goods is a nontradable good and the other is a country specific tradable good. Preferences over goods in the two regions are identical and given by

$$C_t = [\gamma^{\frac{1}{\theta}} C_{T,t}^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_{N,t}^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \tag{1}$$

where

$$C_{T,t} = [\alpha^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}. \tag{2}$$

$\theta$ and $\eta$ represent the elasticity of substitution between nontraded goods and the traded goods aggregate and between the two traded goods respectively. The preference structure gives the following price indices

$$p_t = [\gamma p_{T,t}^{1-\theta} + (1-\gamma) p_{N,t}^{1-\theta}]^{\frac{1}{1-\theta}} \ , \ p_{T,t} = [\alpha + (1-\alpha) p_{F,t}^{1-\eta}]^{\frac{1}{1-\eta}} \tag{3}$$

The formulation in terms of Home and Foreign is made for simplicity and clearer subscripts. In the analysis, the periphery is assumed to be the Home region. Following standard notation, a star (*) indicates Foreign (core) variables, and subscript F, the core's tradable good. All prices are in units of the periphery's tradable good and the law of one price holds for tradable goods. Because preferences are identical, the basket of traded goods has the same price in both countries and the law of one price holds for this basket. However, as the two countries potentially have different wealth positions and endowments of nontraded goods, the law of one price does not necessarily

hold for aggregate consumption. All goods are perishable and last one period. This implies that consumption of the nontraded good is forced to follow the endowment process in each country. However, consumers may smooth their consumption of tradable goods through trade. Given preferences, the price of nontraded goods is given by

$$\frac{p_{N,t}}{p_{T,t}} = \left( \frac{1-\gamma}{\gamma} \frac{C_{T,t}}{Y_{N,t}} \right)^{\frac{1}{\theta}} . \tag{4}$$

Consumption in each period is determined by maximizing life-time utility with a constant elasticity of intertemporal substitution period utility function. This results in the following Euler equation governing aggregate consumption

$$C_{t+1} = [\beta(1 + r_{t,t+1})]^{\sigma} \left( \frac{p_t}{p_{t+1}} \right)^{\sigma} C_t. \tag{5}$$

Finally, markets for the two traded goods clear

$$C_{H,t} + C^*_{H,t} = Y_{H,t} \ , \ C_{F,t} + C^*_{F,t} = Y_{F,t} \tag{6}$$

The growth rate of endowments follow an AR(1) process.

Both consumers live a finite number of periods, T. A finite horizon implies that the Target2 balances will be zero when the model ends. As the Target2 balances were close to zero in the run up to the crisis, this seems as a reasonable choice. Choosing an infinite horizon would cause the assets positions to continue growing, which may seem unreasonable if they represent any of the risks claimed by Sinn and Wollmershäuser (2012).

## Prices with Exogenous Current Account

To study the case of suboptimal consumption allocation, the periphery's current account follows an exogenous process $\{CA_t\}_{t=0}^{T-1}$. To match the observed Target2 deficits in figure 1, the periphery's current account is assumed to be negative initially. In this regime the consumption path will be entirely exogenous compared to previously when the consumers chose $\{C_{T,t}\}_{t=0}^{T_1}$ to maxi-

mize life-time utility. Because the current account is exogenous, expenditure on traded goods is fixed at $r_{t-1,t}Q_t + Y_{H,t} - CA_t$ and $-r_{t-1,t}Q_t + p_{F,t}Y_{F,t} + CA_t$ for the periphery and the core respectively. Given these expenditures the relative price of the core's tradable good and the interest rate do not change. This is because even though the consumers' expenditure on tradable goods is fixed, their expenditure allocation between the periphery's and the core's good is not altered. Hence, the relative demand for the periphery's and the core's good is unchanged, and the relative price is the same.

On the other hand, changing the path of the current account has implications for the relative prices of nontraded goods. A current account deficit in one region can be seen as a transfer of resources from the surplus region. This transfer increases (reduces) aggregate expenditure in the region running a deficit (surplus) and hence demand for the tradable goods and the nontraded good increases (falls). Because the supply of the nontraded good is inelastic at $Y_{N,t}$ ($Y^*_{N,t}$), the price of the nontraded good increases (falls) to clear the market. This is the *transfer effect* discussed in chapter 4.5.5.4 in Obstfeld and Rogoff (1996).

In the analysis to come, it will turn out that the periphery optimally runs a current account surplus to repay its debt. This current account surplus is due to the finite horizon and the terminal condition[4]. One implication is that when going from the optimal to the suboptimal consumption path the transfer effect will be larger and the periphery (core) will have a higher (lower) aggregate price level and thus face a stronger (weaker) real exchange rate than it would have on the optimal path. A second implication is that the relative price of nontradables will decline over time in the periphery, and increase in the core. This price decline is due transfers decreasing as the current account eventually turns positive and the debt is repaid. At the same time, the aggregate price level falls and the periphery's real exchange rate depreciates from a level that was "too high" compared the optimal path.

Equation (4) gives the price of the nontraded good on the optimal con-

[4]The qualitative result does not change when moving to an infinite horzion. A transversality condition replaces the terminal condition and the periphery still has to run current account surpluses to pay back its initial debt. For details, see math appendix of Obstfeld and Rogoff (1996)

sumption path. By substituting the optimal value of $C_T$ with the value of $C_T$ on the suboptimal adjustment path one finds the price of the nontraded good on the suboptimal adjustment path. Letting a hat ($\hat{}$) indicate the variables' value on the suboptimal adjustment path, the misalignment of the nontraded good price at time $t$ can be calculated by

$$\frac{\hat{p}_{N,t}}{p_{N,t}} = \left(\frac{\hat{C}_{T,t}}{C_{T,t}}\right)^{\frac{1}{\theta}}. \tag{7}$$

Taking logarithms and linearizing the above equation gives a useful rule of thumb for the misalignment in the price of the nontraded good. If traded goods consumption deviates from its optimal level by $k_{T,t}$ percent, the price of the nontraded good deviates by approximately

$$k_{N,t} \approx \frac{1}{\theta} k_{T,t} \tag{8}$$

percent. By using equation (7), one can separate two effects that cause changes in the price of nontradable goods on the suboptimal path. Using equation (7) for period $t$ and $t+1$, the change in the price of the nontraded good is given by

$$\frac{\hat{p}_{N,t+1}}{\hat{p}_{N,t}} = \left(\frac{\hat{C}_{T,t+1}/C_{T,t+1}}{\hat{C}_{T,t}/C_{T,t}}\right)^{\frac{1}{\theta}} \frac{p_{N,t+1}}{p_{N,t}} \tag{9}$$

The last term on the right hand side reflects changes in the price on the optimal path. On the optimal path, as seen in the appendix, the prices only change in response to changes in supply. On the other hand, the first term reflects the suboptimal allocation of traded goods consumption. Hence, this term reflects price changes due to the transfer effect. Using equation 8 one can approximate the excess price changes resulting from suboptimal consumption allocation to be $k_{N,t+1} - k_{N,t} = \frac{1}{\theta}(k_{T,t+1} - k_{T,t})$. From this equation, we see that the elasticity of substitution between traded goods and the nontraded good plays an important role in determining the real exchange rate changes.

Although the current account is taken as given, the regions have to satisfy

their budget constraints. Net foreign assets of the periphery evolve according to $Q_{t+1} - Q_t = CA_t$ which implies that the sequence of current accounts must satisfy

$$\Sigma_{t=0}^{T-1} CA_t = -Q_0.$$

If the periphery is a net debtor, $Q_0 < 0$, the periphery must run current account surpluses sufficient to pay back the core. To obtain closed form solutions, the current account closes linearly over $\tau$ periods and then grows at a rate $g^{CA}$. That is, the period $t$ current account of the periphery is given by

$$CA_t = \begin{cases} CA_0 - \frac{CA_0}{\tau - 1} t & \text{if } 0 \leq t \leq \tau - 1 \\ (1 + g^{CA})^{t-\tau} CA_\tau & \text{if } \tau \leq t \leq T - 1 \end{cases} \tag{10}$$

The necessary current account position at time $\tau$ is found by substituting for $CA_t$ in the budget constraint. Doing so results in[5]

$$CA_\tau = -\frac{Q_0 + \frac{\tau CA_0}{2}}{\Sigma_{t=\tau}^{T-1} (1 + g^{CA})^{t-\tau}}$$

The intuition is clear. The more negative the asset position is and the longer the region uses to balance the current account, the larger is the necessary current account payments from time $\tau$ to $T-1$. Finally, $CA_\tau$ is decreasing in $g^{CA}$ reflecting that the necessary payment at time $\tau$ is smaller if the payments grow at a higher rate.

[5]The derivations uses the formula

$$\Sigma_{j=1}^{\tau-1} j = \frac{(\tau - 1)\tau}{2}$$

# Parametrization and Calibration

## Parametrization

As showed previously, the changes in the real exchange rate and terms of trade depend crucially on the elasticity of substitution between traded and nontraded goods and the between the two traded goods. The equilibrium is described when the elasticity of intertemporal substitution is equal to the elasticity of substitution between the traded goods basket and the nontraded good. That the two elasticities are set equal may seem arbitrary, however studies show that it may not be implausible.

Research estimating the elasticity of intertemporal subsitution find values of $\sigma$ between zero and unity. For example Hall (1988) estimates the elasticity of intertemporal substitution based on the relationship between aggregate consumption growth and the interest rate and concludes: "... the evidence points in the direction of a low value for the intertemporal elasticity. The value may be even be zero and is probably not above 0.2". On the other hand, research based on calibrating real business cycle models to fit observed relationships in data require $\sigma$ to be close to unity. Lucas (1990) argues that $\sigma < 0.5$ is implausible as that would imply real interest rate differences between countries that are much larger than those observed, even $\sigma = 0.5$ may be too low. Another study arguing for a higher elasticity of intertemporal substitution is Jones et al. 2000. In a real business cycle model with endogenous growth, $\sigma = 0.8$ gives the best fit to data. Obstfeld (1994)) concludes

that $\sigma = 0.5$ is a reasonable estimate of the intertemporal elasticity of substitution. Based on this research, the article uses an elasticity of intertemporal substitution, $\sigma$, of 0.5.

Obstfeld and Rogoff (2005) use elsticities of substitution between nontraded and traded goods ($\theta$) of 2 and 3 to obtain conservative estimates of the needed depreciation of the US real exchange rate. Ostry and Reinhart (1992) estimates the elasticity of substitution between tradable and nontradable goods, the intertemporal elasticity of substitution and the utility discount factor in a model where the preference structure is similar to the one presented earlier. They estimate $\theta$ to be between 0.66 and 1.28, with most estimates above unity. $\sigma$ is estimated to be between 0.37 and 0.80 and $\beta$ between 0.940 and 0.995. Most notably, the estimates of $\sigma$ are significantly different from zero. This is in stark contrast to the results of Hall (1988), where the intertemporal elasticity of substitution could not be said to be significantly different from zero. Hence, the existence of a nontradable good may explain why Hall's estimates failed to be significantly different from zero. Stockman and Tesar (1995) use values of 0.44, 0.50 and 0.96 for $\theta$, $\sigma$ and $\beta$ respectively when calibrating a "two sector - two country" model. Further, Tesar (1993) uses a value of $\theta$ equal to 0.44.

Based on the values chosen by others for the elasticity of intertemporal elasticity of substitution and the elasticity of substitution between the traded goods basket and the nontraded good, the assumption that they are equal seems plausible. Based on the reviewed studies and for analytical tractability, the article uses $\sigma = \theta = 0.5$. One could consider the model with unequal elasticities, but would then have to approximate the model around steady state. Hence, another advantage of choosing $\sigma = \theta$ is that it allows for global analysis of disequilibrium effects.

With respect to the elasticity of substitution between export and import goods, $\eta$, the empirical estimates varies more. The analysis makes use of an elasticity of substitution between the periphery and core good of 2. This value is in line with Obstfeld and Rogoff (2005). They report estimates of $\eta$ ranging from below one to way above 2. Choosing $\eta = 2$ is a compromise between the two sets of estimates. With $\eta = 2$, the elasticity of substitution

| Parameter | Value |
|---|---|
| $\beta$ | 0.96 |
| $\sigma = \theta$ | 0.50 |
| $\eta$ | 2.00 |
| $\alpha$ | 0.50 |
| $\gamma$ | 0.40 |

Table 1: Utility function parameters.

between the two traded goods is higher than between the traded goods basket and the nontraded good. This seems reasonable as traded goods are of similar nature, but potentially very different from nontraded goods.

Following Stockman and Tesar (1995), each period represents one year and thus the utility discount factor is set equal to 0.96. Further, the two regions put equal weight to consumption of the two tradable goods. Hence, $\alpha = 0.5$. A rough measure of how big the traded sector is compared to economy can be obtained by taking total GNP and subtracting public and private services plus construction. For OECD, Obstfeld and Rogoff (2000) find this to be "roughly 65%" for OECD countries. However, given the amount of nontradable goods that go into production of traded goods, e.g. transportation, this measure is likely to overestimate the relative size of the traded sector. In their article series on the US current account deficit, Obstfeld and Rogoff (2000, 2004, 2005) settle on a traded sector as a share of GDP of 25% for the US. Several of the countries in the sample are small open economies, e.g. the Netherlands, with a sizeable traded sector. Hence, following a golden mean, the relative size of the traded goods sector is set to 40%. In line with this, $\gamma = 0.4$. Table 1 summarizes the chosen parameter values.

# Calibration

The results are dependent on the ratios of different endowment types[6]. For example, the ratio of the periphery's endowment of the tradable good to the endowment of the nontraded good etc. Although these ratios are unobserv-

[6]See appendix B for derivations

able, they can be infered from the model under the assumption that the world behaves rationally and as modelled. Using the current account identity, the assumption on industry structure and the observed asset to GDP and current account to GDP ratios, the expenditure on traded goods can be infered. These values are all that are needed to infer the endowment ratios. Table summarizes the observed values and infered ratios. The assets to GDP ratios are calcuated as the Target2 balance of the region at the end of 2011 divided by GDP in current prices published by the International Monetary Fund (IMF). The current account to GDP ratio is calculated using the change in Target2 balances from the end of 2011 to the end of 2012 as an estimate of the current account in 2012. This change is approximately €170, from just below €800 to about €970. The numbers are found from figure 1, which can be found in the ECB's "Annual Target Report" (ECB (2013)). The ratio of the two regions' GDP is measured by 2011 GDP at constant prices adjusted for investment.

In the calculations, the assumption that individuals behave optimally and according to the model is critical. This may be reasonable when it comes to allocation of consumption between periphery and core traded goods, but the observed current accounts are likely not optimal (given the IMF's growth forecasts, the calculated ratio of periphery to core tradable endowment and the current debt position the periphery should, theoretically, run a current account surplus to smooth consumption of tradables optimally). Because the prices estimated from observed values will over (under) estimate the price of nontradables in the periphery (core) compared to the theoretically correct price, there will be a bias in the calculated ratios of each country's endowment of nontraded good to its traded good. However, I will use the estimates as a starting point.

A key feature of intertemporal utility maximization is that consumers are forward looking and adapt their consumption based on (expectations of) future income. Hence, the way income is modelled is crucial. IMF's projections in World Economic Outlook 2013[7] serves as the point of departure. In the

[7]IMF World Economic Outlook database: `http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/index.aspx`

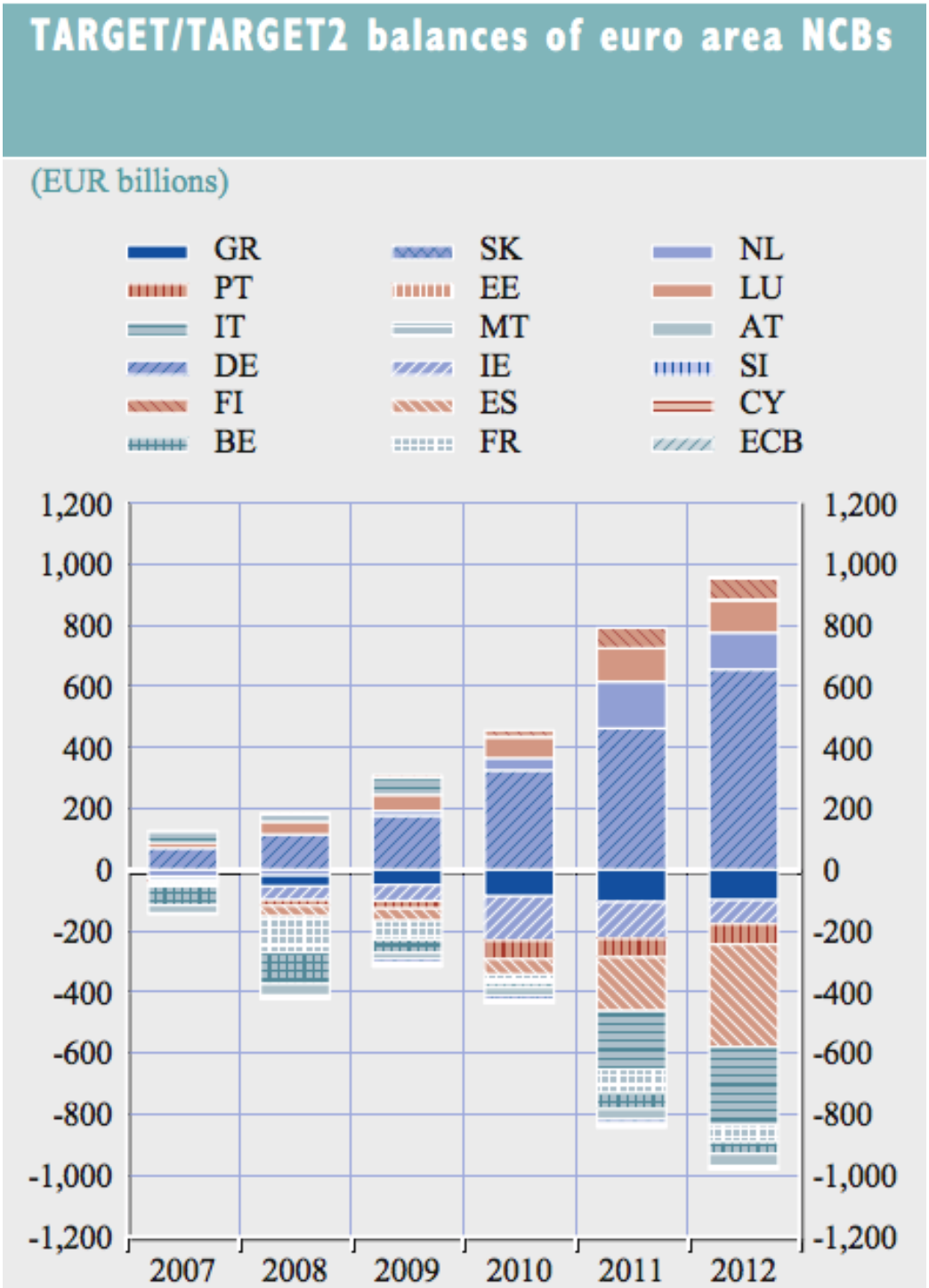


Figure 1: Target2 balances from 2007 to 2012. Source: ECB (2013)

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| **Observed values** (% of 2012 GDP) | Core | Periphery |
|---|---|---|
| Assets | 27.78 | -16.85 |
| Current account | 5.90 | -3.58 |
| Traded goods consumption | 46.7 | 43.12 |
| Relative size of GDP (Periphery/Core) | 1.65 | |
| **Infered ratios** | | |
| $Y_H/Y_F$ | | 2.72 |
| $Y_H/Y_N$ | | 0.71 |
| $Y_F/Y_N^*$ | | 0.61 |

Table 2: The first part of the table reports observed values of important variables in shares of 2012 GDP for the two regions. Using the equilibrium price equation for the traded good, the ratio of output in the two traded sectors is calculated as $Y_H/Y_F$. By using traded goods consumption as a share of GDP, the price of the nontraded good can be found. Further, using the assumption on industry structure, the ratio of output in each region's traded to nontraded sector can be calculated. These are the values $Y_H/Y_N$ and $Y_F/Y_N^*$ for the periphery and the core respectively. See the appendix section B for more details.

"World Economic Outlook"-database, the IMF projects GDP in current and constant prices, real GDP growth and investment as a share of GDP up until 2018. Future real GDP net of investment is calculated for the two regions by adjusting forecasted GDP at constant prices for investment. Growth rates are found by simply calculating the annual growth in each region's GDP net of investment [8]. The estimated growth rates are presented in table 3 and figure 2. Growth from 2011 to 2012 is included because it is needed to calculate the interest rate between 2011 and 2012. Finally, the growth rate from 2012 to 2013 is included because the consumers start to plan their consumption path at the beginning of 2012. This way the theoretical current account and the observed current account in 2012 can be compared.

After the growth forecasts end, the AR(1) process from section A.1 brings the two regions back to long run growth. This gives rise to two crucial parameters, namely the long run growth rate $\overline{g}$ and the persistence of real

[8] Another underlying assumption is that tradable GDP is constant at 40% of GDP. In particular, government spending as a share of GDP is constant.

| Forecasts (%) | | |
|---|---|---|
| Year | Core | Periphery |
| 11 - 12 | 1.82 | 0.46 |
| 12 - 13 | 0.40 | -0.15 |
| 13 - 14 | 1.28 | 0.61 |
| 14 - 15 | 1.13 | 1.23 |
| 15 - 16 | 1.11 | 1.39 |
| 16 - 17 | 1.07 | 1.54 |
| 17 - 18 | 0.93 | 1.60 |

Table 3: Forecasted year on year growth in GDP excluding investment. Source: IMF World Economic Outlook database.

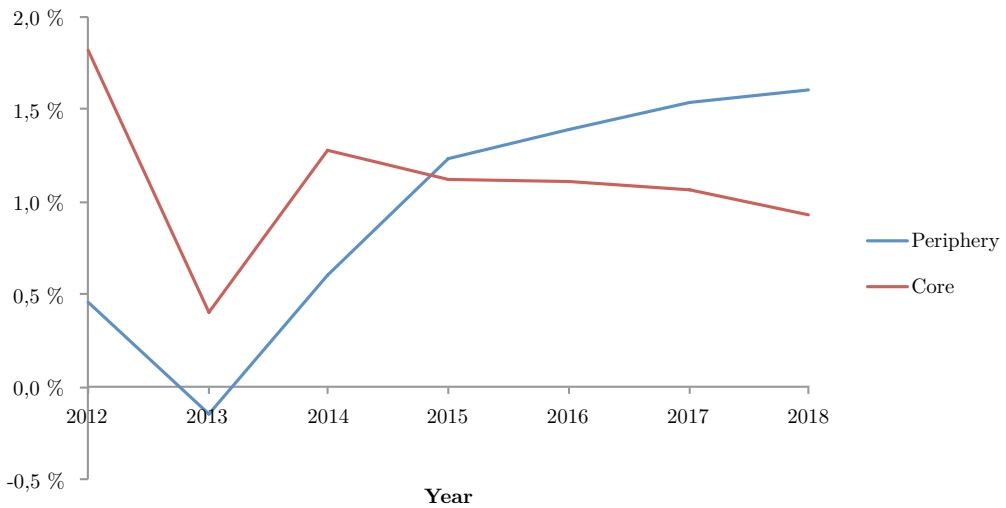



Figure 2: Forecasted year on year growth in GDP excluding investment. Source: IMF World Economic Outlook database.

growth rates $a$. Where $\overline{g}$ includes labour productivity growth and labour force growth.

In 2006 the European Commision's directorate-general for economic and financial affairs projected that the annual growth rate of potential GDP would be 1.6% for the EU15 countries between 2004 and 2050. The EU15 includes the countries defined as the core and the periphery in addition to Denmark, Sweden and the United Kingdom. The projection assumes that there is "no policy change" and should therefore be interpreted as "an indication of likely developments if past trends were to persist in the future" (Carone et al., 2006). As the projections were made before the financial crisis and the following sovereign debt crisis in the Eurozone, it may be unreasonable to assume that there has been "no policy change". For example, the structural reforms that are carried out in several of the periphery countries are different from the policies followed in the years previous to 2004. However, one of the assumptions underlying the projection is that annual labour productivity growth is equal to its historical average of 1.7% from 1973 to 2003. In the model, real GDP growth consists of labour productivity growth and labour force growth. Hence, the analysis uses 1.7% as a estimate of long run labour productivity growth.

The analysis uses population growth as an estimate of growth in the labour force. According to the United Nations' forecast[9], the population growth of the twelwe countries will be 0.25% annually from 2010 to 2015. However, the annual growth rate falls to 0.03‰ per annum when the horizon is changed to year 2100. Because labour productivity growth projections are for the whole Eurozone, the analysis uses populatoin growth for the whole region. With population growth as low as 0.03‰, it is set equal to zero. Hence, the estimate of long run growth, $\overline{g}$, is 1.7% per annum.

The second parameter $a$ reflects the persistence in growth rates. To obtain an estimate of the persistence parameter, the article uses the per capita GDP growth rate for the United States. US data is used to have a time series that

[9]The UN presents four variants of its population forecast. The four variants are low, medium, high and one in which fertility is constant. The forecasts presented here are based on the medium variant.

is long enough. The St.Louis Fed releases data on the annual growth in real GDP per capita in the United States[10]. Figure C.1 shows the sample autocorrelation function (SACF) and sample partial autocorrelation function (SPACF) for the time series. As the SAFC declines quickly and the SPACF only has a significant value at lag one, an AR(1) model is appropriate. Fitting the AR(1) model

$$g_t = \hat{a} g_{t-1} + \hat{c} + \epsilon$$

to the time series results in estimates $\hat{a} = 0.29$ and $\hat{c} = 2.0$[11]. Using the interpretation from section A.1, $\hat{c} = (1 - \hat{a})\hat{\overline{g}}$. The estimated values of $\hat{a}$ and $\hat{c}$ implies a long run growth rate of 2.6%. A long run growth rate of 2.6% seems high compared to historical growth rates and the European Commission projections. Hence, the article uses the long run growth rate projected by the European Commission, $\overline{g}$=1.7%, and the persistence parameter estimated from US data, $a = 0.29$. Finally, the horizon, $T$, is chosen equal to 30, such that the model ends in 2041.

[10]Source: `http://research.stlouisfed.org/fred2/graph/?chart_type=line&s[1][id]=USARGDPC&s[1][transformation]=pc1`

[11]Table C.2 reports the estimation output. The model was fitted using maximum likelihood

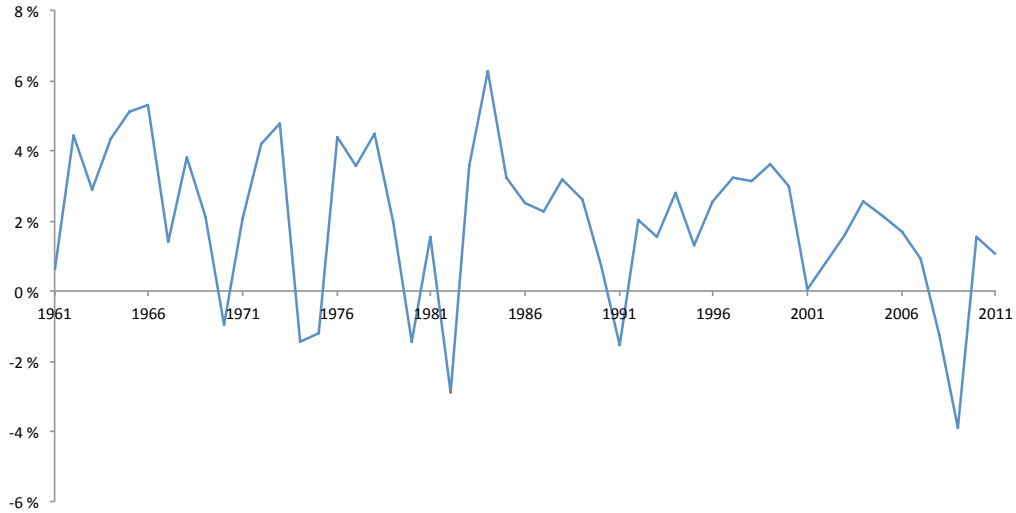



Figure 3: Annual growth in US GDP per capita from 1961 to 2011. Source: St. Louis Fed (2013).

# Quantitative Implications

This chapter discusses the effects of two growth scenarios for the Eurozone. In the first scenario, structural reforms are lacking and the productivity levels in the core and the periphery diverges. In the second scenario, structural reforms are successful in reducing the productivity gap between the two regions. The first section disusses the adjustment along the theoretically optimal path. That is, the consumption profile which would be chosen with adequate financial regulation and a frictionless consumption/savings decision. Section two compares the two growth scenarios on the suboptimal path. The path with weak financial regulation. The third section discusses the welfare losses resulting from suboptimal adjustment.

One of the main results is that the choice of forecasts is important for how the terms of trade and the real exchange rate evolve along the optimal path. However, the price changes on the suboptimal paths are similar. The first scenario makes use of the 2013-2014 forecast, while the second makes use of all forecasts up until 2018.

## Optimal Adjustment

### Scenario I: 2013 - 2014 forecasts

The first scenario uses the IMF forecast for growth from 2013 to 2014. From 2013 to 2014 the IMF expects the core to grow by 1.28%, while the periphery grows by 0.61%. After 2014 growth converges back to its long run rate. Figure 4 illustrates that due to the low value of $a$, growth returns to its long run level within 2020 in both regions. Given these growth prospects,

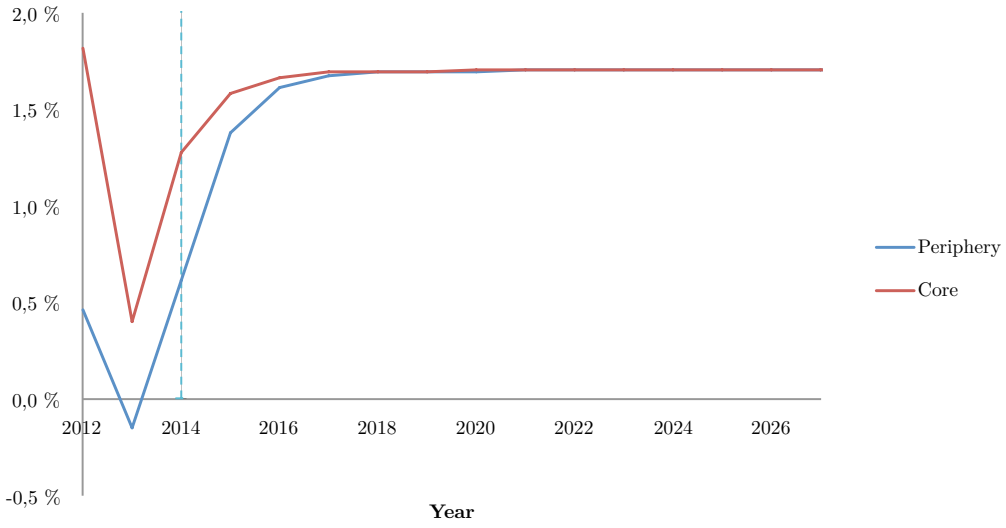



Figure 4: Scenario I growth. IMF forecasts until 2013.

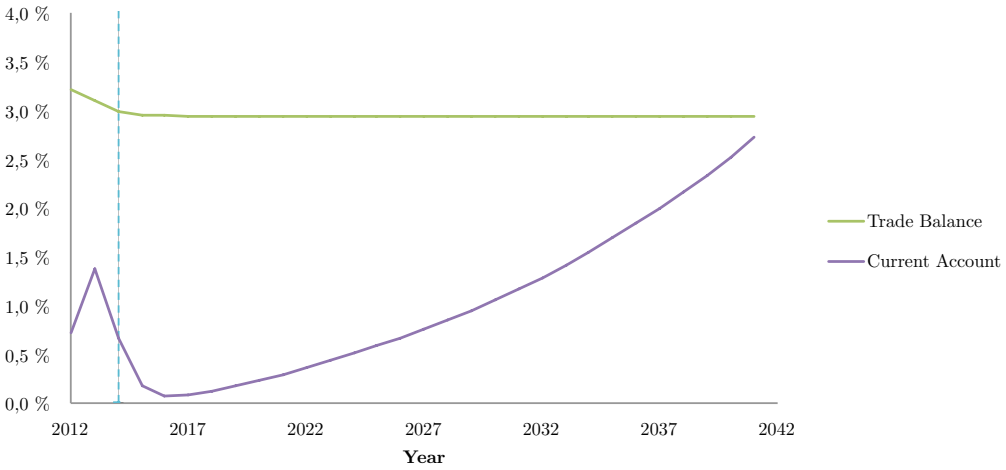



Figure 5: Periphery trade balance and current account to tradable GDP ratios in scenario I.

the periphery allocates consumption of tradables such that it runs a current acocunt surplus in all periods. In equilibrium, consumption of the traded goods basket grows at a rate which is a weighted average of the growth rate of the periphery and the core's tradable endowments. Because growth in the core is higher than growth in the periphery, expenditure on the traded consumption basket grows faster than the periphery's tradable endowment. Hence, the trade balance as a share of tradable GDP falls in the beginning. As growth in the periphery returns to its long run level, the ratio stabilizes around 2.9% of tradable GDP.

Two factors decide the difference between the trade balance and the current account. First of all growth determines the interest rate which in turn affects the interest payments. Second, the principal decreases as debt is repaid. The current account increases in 2013 because growth falls, hence the interest rate falls and interest payments are lower. As growth increases from its 2013 level, interest rates and interest payments increase. After 2016, the periphery repays debt faster than the interest rate increases and the current account as a share of tradable GDP increases.

Comparing the adjustment on the equilibrium path to the real world current account in 2012, it is clear that the model does not fit the observations. Under the assumption that the tradable goods sector makes up 40% of GDP in both regions, the periphery ran a current account to tradable GDP deficit of $3.58\%/0.4 = 8.95\%$ in 2012, which is far below the theoretically optimal level.

When the forecasts end in 2013 the core grows faster than the periphery. Due to the AR(1) process this will be the situation until growth in the two economies converge to the long run growth level. This difference in growth rates results in a lower price for the core's tradable good and the periphery's terms of trade improve. Figure 6 shows the cumulative percentage change in the terms of trade. In the long run the terms of trade improve by 0.7%. The better part of this price change occurs in the beginning. Between 2012 and 2013, the price of the core's traded good falls by 0.3%. By 2017 almost all of the adjustment is done with a total change of 0.7%.

Outside a monetary union, this terms of trade improvement can be acco-

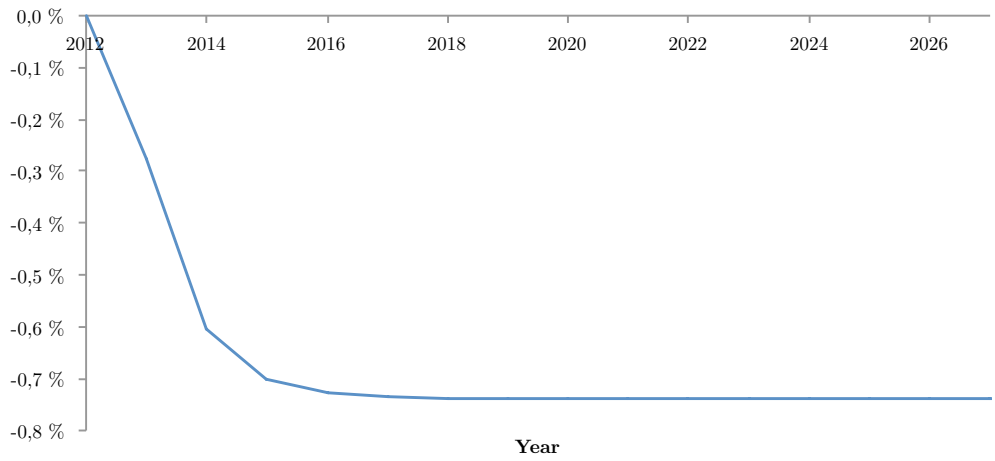



Figure 6: Cumulative percentage change in the terms of trade.

modated by a depreciation of the nominal exchange rate. However, without a nominal exchange rate to adjust between the two regions, the nominal price of the two goods have to grow at different rates. This will imply that the nominal price of the periphery's traded good has to increase more than the nominal price of the core's traded good.

The real exchange rate appreciates because the price of nontraded goods falls in the core and increases in the periphery. Thus, the price level in the periphery increases relative to the price level in the core. Figure 7 reports the model's predictions of the inflation difference estimated by equation (A.3). We see that the real exchange rate appreciation implies a higher inflation rate in the periphery. Between 2012 and 2013 inflation in the periphery will exceed inflation in the core by almost 0.7%. The difference is larger between 2013 and 2014 because the difference in growth is larger in this period. From 2014 and onwards the difference in inflation rates declines as growth rates converge.

The prediction of 2012 inflation does not fit very well with data. Table C.1 reports inflation rates (excluding food and energy prices) in the Eurozone. Between 2012 and 2013 inflation in Germany was 1.3%, while inflation in the other core countries was above 2%. Based on this, the model predicts an average inflation rate just above 2% in the periphery. However, this does not

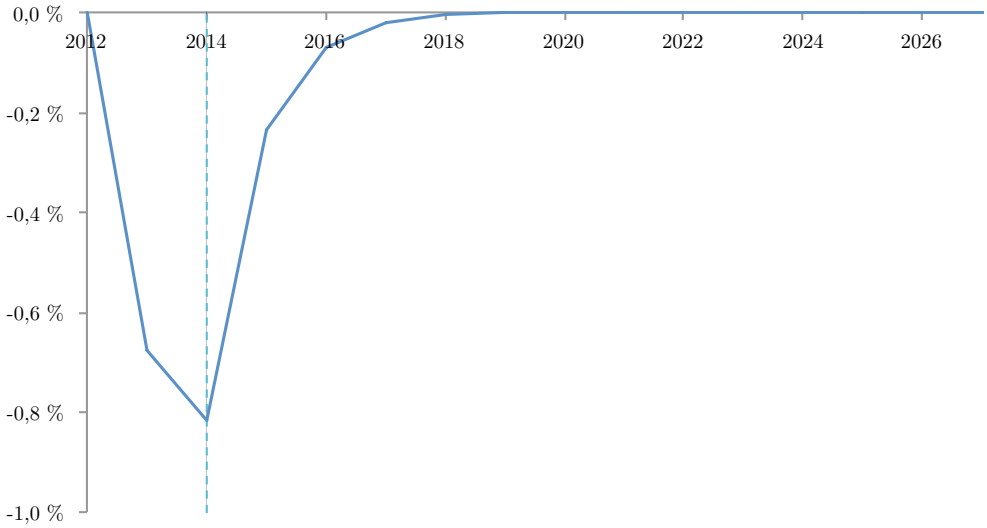



Figure 7: Inflation difference between the core and the periphery in scenario I.

match observations. The periphery can be divided in two groups. Almost all countries with sovereign debt problems had lower inflation than Germany. The only exception to this was Italy. Meanwhile, periphery countries without debt crises had higher inflation than Germany. As Austria, Belgium and Italy were the only countries with inflation above 2%, average inflation in the periphery was likely below 2% between 2012 and 2013.

## Scenario II: 2013 - 2018 forecasts

Figure 8 displays the evolution of growth rates in the second scenario. The implication of including forecasts into 2018 is that growth in the periphery will be higher than in the core from 2014. The IMF forecasts predict a fall in the core growth rate relative to the periphery between 2014 and 2017. This may be explained by Germany, the biggest country in the core, enjoying a swifter recovery from the recession beginning early 2009 than the periphery. The periphery soon after entered a series of government debt crises. After the initial recovery Germany too has been affected by the ongoing debt crises in the periphery and growth has declined.

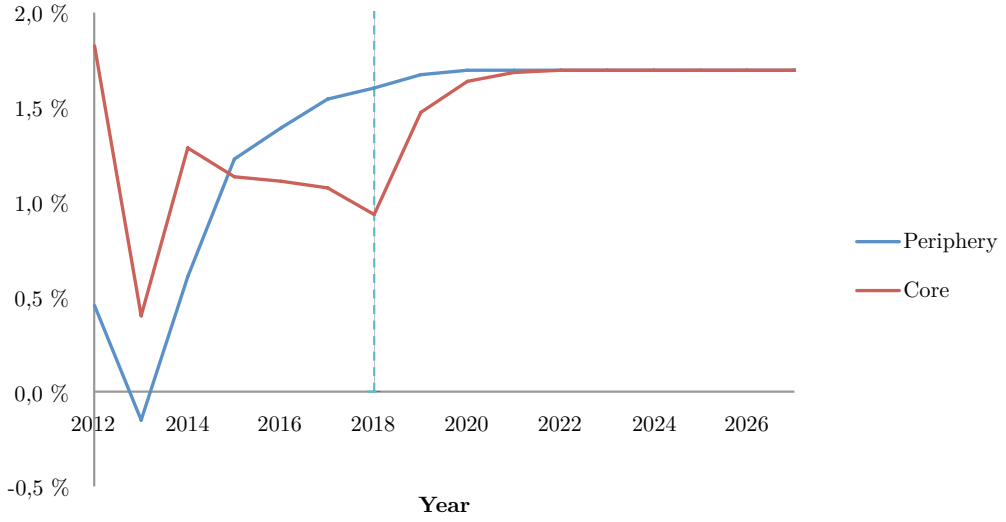



Figure 8: Scenario II growth. IMF forecasts until 2018.

Balke and Wynn (1992) document a significant bounce back effect after recessions. However, the growth projections in the periphery seem optimistic compared to forecasts for growth in the core. Especially in light of Reinhart and Rogoff (2009), which argue that recoveries following financial crises tend to be slow. However, their results have been subject to severe critisism the last months. For an early critic see Bordo and Haubrich (2012) who study recessions in the US. They argue that growth rates tend to be higher after recessions with financial origins, at least for the US. As forecasts by nature are uncertain, the IMF forecasts are accepted at face value to compare different returns to long run growth.

Figure 9 plots the current account to tradable GDP ratio and trade balance to GDP ratio for the periphery along the theoretically optimal path. Comparing figure 9 to 5, there are two differences.

First of all, the periphery runs smaller trade balance and current account surpluses in scenario II than in scenario I. This implies that consumption of the traded goods basket is higher in the initial period in scenario II than in scenario I. Initial traded goods consumption is higher in scenario II because future income is higher due to a swifter recovery.

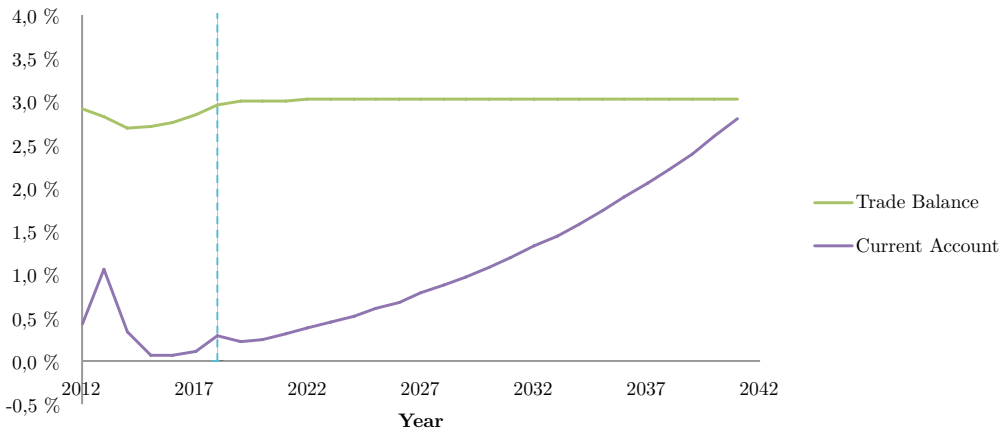



Figure 9: Periphery trade balance and current account to tradable GDP ratios in scenario II.

Because tradable GDP now grows faster than consumption of the traded goods basket, the trade balance to tradable GDP ratio increases over time. The ratio falls in the beginning due to relatively low growth in the periphy. Further, the current account deteriorates between 2013 and 2015 due to a higher interest rate. After 2015 increases in the interest rate due to increased growth are small compared to the debt repayments. Hence, interest payments fall and the current account approaches the trade balance.

Figure 10 illustrates the cumulative change in the terms of trade and the real exchange rate on the optimal consumption path. In the initial years the terms of trade improve and the real exchange rate appreciates. As growth in the periphery is higher than in the core from 2014 onwards, the initial development is reversed and the terms of trade begin to deteriorate and the real exchange rate appreciates. The periphery faces a 0.3% deterioration in the terms of trade and a 0.7% depreciation of the real exchange rate in the long run.

Because growth in the two scenarios is equal up until 2013, the predicted inflation difference is the same between 2012 and 2014. However, as the real exchange rate depreciates in scenario II, inflation in the core will have to be higher than in the periphery in the future. Figure 11 shows the differences in inflation rates implied by the growth forecasts. The pattern after

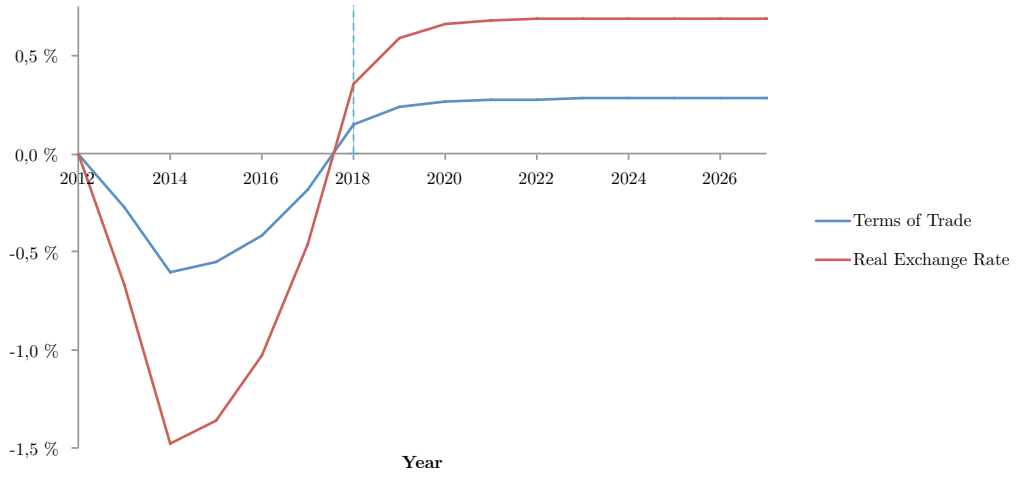



Figure 10: Cumulative changes in the terms of trade and the real exchange rate in scenario II.

the forecasts end is similar in the two scenarios. However, there is a significant difference. In the second scenario the inflation difference goes from -0.8% between 2013 and 2014 to 0.1% the following year because growth in the periphery surpases growth in the core. Such a change in the inflation difference would imply a significant increase in inflation in one region. As the periphery continues to grow faster than the core after 2014, the positive inflation difference persists.

None of the theoretically optimal scenarios are able to replicate the observed current account deficit in the periphery. This disrepancy may be because the model does not include a financial sector. Section  argued that the Target2 system may reduce autorities' incentives to regulate their banking sectors. Thus, the observed current accounts may be optimal responses to a weakly (suboptimally) regulated financial sector. To model the consumption paths resulting from weak regulation, the article assumes the current account process in equation (A.7). Assuming that the optimal paths would result from "optimal" regulation, the article proceeds to analyze the effects of suboptimal regulation. By analyzing the suboptimal paths, the article explores the possible consequences and costs of weak financial regulation.

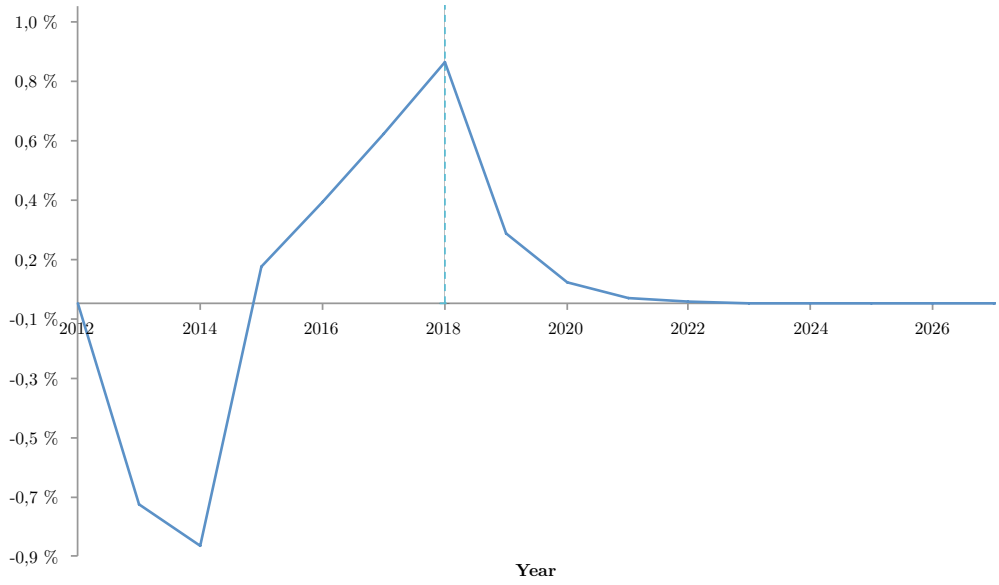



Figure 11: Inflation difference in scenario II.

# Suboptimal Adjustment

Section A.5 discussed the qualitative effects of an exogenous/suboptimal current account. This section discusses the quantitative implications. In the following, the current account closes over five years and follows the process from equation A.7 in section A.5 (that is, $\tau = 5$). In 2017 the current account turns positive and grows at a constant annual rate.

### Adjustment Between 2012 and 2016

On the theoretically optimal adjustment path the periphery runs current account surpluses from 2012 to 2041 in both scenarios. However, in the real world the periphery ran a siezable current account deficit in 2012. The current account deficit implies that the periphery consumed more tradable goods than it would have done on the theoretically optimal path. Consumption of tradable goods will be higher until 2015. In 2016 when the current account closes, the periphery consumes less traded goods than on the optimal path because the interest payments are higher due to a higher debt. Figure 12

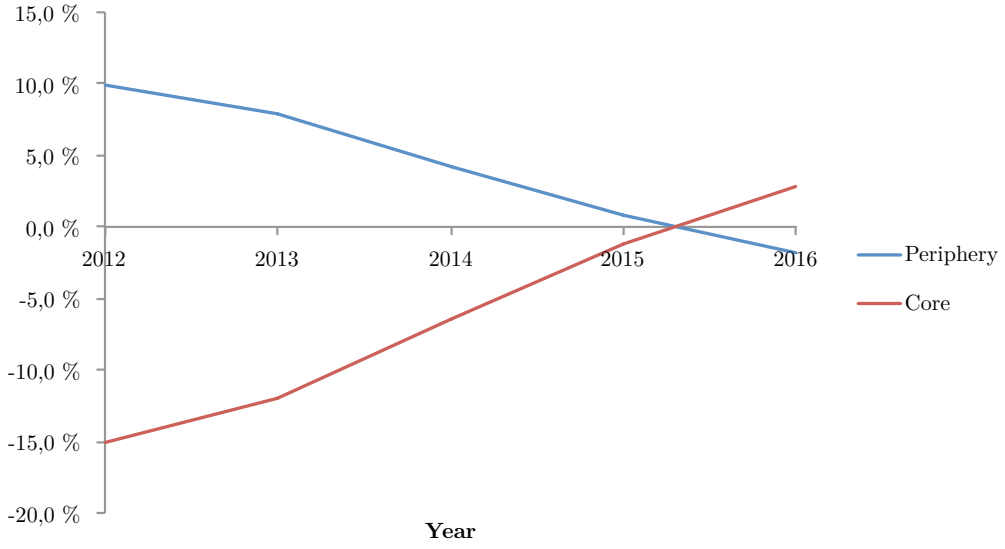
| Scenario | Region | 2012 | 2016 |
|---|---|---|---|
| I | Periphery | 10.0 | -1.8 |
| | Core | -15.1 | 2.8 |
| II | Periphery | 9.6 | -1.6 |
| | Core | -14.7 | 2.5 |

Table 4: Deviation of traded consumption from its theoretically optimal level (%).

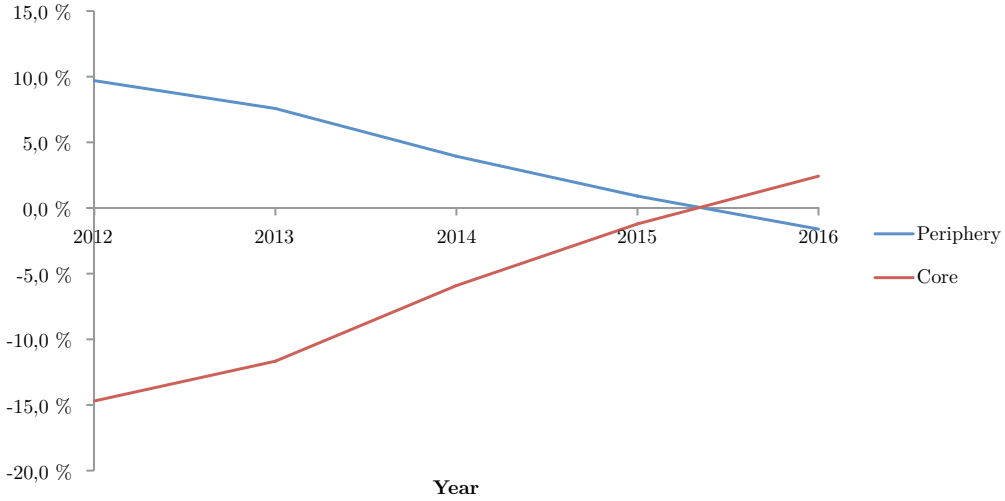
shows how consumption of the traded goods basket evolves on the suboptimal path relative to on the optimal path for the two regions. The figure confirms the intuition that traded goods consumption is relatively high in the periphery and relatively low in the core compared to on the optimal path between 2012 and 2016. Table 4 reports the percentage deviation of traded consumption in 2012 and 2016. The relative deviations in 2012 are smaller in scenario II than in scenario I because income in the periphery (core) is higher (lower) and hence optimal consumption is higher (lower). These growth effects on consumption pushes the theoretical level of consumption towards the observed values.

Section A.5 argued that changes in the price of nontraded goods on suboptimal paths have two sources. One source is the transfer effect which causes the price of nontraded goods in the two regions to differ from their optimal values. Second, there is a supply effect which is the same as on the optimal path.

Using equation (7), the price of the periphery's nontraded good goes from being 21.0% overvalued in 2012 to 1.8% undervalued in 2016 in scenario I. Similarily, the price of the nontraded good in the core goes from 28.0% below its value on the optimal path in 2012 to 5.6% above in 2016. Table 5 reports the misalignment in nontraded goods prices under scenario I and II in 2012 and 2016. Intuitively, we see that the price misalignment is smaller in scenario II because the misalignment in traded goods consumption is smaller. At last we see that the rule of thumb estimate of the price misalignment is relatively accurate. For example, in 2012 under scenario I the rule predicts




(a) Scenario I




(b) Scenario II

Figure 12: Percentage deviation of traded consumption from its theoretically optimal level between 2012 and 2016.

| Scenario | Region | 2012 | 2016 |
|---|---|---|---|
| I | Periphery | 21.0 | -3.6 |
| | Core | -28.0 | 5.6 |
| II | Periphery | 20.2 | -3.2 |
| | Core | -27.3 | 5.0 |

Table 5: Misalignment in the price of nontraded goods compared to the price on the optimal path (%).

| Scenario | Region | Transfer effect | Supply | Total price change |
|---|---|---|---|---|
| I | Periphery | -20.3 | 0.8 | -19.7 |
| | Core | 46.7 | -2.1 | 43.7 |
| II | Periphery | -19.5 | 0.5 | -19.1 |
| | Core | 44.4 | -1.2 | 42.7 |

Table 6: Changes in the price of nontraded goods between 2012 and 2016. The price change is decomposed in the transfer effect and the supply effect according to equation (A.6).

the periphery nontraded good price to be misaligned by $\frac{1}{0.5} \times 10.0\% = 20.\%$ which is close to the actual value of 21.0%.

From the previous paragraph and table 5 we can conclude that the transfer effect is of similar size in the two scenarios and across the two regions.

Between 2012 and 2016, changes in supply result in relatively small changes in the price of nontraded goods in the two scenarios. Table A.6 reports these changes in column four. Column three reports price changes due to changes in the transfer effect. Comparing the numbers in column three and four, it is clear that the transfer effect is the biggest cause of changes in the price of nontraded goods. Even though the supply effect moves in the opposite direction, it does not dampen the price changes significantly.

Typical examples of nontraded goods are real estate and services because they can only be consumed at their location. Hence, the model may explain the fall in house prices observed in the periphery, and predicts that they will continue to fall for quite some time. At the same time real estate prices in the core will rise over the same period. Although real estate is a typical

nontraded good, assume for the moment that real estate can be considered an asset which (if consumed) has to be consumed on location. However, foreigners can own the asset. With this in mind, the observation that Italians and Greeks have bought German real estate (Masoni, 2012) is no surprise. On the other hand, fears of a German housing bubble as reported by (The Economist, 2012), among others are unwarranted if one believes the model is a good description of the real world.

Figure 13 shows how the price of the periphery's nontraded good in units of the core's nontraded good evolves on the suboptimal path compared to on the optimal path. A value above zero implies that the nontraded good in the periphery is overvalued compared to the optimal path. In 2016 the ratio is negative in both scenarios, implying that the periphery's good has gone from being overvalued to undervalued. If investors expect the current account to follow a path similar to the one assumed, one would expect to observe a shift in investment from the periphery nontraded sector to the nontraded sector in the core. Depending on how quickly the current account is expected to close, this flow of capital could take the form of a "capital flight" from the periphery to the core.

Because the prices on nontraded goods are misaligned, the real exchange rate is misaligned. The misaligned nontraded good prices imply that the periphery's real exchange rate is overvalued by 28.6% in 2012 and 2.2% in 2016 in scenario I. The corresponding numbers are 27.9% and 2.7% in scenario II. Figure 14 illustrates the difference in inflation between the core and the periphery as approximated by equation (A.3). The first point represents the inflation difference between 2012 and 2013. The inflation difference is equal in the two scenarios until 2014 because the forecasts are equal. After 2014 the inflation difference is smaller under scenario I. This is because the supply changes imply a negative infation difference in scenario I (see figure 7) and a positive inflation difference in scenario II (see figure 11). Comparing the prediction under the suboptimal adjustment to optimal adjustment, it is clear that what matters in the short run is the demand shock (transfer effect). Looking at figure 14 we see that the transfer effect changes the situation from the optimal adjustment significantly. While the inflation differences under

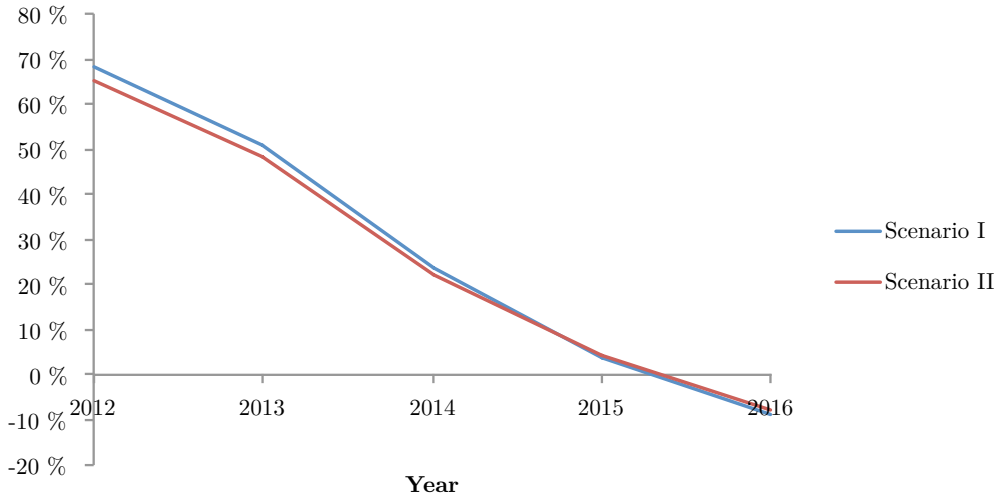



Figure 13: Development in the price of the periphery's nontraded good in units of the core's nontraded good relative to optimal adjustment. A positive value implies that the periphery's nontraded good is overvalued compared to the optimal path.

optimal adjustments were less than 0.9% in absolute value, they are close to 5% or higher under suboptimal adjustment. In particular, the inflation difference is positive in the periods between 2012 and 2016.

### Adjustment Between 2017 and 2041

The main result in this section is that future deviation of traded goods consumption from its optimal level is dependent on how the periphery's current account surplus evolves after 2017. Because the periphery runs up debt between 2012 and 2017, the necessary current account surpluses needed to repay the core increase. Hence, consumption of traded goods in the periphery has to be lower in 2017 than what it optimally would have been. Oppositely, traded goods consumption is higher than its optimal level in 2017 in the core. This is why the graphs in figure 15 do not cross the y-axis. On the other hand, consumption of traded goods can be higher or lower than the optimal level in 2041 depending on the growth rate of the periphery's current account surpluses. This is because traded goods consumption in 2041 is dependent

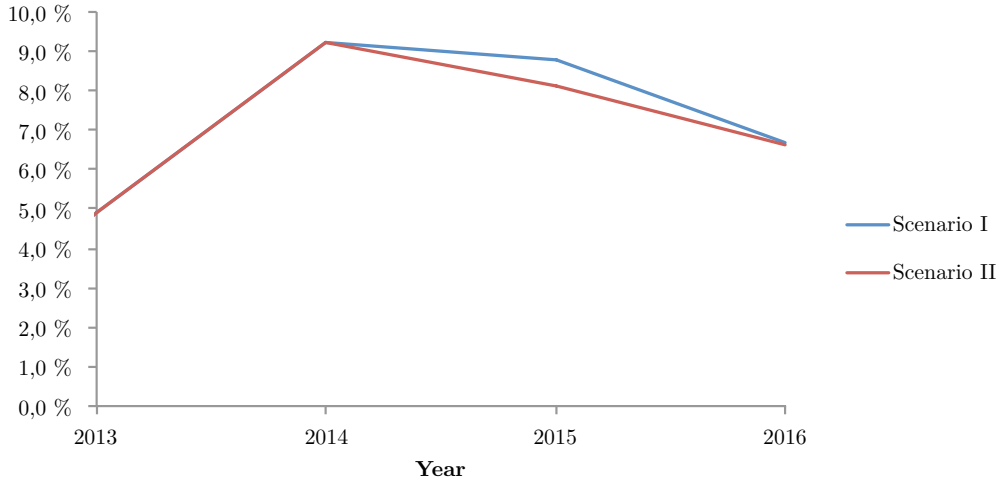



Figure 14: Difference in inflation between the core and the periphery. For positive values, inflation is higher in the core than in the periphery.

on both growth in the periphery's current account surpluses and growth in tradable GDP.

Figure 15 displays how traded consumption deviates from its optimal value in 2017 and 2041 in the two regions depending on the growth rate in the current account surplus from 2017 and onwards. The growth rates vary from -2.0% to 10%. The growth rate of the current account surplus falls as one moves away from the origin along the x-axis.

Because there is a tradeoff between deviations of traded goods consumption in 2017 and 2041, there is a tradeoff in the misalignment of the prices of nontraded goods and thus changes in the real exchange rate. Figure 16 shows the logarithmic changes in the real exchange rate when the periphery's current account surplus grows at 5% per year. We see that the inflation difference falls sharply after 2017. The inflation difference between 2016 and 2017 (the first point) is high because the periphery's current account jumps from zero in 2016. After 2017 the current account evolves smoothly and hence changes in the misalignment of nontraded goods' prices is smoother. This in turn leads to smoother changes changes in the real exchange rate and thus smaller inflation differences.

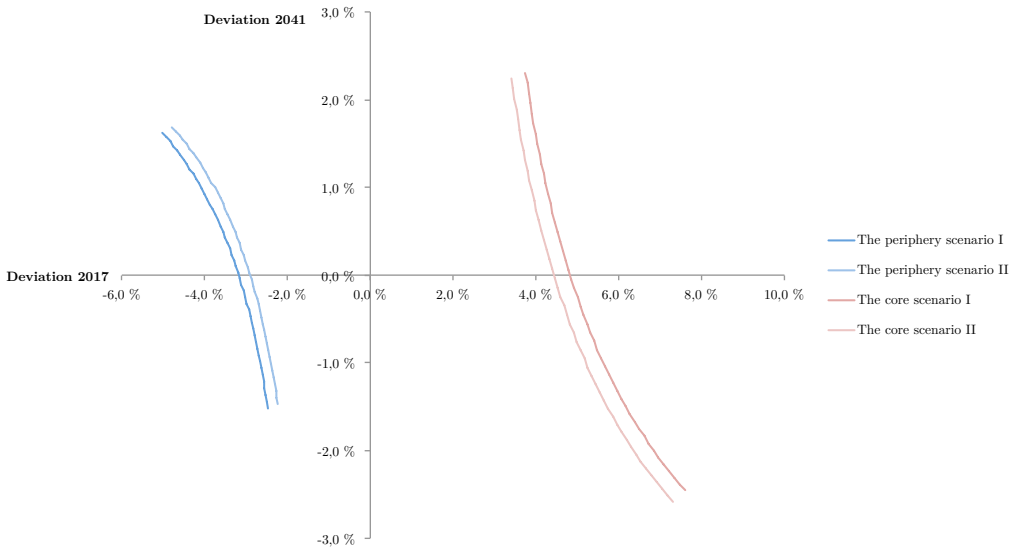



Figure 15: Deviation of traded consumption on the suboptimal path relative to on the optimal path.

Changing the growth rate of the periphery's current account does not change the general picture. If the growth rate increases, the inflation difference will be lower in the first period and increasing towards 2041. Inflation differences increase because the transfer effect is relatively larger than in preceeding periods when the current account grows at a higher rate.

# Welfare Implications

Lucas (2003) reviews the literature on potential welfare gains from eliminating all consumption variation. With a coefficient of relative risk aversion of 1 ($\sigma = 1$) and the standard deviation of the log of real, per capita consumption about a linear trend being 0.032, he estimates that the welfare gain from eliminating all consumption risk is about 0.05% of consumption on the risky consumption path. He also notes that this is likely to be an upper limit for the welfare gain as some of the consumption variability reflects optimal responses to technological shocks or other real shocks. With a coefficient of risk aversion of 2 which is equivalent of an elasticity of intertemporal substi-

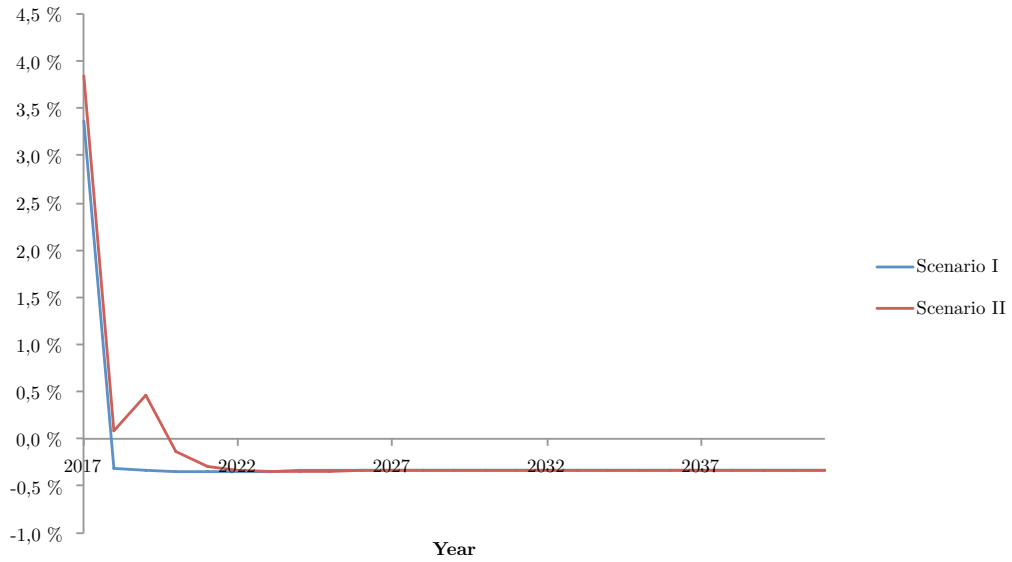



Figure 16: Inflation difference between the core and the periphery given a current account surplus growth rate of 5%. The first point reflects the inflation difference between 2016 and 2017.

tution of 0.5, the upper limit increases to 0.1% of consumption on the risky consumption path.

Compared to welfare gains from other policies a welfare gain 0.1% of consumption seems small. For example, Lucas (2003) estimates the "welfare gain from reducing the annual inflation rate from 10 to 0 percent to be a perpetual consumption flow of 1 percent of income". On the other hand, welfare gains from reducing the capital income tax to zero in the US (compensating with other taxes to keep government spending unchanged) would lead to a welfare gain between 2 and 4 percent of annual consumption in perpetuity.

Lucas (2003) goes on to review how changes in the preference specification, incomplete markets and distribution effects affect the result. In the end he concludes that stabilization policies which go beyond the policies enforced after the second world war will not lead to significant gains in welfare. "The potential gains from improved stabilization policies are on the order of hundredths of a percent of consumption, perhaps two orders of magnitude smaller than the potential benefits of available "supply-side" fiscal reforms."(Lucas,

| Scenario | Region | Growth rate (%) | Welfare loss (%) |
|---|---|---|---|
| I | Periphery | 12.7 | 0.14 |
| | Core | 12.7 | 0.38 |
| II | Periphery | 12.4 | 0.13 |
| | Core | 12.4 | 0.35 |

Table 7: Minimized welfare loss in percent of traded goods consumption.

2003).

The welfare loss measures how many percent of traded goods consumption the consumers would have to give up on the optimal path to be as well off as under the suboptimal current account adjustment. Table 7 reports the current account surplus growth rates that minimize the welfare losses in the different scenarios. Further, figure 17 illustrates the welfare loss of each region as a function of the current account growth rate after 2017. The welfare loss is calculated according to equation (A.8) and set in relationship to the minimized welfare loss. When the current account surplus is constant, the welfare loss is about 15% higher than its minimal value for the periphery and about 11% above its minimal value for the core. Figure 17 shows that the welfare loss is sensitive to the growth rate of the current account. However, the welfare losses are still small compared to the potential welfare gains from "supply-side" fiscal reform reported by Lucas (2003).

Table 7 leads to a few observations.

First of all, the welfare loss is clearly larger for the core than for the periphery. The disrepancy is likely due to the relative size of the two regions. With the periphery being 1.65 times the size of the core, the suboptimal path affects its consumption of tradables relatively less. Figure 12 illustrates this. Hence, the suboptimal adjustment affects the core's consumption allocation to a higher degree than the periphery's and its welfare loss is larger.

Secondly, the welfare estimate is sensitive to the growth forecasts. Changing the growth forecasts changes the two regions' income. As discussed in the beginning of section , growth forecasts affect how large the deviations from optimal traded consumption are. The deviations are larger in the beginning

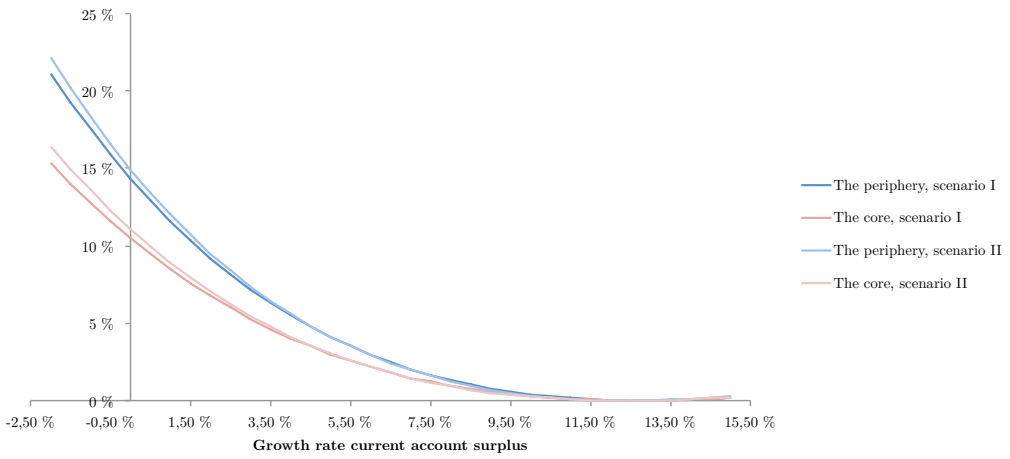



Figure 17: Welfare loss relative to the minimized welfare loss.

of scenario I than in scenario II implying that the optimal path in scenario I is further from the suboptimal path. Hence, the welfare loss is larger in scenario I than in scenario II.

The final observation to make from table 7 is that the periphery's welfare loss is similar to the welfare gain Lucas (2003) estimates from eliminating consumption uncertainty and concludes are rather small. Hence, it is not implausible that possible benefits of the modelled consumption path outweigh the cost of suboptimal consumption allocation for the periphery. On the other hand, the costs carried by the core are significantly higher than those incurred by the periphery. Hence, the core ought to have the highest incentives to get in place a working financial reform and banking union.

One potential pitfall that may have drastic costs is if the modelled current account path slows down necessary "supply-side" reforms other than the banking reform. A second cost the model does not take into account is the possible costs from inflation. Although the ECB cares about aggregate inflation in the eurozone, the relatively large inflation differences between 2012 and 2017 may impose costs on each region.

Finally, one can compare the welare gain (loss) to the periphery (core) which results from writing down the debt position in the beginning of 2012. The following calculations assume that if the debt position is eliminated, the

consumers adapt on the optimal path (thus it is a best case scenario, no welfare loss from suboptimal adjustment later). The debt reduction would result in a welfare gain of about 3.8% (of traded goods consumption) for the periphery and a welfare loss of about 6.4% (of traded goods consumption) for the core in both scenarios. As writing down the two asset positions results in large losses on the core, the suboptimal path is likely to be preferable.

# Conclusions

The article uses a transparent framework to analyze imbalances in the Eurozone. The simulations show that price changes under optimal consumption allocation are small. However, the optimal consumption allocation does not replicate the observed current accounts in the Eurozone. Thus, consumption is assumed to follow an exogenous current account which replicates the observed current account position in 2012. If the current account between the core and the periphery closes over five years, the model predicts significant inflation differences between the two regions. However, the potential welfare costs in terms of tradable goods consumption are relatively small.

### Limitations

Factors in production are inelasticly supplied in this model. Due to retraining costs, changing of location for workers etc., this may be a reasonable assumption in the short run (one to two years). Over longer horizons, workers and capital will adjust to new prices. Reallocation of production factors will then lead to changes in supply and dampen the price changes. However, the analysis highlights that the biggest price changes occur between 2012 and 2017. Thus, if factors are immobile over the short run, short run price changes may not be very affected by factor mobility.

In the model, prices are fully flexible. Allowing for sticky prices could lead to real exchange rate overshooting. Further, the model does not incorporate a central bank. With sticky prices, introducing a central bank could allow for analysis of the costs associated with the increased inflation difference due to the transfer effect.

# Appendix A

# Theory

To analyze the research questions, the article develops a model similar to that of Obstfeld and Rogoff (2000, 2004, 2005). The world consists of two regions, Home (H) and Foreign (F), which are endowed with two goods each. The formulation in terms of Home and Foreign is made for simplicity and clearer subscripts. In the analysis, the periphery is assumed to be the Home region. Following standard notation, a star (*) indicates Foreign (core) variables, and subscript F, the core's tradable good.

One of the goods is a nontradable good and the other is a country specific tradable good. Hence, the consumer in each region has preferences over three goods: the two tradable goods and the country's nontraded good. Both consumers live a finite number of periods, T. A finite horizon implies that the Target2 balances will be zero when the model ends. As the Target2 balances were close to zero in the run up to the crisis, this seems as a reasonable choice. Choosing an infinite horizon would cause the assets positions to continue growing, which may seem unreasonable if they represent any of the risks claimed by Sinn and Wollmershäuser (2012).

All goods are perishable and last one period. Perishable goods imply that consumption of the nontraded good is forced to follow the endowment process in each country. However, the consumers may smooth their consumption of tradable goods through trade.

The two regions have identical preferences implying that there is no home-

bias in consumption of tradable goods. The countries differ along two dimensions; their net foreign asset position and income.

All prices are in units of the periphery's tradable good and the law of one price holds for tradable goods. Because preferences are identical, the basket of traded goods has the same price in both countries and the law of one price holds for this basket. However, as the two countries may have different wealth positions, the law of one price does not necessarily hold for aggregate consumption.

This chapter proceeds in the following way. Firstly, the production side of the economy is defined. Secondly, price indices are derived along with the intratemporal demand functions. These derivations follow chapters 4.3.2 and 4.4.1 of Obstfeld and Rogoff (1996). Chapter 4.4.1 also lays out the foundation of intertemporal utility maximization and its implications. The article adds a second tradable good, but that does not change any of the intuition. The only consequence of a second traded good is another set of Euler equations. The fourth section represents the article's first contribution to research. In this section, the equilibrium prices and interest rates are determined along with first order difference equations governing their paths. Section five contains the article's second contribution to research. The section discusses the implications of suboptimal consumption allocation and provides an approximation to the misalignment in nontraded goods' prices. The article's third contribution follows in section five. Section five discusses the welfare measure.

## A.1 Production

To obtain an endowment like economy, the production structure is very simplified. The production technology for each good is equal and of the Cobb-Douglas kind. Hence, output from each industry can be written as

$$Y_t = A_t f(k) L_t \ , \ k_t = K_t / L_t = constant.$$

Here $k$ is the ratio of capital to labour, $f(k)$ the production per unit of labour and $A$ the level of total factor productivity. Consumers supply labour inelasticly and are endowed with one unit of capital which they use in production. Hence, capital is also supplied inelasticly. As input factors are provided inelasticly, there is no role for wages or interest rates in the allocation of labour and capital. Thus, production will sometimes be referred to as endowments.

As technology is Cobb-Douglas, technological progress has to be labour augmenting for there to be a steady state (Barro and Sala-i-Martin, 2003). Hence, output growth is determined by two factors

- Growth in labour productivity
- Population growth.

Output growth in each industry is defined by

$$\frac{Y_{t+1}}{Y_t} = 1 + g_{t,t+1} = \frac{A_{t+1}}{A_t}\frac{L_{t+1}}{L_t}$$

follows an AR(1) process

$$g_{t,t+1} = ag_{t-1,t} + (1-a)\overline{g}.$$

The constant $a$ represents persistence in the real growth rate and $\overline{g}$ is the long run real growth rate of GDP. The persistence parameter, $a$, and long run growth rate, $\overline{g}$, are identical across the two regions.

To assume that long run growth is equal in the two regions has important implications. First of all it implies that the country growing at a slower pace initially will always grow at a slower rate. This permanent difference in growth rates will lead to permanent differences in income per capita. If the poorest region starts out with the lowest growth rate, the result will be income divergence. Oppositely, when the poorest country starts out with the highest growth rate, there will be income convergence. Che and Spilimbergo (2012) argue that one source of the Eurozone problems is the large difference in productivity and income between the core and the periphery. One goal of introducing the Euro was to "facilitate a rapid convergence in the level

of income and, most importantly, of productivity across countries" (Che and Spilimbergo (2012)). However, lacking structural reforms have been counterproductive to this goal and resulted in the current imbalances.

Based on this, one way to look at the different scenarios presented later is that they represent two possible futures for the Eurozone. In the first scenario structural reforms are still missing. The lack of structural reforms results in divergence in relative productivity between the core and the periphery. The second scenario where periphery growth is higher serves as an example in which structural reforms are successful in reducing the productivity gap.

To introduce a higher long run growth in the periphery, could be one way to avoid this razor edge behaviour of growth. This higher long run growth rate could represent larger potential gains in the core's productivity level. On the other hand, keeping long run growth constant across the two regions can be interpreted as the core being the innovating region. Innovation in the core determines the long run shifts in the production frontier for both regions. Jones (2002) makes a similar assumption in a growth accounting exercise. In his analysis researches from the G-5 countries are the only researchers which are able to extend the production frontier. Given the current situation with austerity measures in the indebted periphery countries, it may be an appropriate approximation that the core drives the technological frontier over the foreseeable future.

The section on general equilibrium illustrates that the total change in the terms of trade and the real exchange rate between the periphery and the core is crucially dependent on the difference in total growth over the horizon. Thus, the persistence of the growth differential $g_{t,t+1} - g^*_{t,t+1} = a(g_{t-1,t} - g^*_{t,t-1})$ is important in determining the path of prices in equilibrium.

## A.2 Price Indices

The intertemporal preference depends on the constant elasticity of substitution (CES) consumption aggregate defined by

$$C_t = [\gamma^{\frac{1}{\theta}} C_{T,t}^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_{N,t}^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}}$$

where

$$C_{T,t} = [\alpha^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}.$$

Here $C_H$, $C_F$ and $C_N$ is consumption of the periphery's tradable good, the core's tradable good and the regions' nontraded good respectively. $C_T$ is an index for consumption of traded goods, often referred to as the basket of traded goods or traded goods consumption. $C$ is an index for aggregate consumption, often referred to as real consumption or aggregate consumption. $\gamma$ and $\alpha$ are strictly positive constants which decide the relative preference of the traded goods basket and the periphery's tradable good relative to the nontraded good and the core's tradable good respectively. $\theta$ and $\eta$ are the elasticities of substitution between the traded goods basket and nontraded goods and the elasticity of substitution between the periphery's traded good and the core's traded good respectively. Both are strictly positive.

This section starts by deriving the price index for the consumption index $C$, before postulating the index for the traded goods basket $C_T$. The following derivations ignore the time subscript because the structure of the problem does not change over time.

Given total spending in each period, $Z$, the consumer maximizes real consumption:

$$max\ [\gamma^{\frac{1}{\theta}} C_T^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_N^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}}$$

$$s.t.\ p_T C_T + p_N C_N = Z.$$

Because marginal utility from each good goes towards infinity as consumption of the good goes to zero, the consumer will always consume a strictly positive amount of each good. This property rules out corner solutions. At the optimum, the consumer adapts such that his marginal rate of substitution between the two goods, is equal to the relative price of the goods

$$\frac{p_N}{p_T} = \left(\frac{1-\gamma}{\gamma}\frac{C_T}{C_N}\right)^{\frac{1}{\theta}}.$$

Solving for $C_T$ (and then $C_N$) and substituting in the constraint gives the

demand for the basket of traded goods and the nontraded good

$$C_T = \frac{p_T^{-\theta}\gamma Z}{\gamma p_T^{1-\theta} + (1-\gamma)p_N^{1-\theta}} \text{ and } C_N = \frac{p_N^{-\theta}(1-\gamma)Z}{\gamma p_T^{1-\theta} + (1-\gamma)p_N^{1-\theta}}.$$

Because these expressions are simplified later, the interpretation is postponed. Substituting for $C_T$ and $C_N$ in the objective function, results in the indirect utility function

$$C^{max}(p_T, p_N, Z) = \frac{Z}{[\gamma p_T^{1-\theta} + (1-\gamma)p_N^{1-\theta}]^{\frac{1}{1-\theta}}}.$$

The indirect utility function translates spending in one period into real consumption. Its properties are intuitive: Doubling spending doubles real consumption, doubling both prices cuts real consumption in half and if prices rise, the same amount of spending results in less real consumption. Solving $C^{max}(p_T, p_N, Z) = 1$ returns the spending required to buy one unit of real consumption. This amount of spending is equivalent to the price of one unit of real consumption. Hence, define the price of one unit of real consumption, $p$, as

$$p = [\gamma p_T^{1-\theta} + (1-\gamma)p_N^{1-\theta}]^{\frac{1}{1-\theta}}.$$

Having defined the price of one unit of real consumption, it's easy to see that a spending level $Z$ results in $C^{max} = Z/p$ units of real consumption and expenditure on consumption can we written as $p_T C_T + p_N C_N = pC$. $p$ will often be referred to the aggregate price level or the perfect price index.

Using the definition of the price index and the indirect utility function, the demand functions simplify to

$$C_T = \gamma \left(\frac{p_T}{p}\right)^{-\theta} C \text{ and } C_N = (1-\gamma)\left(\frac{p_N}{p}\right)^{-\theta} C.$$

These are regular CES demand functions; decreasing in their own price and increasing in real consumption and the preference for the good $\gamma$ or $1-\gamma$.

Following similar steps, demand functions and a price index for tradable

goods can be established. Doing so gives the following price index

$$p_T = [\alpha + (1-\alpha)p_F^{1-\eta}]^{\frac{1}{1-\eta}}$$

and demand functions

$$C_H = \alpha \left(\frac{1}{p_T}\right)^{-\eta} C_T \ , \ C_F = (1-\alpha)\left(\frac{p_F}{p_T}\right)^{-\eta} C_T.$$

Using the price index $p_T$ expenditure on tradable goods can be written as $C_H + p_F C_F = p_T C_T$. $p_T$ will often be referred to as the price of the traded basket or the price of tradable goods.

## A.3 The Intertemporal Problem

Both countries solve the same problem, but with different endowments and initial asset positions. Hence, only the periphery's maximization problem is solved. The change in the country's asset position, denominated in units of the periphery's tradable good, from period $t$ to $t+1$ is given by

$$\Delta Q_{t,t+1} = r_{t-1,t}Q_t + Y_{H,t} + p_{N,t}Y_{N,t} - C_{H,t} - p_{F,t}C_{F,t} - p_{N,t}C_{N,t}$$

$Q_t$ is the asset position going into period $t$ or equivalently the asset position out of period $t-1$. The consumer pays or receives interest payments $r_{t-1,t}Q_t$, where $r_{t-1,t}$ is the interest rate between period $t-1$ and $t$. Each period, the consumer receives endowments of the nontraded good and the country specific tradable good. These are then spent on consumption or potentially interest payments. Using the price indices, rewrite the flow constraint as

$$\Delta Q_{t,t+1} = r_{t-1,t}Q_t + Y_{H,t} + p_{N,t}Y_{N,t} - p_t C_t.$$

Define the present value factor from period 0 to t as

$$R_{0,t} = \prod_{s=0}^{t-1} \frac{1}{1+r_{s,s+1}}$$

with $R_{0,0} = 1$. $1/R_{0,t}$ is the cumulative interest rate factor. Imposing the terminal condition $R_{0,T-1}Q_T = 0$ results in the intertemporal budget constraint:

$$\sum_{t=0}^{T-1} R_{0,t}p_tC_t = (1 + r_{-1,0})Q_0 + \sum_{t=0}^{T-1} R_{0,t}(Y_{H,t} + p_{N,t}Y_{N,t}) = W.$$

The intertemporal budget constraint simply states that the present value of real consumption must be equal to the present value of income and inital assets.

The consumer then solves the problem

$$max \sum_{t=0}^{T-1} \beta^t u(C_t) \ s.t. \sum_{t=0}^{T-1} R_{0,t}p_tC_t = W$$

Where $u(C_t)$ is a constant elasticity of intertemporal substitution utility function: $u(C_t) = \frac{\sigma}{\sigma-1}C_t^{\frac{\sigma-1}{\sigma}}$. $\sigma$ is the elasticity of intertemporal substitution. Setting up the Lagrangian and maximizing w.r.t. to the sequence of consumption from time 0 to $T-1$ results in the Euler equation for real consumption:

$$C_{t+1} = [\beta(1 + r_{t,t+1})]^\sigma (\frac{p_t}{p_{t+1}})^\sigma C_t.$$

In contrast to the model with a single tradable good, the existence of a non-traded good implies that consumption does not have to be perfectly smoothed when $\beta(1 + r) = 1$. If the consumption basket is more expensive in period $t + 1$ than in period $t$, saving one unit of real consumption buys less real consumption in the future and hence it's optimal to consume more today compared to when the price is constant. Obstfeld and Rogoff (1996) define the consumption based real interest rate as

$$1 + r^C_{t,t+1} = (1 + r_{t,t+1})\frac{p_t}{p_{t+1}}.$$

$r^C_{t,t+1}$ has the interpretation as the interest rate on real consumption. If the consumer forgoes one unit of real consumption in period $t$, this has the value of $p_t$ units of the periphery's tradable good. With interest this grows

to $(1 + r_{t,t+1})p_t$ units in the next period and buys $\frac{(1+r_{t,t+1})p_t}{p_{t+1}}$ units of real consumption. The consumption based real interest rate differs between the two regions whenever the price change of the nontraded good is differs.

The Euler equation for the traded goods basket results from substituting for $C_t$ from the demand function for the traded goods basket

$$C_{T,t+1} = [\beta(1 + r^C_{t,t+1})]^\sigma \left(\frac{p_{T,t+1}/p_{t+1}}{p_{T,t}/p_t}\right)^{-\theta} C_{T,t}$$

For now, assume that the future price of the traded goods basket, $p_T/p$, increases. This has two effects

- First of all, the consumption based real interest rate falls because the aggregate price level will be higher. This results in the consumer saving less.
- Secondly, the traded good becomes relatively more expensive and the consumer substitutes towards the nontraded good with elasticity $\theta$.

It is important to distinguish between the nature of the substitution effects. The term $[\beta(1+r^C_{t,t+1})]^\sigma$ affects the intertemporal allocation of the consumption aggregate $C$. On the other hand, the term $(\frac{p_{T,t+1}/p_{t+1}}{p_{T,t}/p_t})^{-\theta}$ reflects the consumer's wish to substitute between nontraded and traded goods as prices change.

Having analyzed the intertemporal allocation, initial consumption of traded goods is found by iterating the traded basket Euler equation back to $t = 0$

$$C_{T,t} = [\beta^t/R^C_{0,t}]^\sigma (\frac{p_{T,t}/p_t}{p_{T,0}/p_0})^{-\theta} C_{T,0}.$$

By imposing market clearing in the nontraded good sector, $C_{N,t} = Y_{N,t}\ \forall t$, and discounting using the utility based real interest rate, the intertemporal budget constraint can be rewritten as

$$\begin{aligned} p_0 \Sigma_{t=0}^{T-1} R^C_{0,t} \frac{1}{p_t}[C_{H,t} + p_{F,t}C_{F,t}] &= p_0 \Sigma_{t=0}^{T-1} R^C_{0,t} \frac{p_{T,t}}{p_t} C_{T,t} \\ &= (1 + r_{-1,0})Q_0 + \Sigma_{t=0}^{T-1} R_{0,t} Y_{H,t} = W_T \end{aligned}$$

The new intertemporal budget constraint simply states that the present value of traded goods consumption is equal to the present value of the region's tradable wealth. Because nontraded goods per definition cannot be traded, the country's asset position ($Q$) only consists of debt to/claims on the other region. Inserting for $C_{T,t}$ and solving for $C_{T,0}$ yields the following consumption of traded goods basket in the first period

$$C_{T,0} = \frac{W_T/p_{T,0}}{\Sigma_{t=0}^{T-1}\beta^{\sigma t}(R_{0,t}^C)^{1-\sigma}\left(\frac{p_{T,t}/p_t}{p_{T,0}/p_0}\right)^{1-\theta}}$$

The initial price of the traded goods basket enters the numerator to translate wealth from units of the periphery good to units of the traded goods basket. Its pressence is new compared to Obstfeld and Rogoff (1996) and reflects the existence of more than one tradable good. A change in the inital price of the tradable goods basket has a wealth effect. If the price increases by 1%, the purchasing power of the consumer falls by 1%. The terms $(R_{0,t}^C)^{1-\sigma}\left(\frac{p_{T,t}/p_t}{p_{T,0}/p_0}\right)^{1-\theta}$ enter the denominator implying that changes in the interest rate and the price of the traded goods basket have regular income and substitution effects.

Because $C_T$ is a composite good similar to $C$, there are Euler equations for the "basic" goods H and F too. To obtain these, follow the same procedure as for $C_T$ and substitute for $C_T$ in the Euler equation for traded consumption from the demand functions for H and F. This results in the following Euler equations:

$$C_{H,t+1} = [\beta(1+r_{t,t+1}^C)]^\sigma \left(\frac{p_{T,t+1}/p_{t+1}}{p_{T,t}/p_t}\right)^{-\theta}\left(\frac{1/p_{T,t+1}}{1/p_{T,t}}\right)^{-\eta} C_{H,t}$$

$$C_{F,t+1} = [\beta(1+r_{t,t+1}^C)]^\sigma \left(\frac{p_{T,t+1}/p_{t+1}}{p_{T,t}/p_t}\right)^{-\theta}\left(\frac{p_{F,t+1}/p_{T,t+1}}{p_{F,t}/p_{T,t}}\right)^{-\eta} C_{F,t}$$

Just as the Euler equation for the traded goods basket introduced an intratemporal effect, so does these new Euler equations. For example, assume that $p_F/p_T$ increases. This price increase has three effects. First of all it increases the aggregate price level and thereby reducing the real interest rate.

Hence future consumption falls. At the same time, the consumer substitutes towards the nontraded good. Finally (and this is new), the consumer substitutes away from the core's tradable good towards the periphery's tradable good. The two first effects reduce consumption of both tradable goods. However, the new effect dampens the effect on consumption of the periphery's tradable good and reinforces the effect on consumption of the core's tradable good.

Knowing the level of $C_{T,0}$, simply use the demand functions to find period 0 consumption of the periphery and the core's goods

$$C_{H,0} = \alpha(\frac{1}{p_{T,0}})^{-\eta} C_{T,0}$$

$$C_{F,0} = (1-\alpha)(\frac{p_{F,0}}{p_{T,0}})^{-\eta} C_{T,0}$$

.

## A.4 Intertemporal General Equilibrium

To obtain closed-form solutions, the intertemporal elasticity of substitution ($\sigma$) takes the same value as the elasticity of substitution between the traded goods basket and the nontraded good ($\theta$). The benefit is a clear cut answer to what drives the terms of trade and the real exchange rate. Although the assumption may seem arbitrary, section  argues that the assumption is inline with empirical evidence.

### Intratemporal prices

The first price to consider is the price of the core good, $p_{F,t}$. $p_F$ also has the interpretation as the terms of trade. The terms of trade is the amount of import goods one unit of the country's export good buys. An increase in $p_F$ is consistent with a deterioration of the periphery's terms of trade as it now must pay more for each unit of imports. On the other hand, the terms of trade for the core improves as they receive more imports per unit exported. Market clearing in the traded goods markets require $C_{H,t} + C^*_{H,t} =$

$Y_{H,t}$ and $C_{F,t} + C^*_{F,t} = Y_{F,t}$ , $\forall t = 0, 1, 2, ..., T-1$. Solving for $p_{F,t}$ in each period, the equilibrium price is

$$p_{F,t} = \left( \frac{1-\alpha}{\alpha} \frac{Y_{H,t}}{Y_{F,t}} \right)^{1/\eta}.$$

The higher the relative preference for the core's tradable good is, the higher is the price of this good. Similarily, the more available the periphery's traded good is, the higher is the price of the core's good. As $\eta$ increases, the consumers' demand for the core's good becomes more sensitive to the price, hence a lower price is needed to incentivize the consumers to shift their demand.

Using the price at $t+1$, a simple first order difference equation can be established which explains the development in the terms of trade.

$$\frac{p_{F,t+1}}{p_{F,t}} = \left( \frac{1+g_{t,t+1}}{1+g^*_{t,t+1}} \right)^{\frac{1}{\eta}}.$$

In which $g$ is growth in the two regions between period $t$ and $t+1$. Taking logarithms and linearizing the right hand side results in $p_{F,t+1}/p_{F,t} = \frac{1}{\eta}(g_{t,t+1} + g^*_{t,t+1}) = \frac{a}{\eta}(g_{t-1,t} - g^*_{t-1,t})$. Thus, the growth persistence parameter $a$ from section A.1 is crucial in detmermining the long run change in the terms of trade. The price of the core's tradable good increases whenever the periphery's tradable good becomes relatively less scarce compared to the core's tradable good. Again the elasticity of substitution between the periphery and the core's good plays a crucial role. The higher $\eta$ is, the lower is the required price change. The higher is $a$, the larger is the price change.

The prices of nontraded goods are decided by the consumers' marginal rate of substitution between nontraded and traded goods. When choosing between the basket of traded goods and the nontraded good, the consumer adapts such that the marginal rate of substitution between nontraded goods and the traded basket is equal to the relative price:

$$\frac{p_{N,t}}{p_{T,t}} = \left( \frac{1-\gamma}{\gamma} \frac{C_{T,t}}{Y_{N,t}} \right)^{1/\theta} \text{ and } \frac{p^*_{N,t}}{p_{T,t}} = \left( \frac{1-\gamma}{\gamma} \frac{C^*_{T,t}}{Y^*_{N,t}} \right)^{1/\theta}. \tag{A.1}$$

Using that $C_{N,t} = Y_{N,t}$ in equilibrium. The nontraded good is expensive in units of the traded consumption basket if the consumers put a relatively large weight on the nontraded good, represented by $1-\gamma$, and when consumption of the traded basket is relatively high. When consumption of the traded basket is high, total expenditure is also high. This leads to a higher demand for nontraded goods and thus a higher price. Consumption of the traded consumption basket grows at a rate $g^T_{t,t+1}$ which is a weighted average of $g_{t,t+1}$ and $g^*_{t,t+1}$[1] . Using this simplification, a first order difference equation can be established for the evolution of the price nontraded goods too

$$\frac{p_{N,t+1}}{p_{T,t+1}} = \left(\frac{1+g^T_{t,t+1}}{1+g_{t,t+1}}\right)^{1/\theta} \frac{p_{N,t}}{p_{T,t}} \text{ and } \frac{p^*_{N,t+1}}{p_{T,t+1}} = \left(\frac{1+g^T_{t,t+1}}{1+g^*_{t,t+1}}\right)^{1/\theta} \frac{p^*_{N,t}}{p_{T,t}}.$$

As consumption of the traded consumption basket grows, demand for the nontraded good also increases. Whether the nontraded good is relatively more scarce depends on the growth rate of the nontraded good compared to that of the traded consumption basket. Because $g^T$ is a weighted average of $g$ and $g^*$, it must lie between these two values. Thus, the price of the nontraded good increases in the region with the lowest growth rate.

The real exchange rate, $q$, is given by

$$q_t = p^*_t/p_t = \frac{[\gamma + (1-\gamma)(p^*_{N,t}/p_{T,t})^{1-\theta}]^{\frac{1}{1-\theta}}}{[\gamma + (1-\gamma)(p_{N,t}/p_{T,t})^{1-\theta}]^{\frac{1}{1-\theta}}} \tag{A.2}$$

What matters for the evolution of the real exchange rate is the evolution in the price of nontradables in units of the traded consumption basket which in turn is determined by the growth rate in consumption of tradables relative

[1]Because the two consumers have identical preferences, we can define

$$Y_{T,t} = [\gamma^{\frac{1}{\eta}} Y_{H,t}^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\eta}} Y_{F,t}^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}}.$$

$Y_T$ has the interpretation as an aggregate tradable good, similar to $C_T$ but as an endowment. The growth in this aggregated endowment can then be written as

$$(1+g^T_{t,t+1})^{\frac{\theta-1}{\theta}} = \left(\frac{Y_{T,t+1}}{Y_{T,t}}\right)^{\frac{\theta-1}{\theta}} = (1+g_{t,t+1})^{\frac{\theta-1}{\theta}} \gamma^{\frac{1}{\theta}} \left(\frac{Y_{H,t}}{Y_{T,t}}\right)^{\frac{\theta-1}{\theta}} + (1+g^*_{t,t+1})^{\frac{\theta-1}{\theta}} (1-\gamma)^{\frac{1}{\theta}} \left(\frac{Y_{F,t}}{Y_{T,t}}\right)^{\frac{\theta-1}{\theta}}.$$

to the growth rates of nontradables. The way the real exchange rate is defined, an increase in $q$ is associated with a depreciation of the periphery's real exchange rate as they now have to pay an increasing number of their own consumption aggregate for one unit of the core's consumption aggregate. Because growth is equal between sectors in a region, the real exchange rate apprciates for the region with the lowest growth rate.

Due to the CES consumption aggregator and CES price index, the definition of the real exchange rate can be rewritten from real terms to nominal terms. The relative changes in the real exchange rate can be interpreted as the difference between the inflation rate in the two regions.

$$\frac{q_{t+1}}{q_t} = \frac{p^*_{t+1}/p_{t+1}}{p^*_t/p_t} = \frac{P^*_{t+1}/P_{t+1}}{P^*_t/P_t} = \frac{P^*_{t+1}/P^*_t}{P_{t+1}/P_t} = \frac{1+\pi^*_{t,t+1}}{1+\pi_{t,t+1}}.$$

Capital letters denote nominal prices and $\pi$ is the inflation rate. Taking logs and linearizing the equation results in

$$\Delta \ln q_{t,t+1} \approx \pi^*_{t,t+1} - \pi_{t,t+1}. \tag{A.3}$$

For example, a 1% real exchange rate appreciation implies that inflation in the core is approximately 1% above inflation in the periphery. In a model with a nomial exchange rate, the nominal exchange rate would be able to do some, if not all, of the adjustment. Thus, leaving the inflation difference unchanged. In the pressence of nominal price rigidities, a nominal exchange rate is a benefit as it would adjust instantly. Instead, the Eurozone has to go through a long period where real prices and real wages adjust through internal devaluation.

The calculation of the nontraded goods' prices requires that consumption at time $t$ is known. To determine initial traded goods consumption, one needs the interest rate.

### Interest Rates

A consequence of setting the intertemporal elasticity of substitution ($\sigma$) equal to the elasticity of substitution between the traded goods basket and the

nontraded good ($\theta$) is that the aggregate price level no longer enters the Euler equation for the basket of traded goods. This happens because a change in the aggregate price level affects the intertemporal allocation of real consumption and substitution between the traded goods basket and the nontraded good in equal, but opposite directions. As a result the two regions have the same Euler equation for the traded goods basket! Hence, they will choose the same growth rate for traded goods basket. Because they have identical preferences for the two tradable goods they will also choose a common growth rate for consumption of each traded good. Thus, the model exhibits perfect consumption correlation[2]. In equilibrium, the only growth rate that can satisfy this condition is the growth rate of the endowments. To see why, assume that the market for the periphery's tradable good clears in the first period. If the two regions' demand grows at a lower rate than the endowment of the periphery's tradable, there will be excess supply of the periphery's tradable in the next period. If their chosen consumption growth rate is higher than the endowment growth rate, there will be excess demand in the next period. Hence, the only growth rate that secures market clearing in all periods is the growth rate of the endowment itself.

Section  argues that empirical estimates of the elasticity of intertemporal substitution and the elasticity of substitution between nontraded and traded goods are close to each other. Setting $\sigma = \theta$ results in the following Euler equations for the periphery good

$$C_{H,t+1} = [\beta(1+r_{t,t+1})]^{\sigma} \left(\frac{p_{T,t+1}}{p_{T,t}}\right)^{\eta-\theta} C_{H,t} \text{ and } C^*_{H,t+1} = [\beta(1+r_{t,t+1})]^{\sigma} \left(\frac{p_{T,t+1}}{p_{T,t}}\right)^{\eta-\theta} C^*_{H,t}.$$

Becuase the two regions choose the same growth rate for consumption of the periphery's traded good, the terms in front of $C_{H,t}$ and $C^*_{H,t}$ has to be equal to the growth rate in the endowment of the periphery's traded good

$$1 + g_{t,t+1} = [\beta(1 + r_{t,t+1})]^{\sigma} \left(\frac{p_{T,t+1}}{p_{T,t}}\right)^{\eta-\theta}$$

[2]As documented by Backus, Kehoe, and Kydland (1992) this property does not hold in the real world.

where $g_{t,t+1}$ is the growth rate of the tradable good in the periphery[3]. Solving for the interest rate results in

$$1 + r_{t,t+1} = \frac{1}{\beta}\left[(1 + g_{t,t+1})\left(\frac{p_{T,t+1}}{p_{T,t}}\right)^{\theta-\eta}\right]^{1/\sigma}.$$

The more impatient the consumers are, lower $\beta$, the higher return they require on their savings. As the consumers want to smooth consumption over time, higher future income is reflected in higher current consumption. Hence, the interest rate increases with growth to incentivize the consumers to save. To interpret the equilibrium interest rate, assume that $p_T$ is falling[4] and that $\theta < \eta$[5] When this is the case, the consumers will substitute away from nontraded goods towards traded goods, but away from the periphery's tradable good towards the core's traded good. When $\theta < \eta$ the net effect is a fall in future demand for the periphery traded good. To increase future demand the interest rate increases.

## A.5 Prices and Interest Rates With an Exogenous Current Account

To study the case of suboptimal consumption allocation, the periphery's current account follows an exogenous process $\{CA_t\}_{t=0}^{T-1}$. To match the observed Target2 deficits in figure 1, the periphery's current account is assumed to be negative initially. In this regime the consumption path will be entirely exogenous compared to previously when the consumers chose $\{C_{T,t}\}_{t=0}^{T_1}$ to maximize life-time utility. Because the current account is exogenous, expenditure on traded goods is fixed at $r_{t-1,t}Q_t + Y_{H,t} - CA_t$ and $-r_{t-1,t}Q_t + p_{F,t}Y_{F,t} + CA_t$ for the periphery and the core respectively. Given these expenditures the rel-

[3]Another way to obtain this equation is to add the two Euler equations and use market clearing.

[4]For $p_T$ to be decreasing in equilibrium, growth in the core's traded endowment must be higher than the growth in the periphery's traded endowment.

[5]Section  argues that this is a reasonable assumption. However, it is quite intuitive. Traded goods from the two countries are likely to be closer substitutes than traded goods and the nontraded good.

ative price of the core's tradable good and the interest rate do not change. This is because even though the consumers' expenditure on tradable goods is fixed, their expenditure allocation between the periphery's and the core's good is not altered. Hence, the relative demand for the periphery's and the core's good is unchanged, and the relative price is the same. Likewise, the interest rates (in units of the periphery's good, the core's good or the traded basket) do not change. These interest rates do not change because fixing the current account does not change the growth in aggregate demand for these goods between periods. Hence, the interest rates are unchanged.

On the other hand, changing the path of the current account has implications for the relative prices of nontraded goods. A current account deficit in one region can be seen as a transfer of resources from the surplus region. This transfer increases (reduces) aggregate expenditure in the region running a deficit (surplus) and hence demand for the tradable goods and the nontraded good increases (falls). Because the supply of the nontraded good is inelastic at $Y_{N,t}$ ($Y^*_{N,t}$), the price of the nontraded good increases (falls) to clear the market. This is the *transfer effect* discussed in chapter 4.5.5.4 in Obstfeld and Rogoff (1996).

In the analysis to come, it will turn out that the periphery optimally runs a current account surplus to repay its debt. This current account surplus is due to the finite horizon and the terminal condition[6]. One implication is that when going from the optimal to the suboptimal consumption path the transfer effect will be larger and the periphery (core) will have a higher (lower) aggregate price level and thus face a stronger (weaker) real exchange rate than it would have on the optimal path. A second implication is that the relative price of nontradables will decline over time in the periphery, and increase in the core. This price decline is due transfers decreasing as the current account eventually turns positive and the debt is repaid. At the same time, the aggregate price level falls and the periphery's real exchange rate depreciates from a level that was "too high" compared the optimal path.

[6]The qualitative result does not change when moving to an infinite horzion. A transversality condition replaces the terminal condition and the periphery still has to run current account surpluses to pay back its initial debt. For details, see math appendix of Obstfeld and Rogoff (1996)

Equation (4) gives the price of the nontraded good on the optimal consumption path. By substituting the optimal value of $C_T$ with the value of $C_T$ on the suboptimal adjustment path one finds the price of the nontraded good on the suboptimal adjustment path. Letting a hat (ˆ) indicate the variables' value on the suboptimal adjustment path, the misalignment of the nontraded good price at time $t$ can be calculated by

$$\frac{\hat{p}_{N,t}}{p_{N,t}} = \left(\frac{\hat{C}_{T,t}}{C_{T,t}}\right)^{\frac{1}{\theta}}. \tag{A.4}$$

Taking logarithms and linearizing the above equation gives a useful rule of thumb for the misalignment in the price of the nontraded good. If traded goods consumption deviates from its optimal level by $k_{T,t}$ percent, the price of the nontraded good deviates by approximately

$$k_{N,t} \approx \frac{1}{\theta} k_{T,t} \tag{A.5}$$

percent. Because both sides are log-linearized, the rule of thumb ought to be robust for values of $k_T$ "not close to" zero. By using equation (7), one can separate two effects that cause changes in the price of nontradable goods on the suboptimal path. Using equation (7) for period $t$ and $t+1$, the change in the price of the nontraded good is given by

$$\frac{\hat{p}_{N,t+1}}{\hat{p}_{N,t}} = \left(\frac{\hat{C}_{T,t+1}/C_{T,t+1}}{\hat{C}_{T,t}/C_{T,t}}\right)^{\frac{1}{\theta}} \frac{p_{N,t+1}}{p_{N,t}} \tag{A.6}$$

The last term on the right hand side reflects changes in the price on the optimal path. On the optimal path, as we have seen, the prices only change in response to changes in supply. On the other hand, the first term reflects the suboptimal allocation of traded goods consumption. Hence, this term reflects price changes due to the transfer effect. Using equation 8 one can approximate the excess price changes resulting from suboptimal consumption allocation to be $k_{N,t+1} - k_{N,t} = \frac{1}{\theta}(k_{T,t+1} - k_{T,t})$. From this equation, we see that the elasticity of substitution between traded goods and the nontraded

good plays an important role in determining the real exchange rate changes.

Although the current account is taken as given, the regions have to satisfy their budget constraints. Net foreign assets of the periphery evolve according to $Q_{t+1} - Q_t = CA_t$ which implies that the sequence of current accounts must satisfy

$$\Sigma_{t=0}^{T-1} CA_t = -Q_0.$$

If the periphery is a net debtor, $Q_0 < 0$, the periphery must run current account surpluses sufficient to pay back the core. To obtain closed form solutions, the current account closes linearly over $\tau$ periods and then grows at a rate $g^{CA}$. That is, the period $t$ current account of the periphery is given by

$$CA_t = \begin{cases} CA_0 - \frac{CA_0}{\tau-1} t & \text{if } 0 \leq t \leq \tau - 1 \\ (1 + g^{CA})^{t-\tau} CA_\tau & \text{if } \tau \leq t \leq T - 1 \end{cases} \tag{A.7}$$

The necessary current account position at time $\tau$ is found by substituting for $CA_t$ in the budget constraint. Doing so results in[7]

$$CA_\tau = -\frac{Q_0 + \frac{\tau CA_0}{2}}{\Sigma_{t=\tau}^{T-1} (1 + g^{CA})^{t-\tau}}$$

The intuition is clear. The more negative the asset position is and the longer the region uses to balance the current account, the larger is the necessary current account payments from time $\tau$ to $T-1$. Finally, $CA_\tau$ is decreasing in $g^{CA}$ reflecting that the necessary payment at time $\tau$ is smaller if the payments grow at a higher rate.

[7]The derivations uses the formula

$$\Sigma_{j=1}^{\tau-1} j = \frac{(\tau - 1)\tau}{2}$$

## A.6 A Welfare Measure of Suboptimal Adjustment

To compare the costs associated with suboptimal adjustment to the optimal path, a welfare measure must be established. One possible way of measuring the welfare loss is to calculate how much real consumption the consumers would have to give up in each period under optimal adjustment to be as well off as under the exogenous adjustment. This approach is similar to that taken by Lucas (2003).

Let $c_A$ be the consumer's consumption under policy A and $c_B$ his consumption under policy B and $U(c_A)$ and $U(c_B)$ the corresponding welfare levels. The consumer prefers policy B such that $U(c_B) > U(c_A)$. Lucas defines the *welfare gain*, $\lambda$, from a change in policy from A to B as

$$U((1+\lambda)c_A) = U(c_B)$$

where $\lambda$ is measured "in units of a percentage of all consumption goods" (Lucas, 2003).

Following the suggestion of Lucas (2003), the welfare measure can be adapted to a subset of goods. In the two scenarios considered later, consumption of nontraded goods is unaffected by the exogenous adjustment of traded goods. Hence, a more specific measure of welfare is the percentage *reduction* in (optimal) tradable consumption that would make the consumers indifferent between the optimal and the exogenous consumption path. Mathematically this can be formulated as

$$\Sigma_{t=0}^{T-1}\beta^t u(C_t((1-\kappa)C_{T,t}^{optimal}, Y_{N,t})) = \Sigma_{t=0}^{T-1}\beta^t u(C_t(C_{T,t}^{suboptimal}, Y_{N,t}))$$

With $u(C_t) = \frac{\sigma}{\sigma-1}C_t^{\frac{\sigma-1}{\sigma}}$ and $\sigma = \theta$, $\kappa$ is defined by

$$\kappa = 1 - \left(\frac{\Sigma_{t=0}^{T-1}\beta^t (C_{T,t}^{suboptimal})^{\frac{\sigma-1}{\sigma}}}{\Sigma_{t=0}^{T-1}\beta^t (C_{T,t}^{optimal})^{\frac{\sigma-1}{\sigma}}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{A.8}$$

The welfare measure for the core, $\kappa^*$, is defined in the same way by just replacing core consumption for periphery consumption.

# Appendix B

# Calculating Unobserved Values

The price of the core's tradable good is crucially dependent on $Y_H/Y_F$. However, these values are not observable. Assuming agents behave optimally, the values can be infered from observed values. One way to do this is to estimate how big the monetary value of production in the tradable sector is compared to GDP. By using the relative value of the two regions' GDP, the relative value of the two regions' tradable GDP can be infered. Let $\omega = \frac{Y_{H,0}+p_{N,0}Y_{N,0}}{p_{F,0}Y_{F,0}+p^*_{N,0}Y^*_{N,0}}$ be the relative value of the two regions' GDP and $y_{H,0} = \frac{Y_{H,0}}{Y_{H,0}+p_{N,0}Y_{N,0}}$ and $y_{F,0} = \frac{p_{F,0}Y_{F,0}}{p_{F,0}Y_{F,0}+p^*_{N,0}Y^*_{N,0}}$ be the shares of tradables in the two regions' GDP. Then the relative value of the two countries's tradables is given by

$$\frac{Y_{H,0}}{p_{F,0}Y_{F,0}} = \frac{y_H}{y_F}\omega.$$

From the section on general equilibrium, $p_{F,0} = \left(\frac{1-\alpha}{\alpha}\frac{Y_{H,0}}{Y_{F,0}}\right)^{1/\eta}$ Multiplying by $p_{F,0}^{-1/\eta}$, substituting the above expression for $\frac{Y_{H,0}}{p_{F,0}Y_{F,0}}$ and solving for $p_{F,0}$ gives the following price of the core's tradable good

$$p_{F,0} = \left(\frac{1-\alpha}{\alpha}\frac{y_H}{y_F}\omega\right)^{\frac{1}{\eta-1}}.$$

Substitute into the expression for $\frac{Y_{H,0}}{p_{F,0}Y_{F,0}}$ to find

$$\frac{Y_{H,0}}{Y_{F,0}} = \left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\eta-1}} \left(\frac{y_{H,0}}{y_{F,0}}\omega\right)^{\frac{\eta}{\eta-1}}.$$

To find the prices of nontradables, proceed in a similar manner. The current account identity gives the amount of traded goods consumption in the economy.

$$\frac{p_{T,0}C_{T,0}}{BNP_0} = \frac{r_{-1,0}B_0}{BNP_0} + y_{H,0} - \frac{CA_0}{BNP_0}.$$

Manipulate the expression for the nontraded price in a similar way to the expression for $p_{F,0}$, to up with

$$\frac{p_{N,0}}{p_{T,0}} = \left(\frac{1-\gamma}{\gamma}\frac{p_{T,0}C_{T,0}/BNP_0}{1-y_{H,0}}\right)^{\frac{1}{\theta-1}}.$$

Finally, on finds the relativ endowment of the periphery tradable and non-tradable good by solving $\frac{Y_{H,0}}{Y_{H,0}+p_{N,0}Y_{N,0}} = y_{H,0}$ w.r.t. $Y_{N,0}/Y_{H,0}$ resulting in

$$\frac{Y_{N,0}}{Y_{H,0}} = p_{N,0}\frac{y_{H,0}}{1-y_{H,0}}.$$

The ratio $\frac{Y_{N^*,0}}{Y_{F,0}}$ is found in a similar manner by using the equivalent variables for the core.

# Appendix C

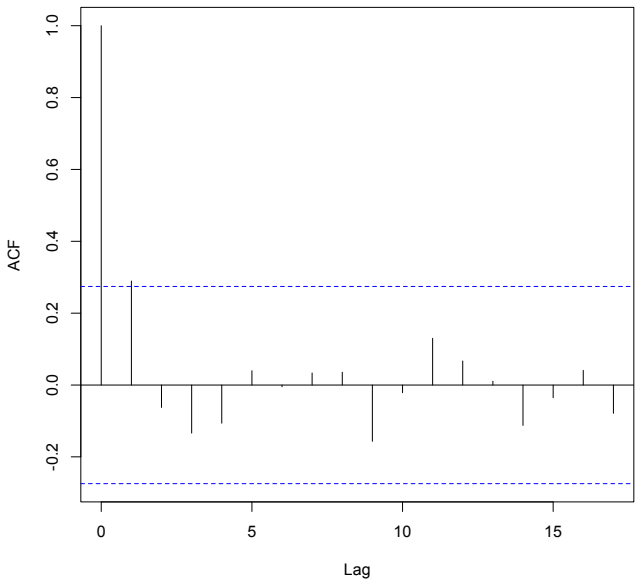
# Tables and Figures

## C.1 Inflation

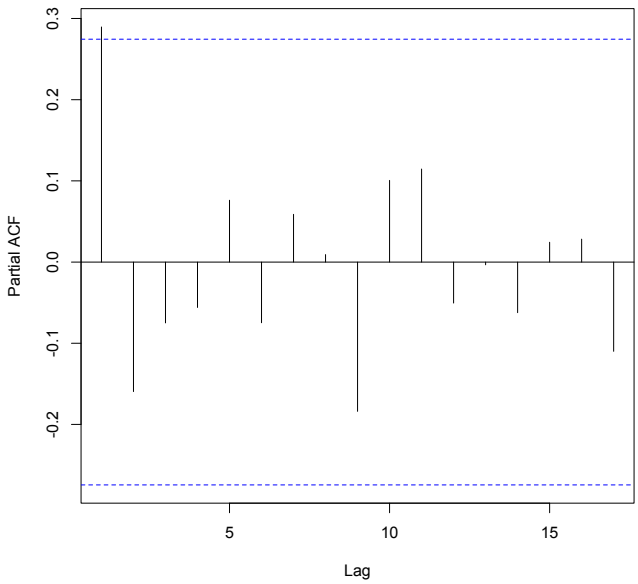
| Country | Inflation(%) |
|---|---|
| **The core** | |
| Finland | 2.1 |
| Germany | 1.3 |
| Luxembourg | 2.1 |
| Netherlands | 2.3 |
| **The periphery** | |
| Austria | 2.2 |
| Belgium | 1.9 |
| France | 1.5 |
| Greece | -0.3 |
| Ireland | 0.8 |
| Italy | 2.0 |
| Portugal | 1.2 |
| Spain | 1.3 |

Table C.1: Inflation rates in the Eurozone in 2012. Source: Eurostat[2] `http://sdw.ecb.europa.eu/browse.do?node=2120778`

## C.2 US GDP per Capita Growth Series




(a) Autocorrelation function of US GDP per capita growth series




(b) Partial autocorrelation function of US GDP per capita growth series

Figure C.1: Correlation functions of US GDP per capita growth series

| | Variable | |
|---|---|---|
| | $\hat{a}$ | $\hat{c}$ |
| Point estimate | 0.2874 | 1.9802 |
| Standard error | 0.1332 | 0.3992 |
| Sigma$^2$=4.189 | Log likelihood=-108.94 | AIC=223.87 |

Table C.2: Output from fitting of an AR(1) process to the series in figure 3.

# Appendix D

# Extension: Model with Home-Bias

## D.1 Inter- and intratemporal equilibrium

In order to obtain closed-formed solutions I will restrict the elasticities to satsify $\sigma = \theta = \eta = 1$. That is, logarithmic intertemporal utility and Cobb-Douglas preferences over the goods. With home-bias and Cobb-Douglas preferences, preferences reduce to:

$$C = C_T^{\gamma} C_N^{1-\gamma} \text{ and } C^* = C_T^{*\gamma} C_N^{1-\gamma}$$

where

$$C_T = C_H^{\alpha} C_F^{1-\alpha} \text{ and } C_T^* = C_H^{1-\alpha} C_F^{\alpha} \text{ , } \alpha \in [1/2, 1)$$

The new price indices are:

$$p = p_T^{\gamma} p_N^{1-\gamma} \text{ and } p^* = p_T^{*\gamma} p_N^{*1-\gamma}$$

where

$$p_T = p_F^{1-\alpha} \text{ and } p_T^* = p_F^{\alpha}.$$

Assume for the moment that the trade balance of each country is exogenously determined such that expenditure on traded goods is fixed. The market

clearing price for the core's traded good has to satisfy:

$$Y_H = \alpha p_T C_T + (1-\alpha) p_T^* C_T^* = \alpha(Y_H - TB) + (1-\alpha)(p_F Y_F + TB).$$

Where $TB$ is the trade balance of the periphery. Solving for $p_F$ yields

$$p_F = \frac{Y_H}{Y_F}\left[1 + \frac{2\alpha - 1}{1-\alpha} tb\right]$$

where $tb = TB/Y_H$. The second term in the bracket drops out when the consumer values the two goods equally, i.e. $\alpha = 1/2$. With home bias, $\alpha \in (1/2, 1)$, a negative trade balance of the periphery shifts relative demand away from the core's traded good compared to the situation without home-bias. Thus, the price of the core's traded good is lower.

With all elasticities equal, the Euler equations for the periphery traded good can be written as

$$\frac{C_{H,t+1}}{C_{H,t}} = \beta(1 + r_{t,t+1}) = \frac{C^*_{H,t+1}}{C^*_{H,t}}$$

implying that the two regions choose the same consumption growth for traded goods (similarily for the core's traded good). Adding the two regions' Euler equations and imposing market clearing gives the equilibrium real interest rate

$$1 + r_{t,t+1} = \frac{1}{\beta}(1 + g_{t,t+1})$$

By substituting into the Euler equation for traded goods consumption, it's clear that expenditure on traded goods grows at the rate $g_{t,t+1}$ aswell. Thus, income and traded goods expenditure grows at rate $g_{t,t+1}$ in the periphery. As a consequence the trade balance to tradable GDP ratio, $TB/Y_H = (Y_H - p_T C_T)/Y_H$, is constant in equilibrium. Hence, the terms of trade ($p_F$) only change due to changes in the relative supply of the two traded goods.

Further, equation 4 still gives the price of nontraded goods in the two regions. In the periphery it will remain constant because traded goods expenditure and the supply of nontraded goods grow at the same rate. In the

core the supply of nontraded goods will grow at rate $g^*_{t,t+1}$, thus

$$\frac{p_{N,t+1}}{p_{N,t}} = \frac{1 + g_{t,t+1}}{1 + g^*_{t,t+1}}.$$

The real exchange rate is defined by

$$q = \left(\frac{p^*_T}{p_T}\right)^{\gamma} \left(\frac{p^*_N}{p_N}\right)^{1-\gamma}.$$

In the specification without home-bias, the price of traded goods would cancel and the real exchange rate would only depend on the price of nontraded goods. However, with home-bias the traded goods basket differ across the two countries and the differs. Thus, including home-bias results in the terms of trade affecting the real exchange rate. The dynamics of the real exchange rate is

$$\frac{q_{t+1}}{q_t} = \left(\frac{p_{F,t+1}}{p_{F,t}}\right)^{\gamma(2\alpha-1)} \left(\frac{p^*_N}{p_N}\right)^{1-\gamma} = \left(\frac{1 + g_{t,t+1}}{1 + g^*_{t,t+1}}\right)^{\gamma(2\alpha-1)+(1-\gamma)}.$$

From this it's clear that home-bias increases the exchange rate movement for a given difference in growth rates.

## D.2 Exogenous Current Account

In the counterfactual analysis [1] the current account identity still determines traded goods consumption. In general, the trade balance to tradable GDP ratio of the periphery will no longer stay constant. Thus the terms of trade will differ between the "optimal" path and the counterfactual. First of all, this leads to different price dynamics and potentially exacerbated inflation differences. Second, the effect on the terms of trade has an impact on the purchasing power of the two regions. Hence, it will lead to an "income efffect" in the welfare criterion and one region does not necessarily have to be worse off in the counterfactual analysis.

[1] Where I in the previous analysis chose the word "suboptimal" to describe the alternative consumption path, I have here chosen to use "counterfactual".

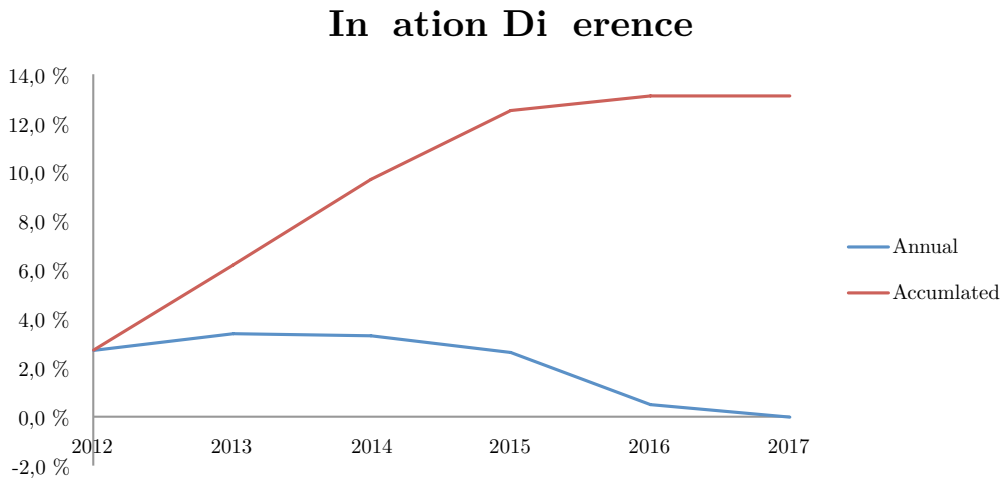



Figure D.1: Inflation difference between the two regions.

The following analysis assumes a somewhat different adjustment of the current account. Instead of it closing linearly in levels (in units of the periphery's traded good), the current account to tradable GDP falls linearly. Secondly, it's the current account to tradable GDP ratio that grows exponentially after 2017 (not the level as previously).

Figure D.1 displays the inflation difference between the periphery and the core in the short to medium run under the counterfactual adjustment path. The inflation difference following a rebalancing of the current account is smaller compared to earlier due to lower elasticities.

Figure D.2 shows the welfare loss of the regions under the current counterfactual analysis. The higher elasticity of intertemporal substitution makes the consumer more willing to substitute consumption at different dates and thus his welfare loss is lower compared to the previous analysis. The reason why the welfare measure takes on negative values for the core (implying that the core is better off) is currently not identified.

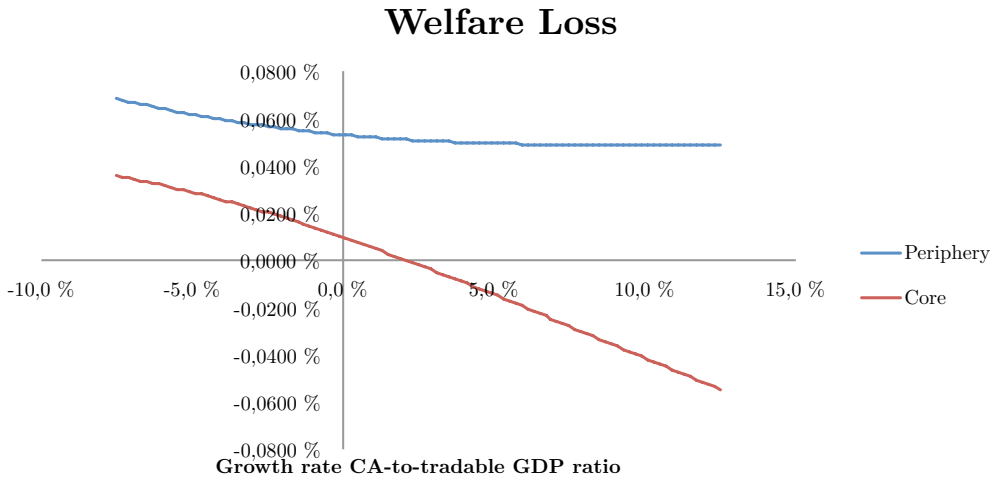



Figure D.2: Welfare loss as a function of the current account to tradable GDP growth rate after 2017.

# Bibliography


Auer, R. A. (2012). What Drives Target2 Balances? Evidence from a Panel Analysis. Swiss National Bank Working Papers.

Backus, D. K., P. J. Kehoe, and F. E. Kydland (1992, August). International Real Business Cycles. *Journal of Political Economy 100*(4), 745–775.

Barro, R. J. and X. Sala-i-Martin (2003). *Economic Growth, Second Edition*. MIT Press.

Bordo, M. D. and J. G. Haubrich (2012, June). Deep Recessions, Fast Recoveries, and Financial Crises: Evidence from the American Record. Federal Reserve Bank of Cleveland.

Carone, G., C. Denis, K. M. Morrow, G. Mourre, and W. Röger (2006, June). Long-term Labour Productivity and GDP Projections for the EU25 Member States: a Production Function Framework. Technical Report 253, Directorate-General for Economic and Financial Affairs.

Che, N. X. and A. Spilimbergo (2012, April). Structural Reforms and Regional Convergence. IMF Working Paper.

Cour-Thimann, P. (2013). Target Balances and the Crisis in the Euro Area. *CES ifo 14*.

ECB (2013). Target Annual Report. Report, European Central Bank.

European Commission (2012, September). Commission proposal for a single supervisory mechanism (2012). `http://ec.europa.eu/internal_market/finances/banking-union/index_en.htm`.

Hall, R. E. (1988, April). Intertemporal Substitution in Consumption. *Journal of Political Economy 96*(2), 339–357.

Jones, C. I. (2002, September). Sources of U.S. Economic Growth in a World of Ideas. *American Economic Review 92*(1), 220–239.

Jones, L., R. Manuelli, and H. Siu (2000). *Growth and Business Cycles*, Volume no. w7633 of *NBER working paper series*. Cambridge, Mass: National Bureau of Economic Research.

Lucas, R. E. (2003, September). Macroeconomic Priorities. *American Economic Review 93*(1), 1–14.

Masoni, D. (2012, January). Italians, Greeks seek shelter in Berlin house market. `http://www.reuters.com/article/2012/01/19/italy-berlin-property-idUSL6E8CI4D520120119`.

Obstfeld, M. (1994). Evaluating Risky Consumption Paths: The Role of Intertemporal Substitutability. *European Economic Review 38*(7), 1471–1486.

Obstfeld, M. and K. Rogoff (1996). *Foundations of International Macroeconomics*. MIT Press.

Obstfeld, M. and K. Rogoff (2000). Perspectives on OECD Economic integration: Implications for US Current Account Adjustment. UC Berkeley: Center for International and Development Economics Research.

Obstfeld, M. and K. Rogoff (2004). *The Unsustainable US Current Account Position Revisited*, Volume no. w10869 of *NBER working paper series*. Cambridge, Mass: National Bureau of Economic Research.

Obstfeld, M. and K. Rogoff (2005). Global Current Account Imbalances and Exchange Rate Adjustments. *Brookings Papers on Economic Activity* (1).

Reinhart, C. M. and K. S. Rogoff (2009, May). The Aftermath of Financial Crises. *The American Economic Review 99*(2), 466–472.

Sinn, H.-W. and T. Wollmershäuser (2012). Target Loans, Current Account Balances and Capital Flows: the ECB's Rescue Facility. *International Tax and Public Finance 19*(4), 468–508.

Stockman, A. C. and L. L. Tesar (1995, March). Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements. *The American Economic Review 85*(1), 168–185.

Tesar, L. L. (1993). International Risk-Sharing and Non-Traded Goods. *Journal of International Economics 35*(1–2), 69 – 89.

The Economist (2012, November). Euro angst hits home. `http://www.economist.com/news/finance-and-economics/21567137-big-cities-feel-rush-bricks-and-mortar-euro-angst-hits-home`.