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Specialization Patterns, GDP Correlations, and External Balances

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Abstract

This article provides evidence of a link between specialization patterns—in intermediate inputs or final goods—and business cycle correlations: countries with a similar intermediate goods content of exports tend to have more correlated gross domestic product fluctuations and external balances. We produce a model that replicates these facts. A productivity shock in a large country ('the U.S.') has a smaller effect on the terms of trade of countries that share its specialization, while being shared fully with countries specialized in the other type of good through a terms-of-trade effect. In the presence of complete asset markets, the trade balance reflects the flow of insurance payments. All countries who benefit little from the shock in the large country will have correlated, negative net exports. The trade balances of all other countries will jointly move in the opposite direction.

JEL classification: F4

Key words: international business cycles, net exports, intermediate inputs

1 Introduction

International trade is widely recognized as an important transmission mechanism of international business cycles (Baxter and Kouparitsas 2005). However, as yet there seems to be little understanding of how differences in industrial structures across countries affect the business cycle transmission via trade linkages, and the determination of trade balances.[1]

This article considers one key difference between countries—the extent to which they act as intermediate input suppliers as opposed to final goods producers in international

1 Backus et al. (1992) first pointed out a number of anomalies in the canonical open-economy real business cycle model. The most relevant of these to our work is the so-called 'trade co-movement puzzle', established by Kose and Yi (2006): the empirically observed relationship between bilateral trade and GDP correlations is far stronger than the standard model would suggest. Subsequently, Kraay and Ventura (2007) pointed out that the strength and synchronization of business cycles may vary across country pairs in a model of trade due to comparative advantage.

production chains. We gauge the difference in countries' production structures along this dimension from the share of their exports used as production inputs, and highlight that this measure of specialization seems to be relevant for predicting the strength of business cycle co-movement: country pairs that display more similar specialization patterns appear to have more correlated gross domestic product (GDP) fluctuations and trade balances.

We then offer an explanation for our empirical findings based on a model with a large country ('the U.S.') and many small countries specialized either in intermediate or final goods production. A crucial assumption of the model is that the elasticity of substitution between intermediate and final goods is 1, while the elasticity of substitution between different varieties of intermediate goods, or different varieties of final goods, is larger than 1. In this setting, shocks to the large country affect countries with different specialization patterns differently through the terms of trade. Countries sharing the large country's specialization experience a smaller increase in incomes than the rest of the world because their terms of trade respond less strongly. This gives rise to a positive association between similarity in specialization patterns and GDP correlations.

When allowing for international asset trade, our model also has implications for the trade balance. The GDPs of countries that share the same specialization pattern are affected similarly by shocks originating in the large country. Thus, to the extent that the trade balance reflects international insurance payments, the trade balances of similarly specialized countries will move in the same direction.

International production linkages—whereby industries in some countries emerge as input suppliers for industries in others—are an increasingly important phenomenon in the global economy: recent estimates suggest that they have been responsible for 30–50% of the expansion of world trade since 1970 (Hummels et al. 2001; Yi 2003). A growing literature explores the influence of trade in intermediate goods in different areas of macroeconomics: Yi (2003, 2010) first introduced input trade in standard international macro models, showing that this improves the ability of quantitative trade models to account for the growth of trade during the second half of the twentieth century, and the size of the perceived 'home bias' in international trade; Bems et al. (2011) use a global input–output framework to study the decline of international trade during the global recession of 2008–2009; Bems (2014) highlights the importance of intermediate input trade when assessing the quantitative response of relative prices to external rebalancing; finally, Johnson (2014) shows that introducing intermediate input trade into a standard international business cycle model improves its ability to replicate the relation between bilateral trade and business cycle co-movement.

Our model can be viewed as a stylized version of the many-country, input–output model of international business cycles in Johnson (2014). By adopting stark but tractable assumptions about the nature of international production linkages, production technologies, and country sizes, we are able to derive analytically several predictions about international business cycle co-movement which seem to accord with the data. In particular, our simple model allows us to cast the spotlight on the cross-country correlation of trade balances, and to illustrate a novel insight: generating a trade surplus over the long run is much less costly for a country (in utility terms) if other countries generating trade surpluses at the same time do not share its specialization pattern; by contrast, if 'similar' countries are attempting to generate a trade surplus at the same time, the resultingly depressed terms of trade imply that lower consumption levels and leisure are required to maintain the same external position in a given country.[2]

The rest of the article is structured as follows. Section 2 presents some empirical evidence about countries' specialization in international production networks and the association between specialization and business cycle comovement. Section 3 outlines a many-country model with different specialization patterns and different country sizes which we use to interpret that evidence. We also use the model to assess the determinants of the costs of servicing a given level of external liabilities. Section 4 offers some conclusions.

2 Empirical Evidence

2.1 Data and variables

In the following, we use data from two main sources: the value of trade in intermediate and final goods from the World Input Output database (WIOD), and seasonally adjusted GDP and net exports statistics from the Organisation for Economic Co-operation and Development (OECD) quarterly national accounts.

The WIOD provides a global input–output table covering 40 economies, detailing the value of goods purchased from 35 industries in each country by the same 35 industries as well as 5 'final' sectors (roughly, consumption, investment, and government spending) in each country. The WIOD covers the years 1995–2011, and makes it possible to identify the value of exports of each country–industry, as well as the share of these exports being used as intermediate goods by industries in the importing countries.[3] We use this information to calculate, for each country, the average share of intermediate goods in the value of exports across the 16 goods (i.e. manufacturing) industries in the WIOD, and treat this statistic as a measure of the country's specialization in international production networks.

GDP and trade-balance correlations are calculated in line with standard practice in the international business cycles literature. We de-trend quarterly data on seasonally adjusted constant-dollar GDP and net exports as a share of GDP using the Hodrick–Prescott filter. Business cycle correlations are then derived as the simple pairwise correlation of the de-trended GDPs and trade balances. We restrict ourselves to the years 1990–2014 for

2 Casual comments by policy makers suggest that production linkages, specialization patterns, and the cross-country allocation of trade surpluses are understood to play an important role in external adjustment episodes in practice. For example, contrary to the conventional wisdom about German export surpluses in the context of the euro-area crisis, the Spanish government explicitly defended Germany's surpluses in the autumn of 2013 on the basis that '. . .Spain benefits from Germany's export success because so many of Spain's own exports to Europe's largest economy come in the form of intermediate goods. Spanish shipments of car parts and chemicals are then used by German companies to create finished products that are in turn sold overseas' (Financial Times, 19 November 19 2013).

3 While the construction of international input–output tables generally needs to rely on so-called 'import proportionality' assumptions to allocate the observed use of imports by industries and final consumers to their likely countries of origin, the WIOD improves on common practices by using more disaggregated trade data to ensure that proportionality assumptions are only used within use categories (intermediate or final), rather than across those categories (Timmer et al. 2015). This makes it especially suitable for our purpose.

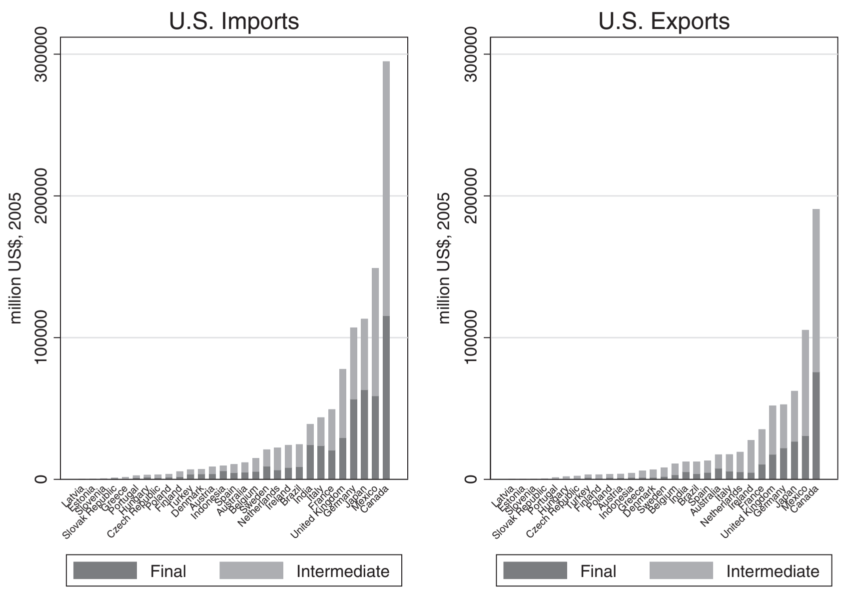

Figure 1. US trade in intermediate and final goods.

calculating the correlations, in line with the time coverage of the WIOD. Combining the OECD and WIOD data, we end up with pairwise correlations and specialization measures for a sample of 30 major economies.

2.2 Specialization patterns

In this section, we first describe the international specialization patterns—in intermediate inputs or final goods—which we obtain from the data. To illustrate the importance of international trade in intermediate goods, Figure 1 reports the dollar value of US imports from (left-hand panel) and exports to (right-hand panel) various trade partners for the year 2005, segmented by use category. Trade partners are ranked by the corresponding volume of trade. In both panels, the red segment of each bar represents the value of goods shipped for use as intermediate inputs, whereas the green segment represents the value of final goods shipped. For example, out of a total of 300 billion dollars of US imports from Canada, just over a third were imports of final goods, with the remaining two-thirds accounted for by intermediate goods imports.[4] More generally, the right-hand panel shows that most of the value of US exports to its various trading partners in 2005 was derived from intermediate goods shipments.

In the following, we will use the simple average of the share of intermediates in a country's exports across the 16 WIOD manufacturing industries as a measure of the country's specialization in international production networks. Figure 2 reports the 2005 value of this statistic for each of the countries in our sample. Countries are ranked from lowest to highest intermediate goods content of exports. In comparison with the rest of the sample,

4 Note that US imports from each of its trading partners exceeded US exports to that trading partner in 2005, reflecting the US trade deficit in that year.

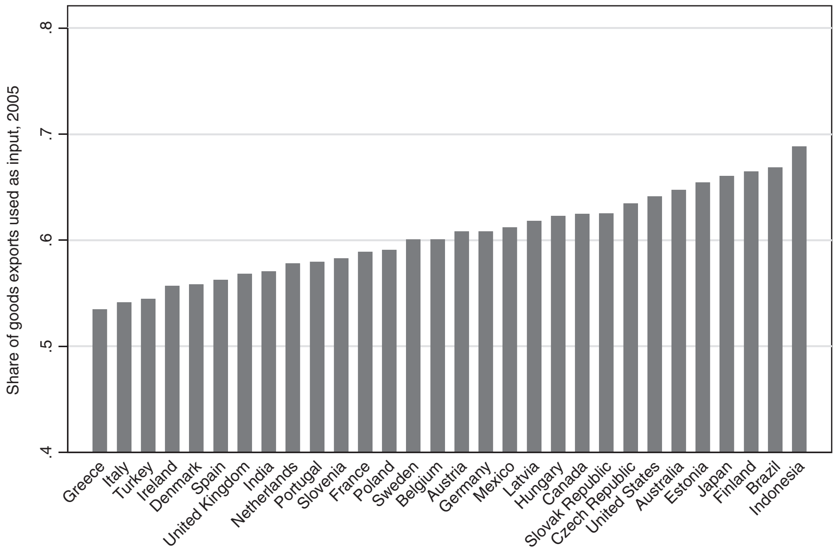

Figure 2. Intermediate goods content of exports.

Greece appears to be most specialized in final goods, while Indonesia appears to be primarily an intermediates exporter. Note also that the USA has a relatively high intermediate goods content of exports.

Our preferred measure of specialization is the 'simple' average of the intermediates' share of exports across industries. Alternatively, we could weight each industry by its share in the country's overall manufacturing exports—which is equivalent to aggregating all industries into one and calculating the intermediate share of exports for the country's manufacturing sector as a whole. Figure 3 plots these two alternative measures of specialization against each other. The figure shows that, with the exception of Australia, all observations are roughly distributed along a straight line. This suggests that, for most countries, a high aggregate intermediates' share of exports is driven by a high intermediate goods content of exports at the industry level, rather than by composition effects. Not surprisingly in the light of this finding, our results below are robust to the use of either specialization measure.

Figure 4 shows that our measure of specialization is relatively persistent over time. We plot each country's measure of the intermediate goods content of exports for the year 2011 against the corresponding value for the year 1995 and find that most observations are roughly aligned along the 45-degree line. For the regressions below, we will use the 2005 value of countries' intermediate goods content of exports, but all results are robust to using other years, or the 1995–2011 average.

2.3 Production structures and business cycle correlations

We now turn to the relationship between similarity in specialization patterns and business cycle correlations. Table 1 reports some descriptive statistics for the correlations of GDPs and net exports among our sample countries. As is well known, cross-country correlations in GDP fluctuations are generally positive, but there is a large degree of variation in the observed pairwise correlations. Cross-country trade-balance correlations have received less

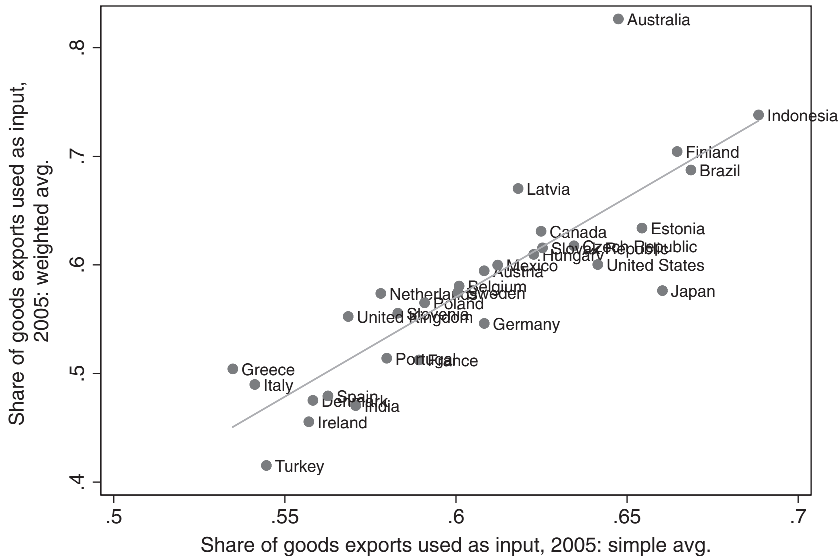

Figure 3. Alternative measures of specialization.

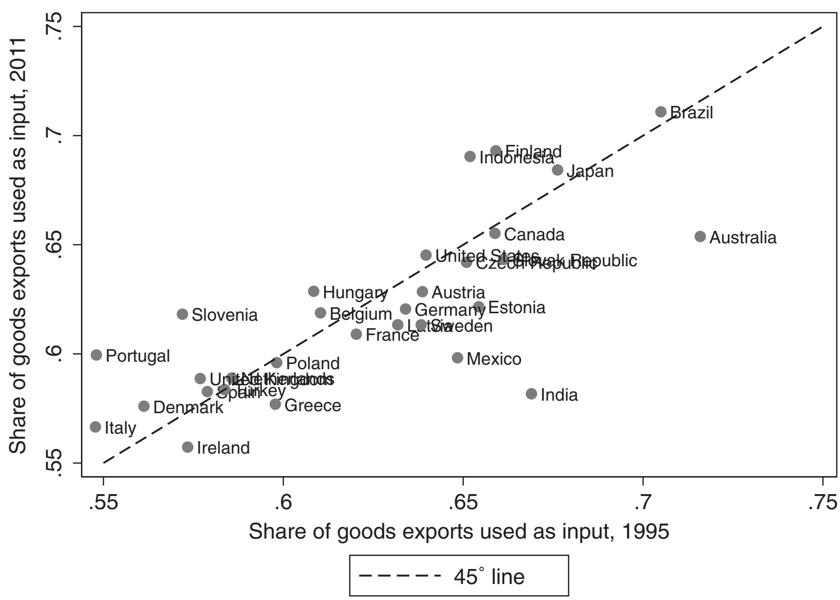

Figure 4. Intermediate goods content of exports over time.

attention in the literature. We find that the average net-export correlation is close to zero. However, just as with GDPs, there is a significant variation in the correlation of trade balances across country pairs.

Table 2 analyzes the relationship between similarity in specialization—as measured by countries' average intermediates' share of industry-level exports—and business cycle synchronization. It reports the results from running an ordinary least squares regression with

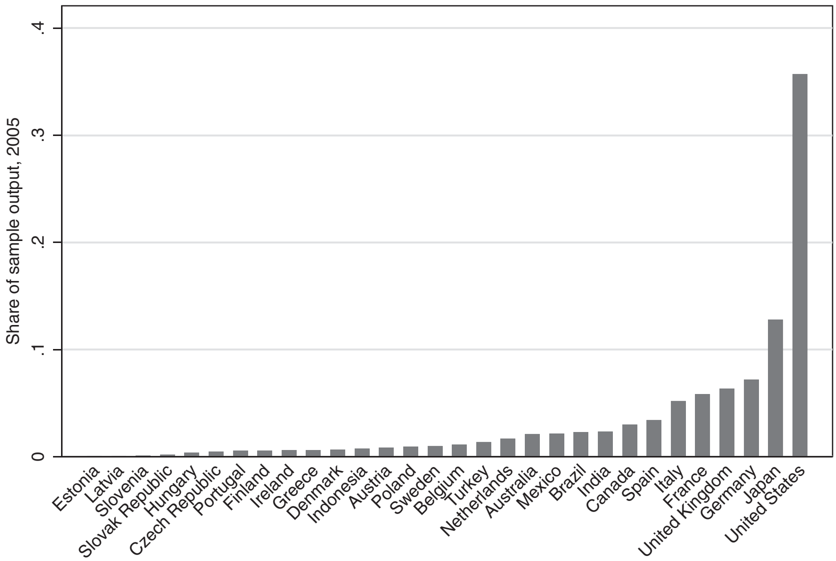

Figure 5. Country shares of sample output.

Table 1. Business cycle correlations—summary statistics

Variable	Observed	Mean	Minimum	Maximum
Correlation (Y1,Y2)	435	0.553	−0.212	0.935
Correlation (NX1/Y1,NX2/Y2)	435	0.024	−0.563	0.625

Note: 30 countries, 1990–2014.

Table 2. GDP correlations

Dependent variable: Correlation (Y1,Y2)	Goods average	Foods average	Goods average, OECD countries	Goods average, OECD countries	Goods average, w/o Australia	Weight average, w/o Australia
Difference inputs/exports	−2.231	−0.878	−1.200	−0.188	−0.895	−0.647
	(0.389)***	(0.365)**	(0.460)***	(0.417)	(0.381)**	(0.174)***
Log-distance (capitals, km)		−0.094		−0.071	−0.089	−0.086
		(0.008)***		(0.009)***	(0.009)***	(0.009)***
Adjusted R^2	0.08	0.27	0.03	0.17	0.24	0.25
Observations	435	435	276	276	406	406

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Note: Robust standard errors in parentheses.

Table 3. NX correlations

Dependent variable: Correlation (NX1/Y1, NX2/Y2)	Goods average	Goods average	Goods average, OECD countries	Goods average, OECD countries	Goods average, w/o Australia	Weight average, w/o Australia
Difference inputs/exports	−0.942	−0.837	−1.175	−1.035	−1.146	−0.297
	(0.330)***	(0.348)**	(0.431)***	(0.458)**	(0.359)***	(0.166)*
Log-distance (capitals, km)		−0.007		−0.010	−0.011	−0.017
		(0.009)		(0.012)	(0.010)	(0.010)*
Adjusted R^2	0.02	0.01	0.02	0.02	0.03	0.02
Observations	435	435	276	276	406	406

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.
Note: Robust standard errors in parentheses.

the pairwise GDP correlation as the dependent variable and the pairwise absolute difference between specialization measures as the main independent variable. We also use the log of distance between country pairs as an additional control, since GDP correlations are known to decline with distance. In the first five columns, we use simple industry averages to construct our specialization measure, whereas in the sixth column, we use the weighted average. In the first two columns, we consider all countries, whereas in columns three and four, we exclude non-OECD countries. In columns five and six, we exclude Australia only.

In line with the earlier literature, we find a robust and statistically significant negative relationship between distance and GDP correlations. In addition, differences in countries' specialization patterns appear to reduce business cycle synchronization. This effect is statistically and economically significant: our estimates in Column (2) suggest that an increase in specialization differences from the 10th to the 90th percentile of the country-pair distribution should be associated with a reduction in the pairwise GDP correlation by 0.07.[5] The effect appears to be weaker for OECD countries, but this may be due to the fact that there is less variation in specialization patterns in this much smaller, more homogeneous sample.

Table 3 repeats the regression analysis presented in Table 2 with net-export correlations as the dependent variable. We find little evidence of a relationship between distance and net-export correlations but, once again, observe that specialization differences appear to go hand-in-hand with lower trade-balance correlations. This effect is statistically and economically significant, and very robust: again, our estimates in Column (2) suggest that an increase in specialization differences from the 10th to the 90th percentile of the country-pair distribution should be associated with a fall in the pairwise net-export correlation by 0.07.

If trade balances respond to GDP shocks, it is conceivable that the association between trade-balance correlations and specialization differences results from the relationship

5 For comparison, an increase in distance from the 10th to the 90th percentile of the country-pair distribution would reduce the pairwise GDP correlation by 0.26.

Table 4. NX correlations (instrumented)

Dependent variable: Correlation (NX1/Y1, NX2/Y2)	Goods average	Goods average	Goods average, OECD	Goods average, OECD	Goods average, w/o Australia	Weight average, w/o Australia
Correlation (Y1,Y2)	0.422	0.953	0.979	5.497	1.280	1.280
	(0.155)***	(0.527)*	(0.513)*	(12.338)	(0.638)**	(0.638)**
Log-distance		0.083		0.383	0.102	0.102
		(0.055)		(0.892)	(0.062)*	(0.062)*
F statistic	7.40	2.58	3.64	0.15	3.01	3.01
Observations	435	435	276	276	406	406
Instruments	Difference inputs/ exports	Difference inputs/ exports Log-distance	Difference inputs/ exports	Difference inputs/ exports Log-distance	Difference inputs/ exports Log-distance	Difference inputs/ exports Log-distance

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.
Note: Robust standard errors in parentheses.

between 'GDP correlations' and specialization differences documented above. To assess this, we regress the correlation of net exports on the part of the GDP correlation explained by specialization differences. In a first stage, we instrument for the GDP correlation with the similarity proxy (as well as the log of distance). In the second stage, reported in Table 4, we regress the net-export correlation on the instrumented GDP correlation. The results suggest that the intuition set out above may be correct: differences in specialization patterns result in less correlated business cycles, and these in turn reduce the correlation of trade balances. In the rest of the article, we formalize this intuition and explore some of its implications for the costs of servicing a given level of foreign liabilities through trade surpluses.

3 The Model

Consider a world with one large country and a continuum of small countries.[6] There is an infinitely lived representative consumer in each country n with instantaneous utility function:

$$U[C_t(n), L_t(n)] = \ln C_t(n) - \frac{L_t(n)^{1+\eta}}{1+\eta}, \tag{1}$$

where C denotes final consumption and L denotes labor. Consumers maximize the expected present value of lifetime utility, valued with a common discount factor $\beta \in (0, 1)$.

Let there be a total mass $2 - n^*$ of small countries. All $n \in [0, 1]$ produce a unique variety of F-goods. F-goods are used in final consumption. All $n \in [1, 2 - n^*]$ produce a unique variety of M-goods, whereas the large country produces a mass n^* of varieties of the M-goods. M-goods serve as intermediate inputs in the production of F-goods, which are

6 In accordance with some of the evidence presented above, we think of the USA as the large country. Figure 5 plots the share of output of each country in our sample over the total sample output for the year 2005. The USA stands out as the largest country, with a large advantage over the second-largest country, Japan.

produced by aggregating labor services and a CES aggregator of all available M-goods in a Cobb–Douglas fashion:

$$Q_{Ft}(n) = \left(\frac{A_t(n)L_{Ft}(n)}{1-\gamma}\right)^{1-\gamma}\left[\int_1^2\left(\frac{X_t(m,n)}{\gamma}\right)^{\frac{\varepsilon-1}{\varepsilon}}dm\right]^{\frac{\gamma\varepsilon}{\varepsilon-1}}. \tag{2}$$

M-goods are produced with labor only:

$$Q_{Mt}(n) = A_t(n)L_{Mt}(n), \tag{3}$$

$$Q_{Mt}(n^*) = A_t^* L_{Mt}^*. \tag{4}$$

$L_{kt}(n)$ is labor used in the production of variety n of good k, $A_t(n)$ is labor productivity in country n, and $X_t(m,n)$ denotes the use of variety m of good M as 'intermediate input' in the production of n, with $k \in \{F, M\}$ and asterisks denoting aggregate variables in the large country. The parameter $\varepsilon \geq 1$ captures the elasticity of substitution between varieties of different goods, and the parameter $\gamma \in (0,1)$ reflects the 'intermediate-input intensity' of final production.

Final consumption in each country is a CES aggregator of F-goods:

$$C_t(n) = \left[\int_0^1 C_t(f,n)^{\frac{\varepsilon-1}{\varepsilon}}df\right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{5}$$

All goods and labor markets are perfectly competitive. Varieties of F-goods and M-goods can be traded freely between countries. We find it convenient to take the price of the final goods as the numéraire.

We consider two different scenarios: one in which consumers cannot trade assets internationally (financial autarky), and one in which consumers can also trade a complete set of state-contingent Arrow–Debreu securities (complete asset markets).

3.1 Financial autarky

In the Appendix, we discuss the model's equilibrium conditions. Manipulating them we can obtain expressions for each country-type's world income share. In the case of F-good producers,

$$\frac{W_t(n)L_t(n)}{Y_t} = (1-\gamma)\frac{[A_t(n)]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}}{\int_0^1 [A_t(n)]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}dn}, \tag{6}$$

where

$$Y_t \equiv \int_0^{2-n^*} W_t(n)L_t(n)dn + W_t^* L_t^* \tag{7}$$

denotes world income: due to perfect competition, the only source of income in the model is labor income.

Note that the shares in world income of producers of different types of goods are isolated from whatever happens to the other type. This is due to the unitary elasticity of substitution implicit in the Cobb–Douglas production function for F-goods: world expenditure on final output is always split in proportion $(1-\gamma)$ for the producers of final goods and γ for the producers of intermediate inputs used in the production of those final goods, ensuring that the aggregation of income over all producers of a type always yields a constant share of world GDP.

How individual F-good producers' incomes compare with one another depends on their relative productivity shocks. Since the elasticity of substitution between varieties of final goods is larger than one (by assumption), final-good producers with higher productivity levels command larger market shares in the final goods market and thus earn a higher income share than low-productivity final goods producers. By the law of large numbers, the income of F-good producers only depends on the realization of their own productivity level: the average realization of productivities of F-good producers is always the same.

In the case of M-good producers,

$$\frac{W_t(n)L_t(n)}{Y_t} = \gamma \frac{[A_t(n)]^{\frac{\varepsilon-1}{\varepsilon}}}{\int_1^{2-n^*} [A_t(n)]^{\frac{\varepsilon-1}{\varepsilon}} dn + n^* \left(\frac{A_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}}, \tag{8}$$

$$\frac{W_t^* L_t^*}{Y_t} = \gamma \frac{n^* \left(\frac{A_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}}{\int_1^{2-n^*} [A_t(n)]^{\frac{\varepsilon-1}{\varepsilon}} dn + n^* \left(\frac{A_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}}. \tag{9}$$

The presence of a large M-good producers makes a difference for M-producing countries, as the productivity shifter A^* contributes to a positive correlation between the income shares of any two small M-good producers. A shock to A^* also raises world income, Y_t, but alters its distribution because the resulting changes in world prices affect different countries differently: a stronger terms-of-trade response implies that the GDP of F-good producers will rise proportionally with world income, while the GDP of small M-good producers will rise less than proportionally. Thus, the incomes of country pairs with similar specialization patterns are more positively correlated than the incomes of country pairs with different specializations.[7]

3.2 Complete asset markets

Let us now assume that representative agents can also trade a complete set of state-contingent Arrow–Debreu securities.[8] In this section, we first show that the results we derived above under financial autarky also hold in the presence of asset trade. More importantly, allowing for international asset trade enables us to study the implications of international differences in specialization patterns for the trade balance (which is, of course, zero under financial autarky), and how changes in asset positions affect different types of countries according to the environment they find themselves in.

With complete asset markets, the competitive-market equilibrium allocations coincide with those of the solution to the following planner problem:

$$\max_{\{C_t(n), L_t(n)\}_{n,t}} E_0 \left\{ \beta^t \left[\int_0^{2-n^*} \theta(n) U[C_t(n), L_t(n)] dn + \theta^* U(C_t^*, L_t^*) \right] \right\} \tag{10}$$

7 The correlation between the incomes of any small M-country and the large country is lower than the correlation between any two small M-countries, as a positive shock to A^* contributes negatively to the income of the former and positively to the income of the latter.

8 See the Appendix for the derivation of all the results discussed here.

subject to

$$\int_0^{2-n^*} C_t(n)dn + C_t^* \leq Y_t. \tag{11}$$

$\theta(n) \geq 0$ represents the planner's weight on country n, which depends on its expected future income and initial foreign asset position, and $\int_0^{2-n^*} \theta(n)dn + \theta^* = 1$.

The above expressions for pricing conditions, goods market clearing conditions and labor demands still hold under complete asset markets. The solution to the planner's problem above yields final-consumption levels as follows:

$$C_t(n) = \theta(n)Y_t, \tag{12}$$

$$C_t^* = \theta^* Y_t, \tag{13}$$

and labor supplies

$$L_t(n)^\eta = \frac{\partial Y_t/\partial L_t(n)}{\theta(n)Y_t}, \tag{14}$$

$$L_t^{*\eta} = \frac{\partial Y_t/\partial L_t^*}{\theta^* Y_t}. \tag{15}$$

With complete asset markets, a country's consumption level is insulated from any idiosyncratic risk. Its representative consumer simply receives a share of world output (the size of which depends on her share of world wealth in the decentralized equilibrium, as we show in Section 3.2.3). A country's labor supply now increases in the states of nature in which its marginal contribution to world income is high.

3.2.1 Income shares

Manipulation of the equilibrium conditions yields expressions for each country-type's world income share. In the case of F-good producers:

$$\frac{W_t(n)L_t(n)}{Y_t} = (1-\gamma)\frac{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}}}{\int_0^1 \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}} dn}. \tag{16}$$

In the case of M-good producers:

$$\frac{W_t(n)L_t(n)}{Y_t} = \gamma\frac{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{\int_1^{2-n^*}\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^*\left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}, \tag{17}$$

$$\frac{W_t^* L_t^*}{Y_t} = \gamma\frac{n^*\left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{\int_1^{2-n^*}\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^*\left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}} \tag{18}$$

These expressions are very similar to the ones we obtained under financial autarky and display qualitatively similar results: the incomes of country pairs with similar specialization patterns are more positively correlated than the incomes of country pairs with different specializations.

The differences between equations (6), (8), and (9) and (16)-(18) boil down to the presence of parameters θ and η. Parameter η controls the elasticity of labor supply, which now reacts to changes in the marginal product of labor.[9] This modifies the quantitative response of income shares to productivity shocks. Parameter $\theta(n)$ is the corresponding country's planner weight. We will show in Section 3.2.3 that it maps into the country's share of world wealth in the decentralized equilibrium. The higher $\theta(n)$, the less need for country n to generate individual income, as a larger share of world income accrues to it anyway.

3.2.2 Trade balances

Define $NX_t(n)$ as the trade balance of country n at time t:

$$\frac{NX_t(n)}{Y_t(n)} = 1 - \frac{C_t(n)}{W_t(n)L_t(n)} = 1 - \frac{1}{L_t(n)^{1+\eta}} = 1 - \frac{\theta(n)Y_t}{W_t(n)L_t(n)} \tag{19}$$

Substituting the income share we obtained above yields the following expression for the case of F-good producers:

$$\frac{NX_t(n)}{Y_t(n)} = 1 - \frac{\theta(n)}{1-\gamma}\frac{\int_0^1 \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}} dn}{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}}}. \tag{20}$$

Similarly, for M-good producers we obtain:

$$\frac{NX_t(n)}{Y_t(n)} = 1 - \frac{\theta(n)}{\gamma}\frac{\int_1^{2-n^*} \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^*\left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}, \tag{21}$$

$$\frac{NX_t^*}{Y_t^*} = 1 - \frac{\theta^*}{\gamma}\frac{\int_1^{2-n^*} \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^*\left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{n^*\left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}. \tag{22}$$

In the decentralized equilibrium, a shock to A^* raises Y_t and changes world relative prices. The resulting terms-of-trade changes offer insurance to F-good producers in the sense that their incomes rise proportionally to world income. However, M-producers experience a fall in their share of world GDP.[10] With complete asset markets, goods flow from the large country to the other, small M-good producers as insurance payment in this scenario. The correlation of net exports is therefore also higher for country pairs that share the same specialization pattern than for country pairs with different specializations.

3.2.3 Decentralization

A comparison between the planner's problem and the representative agent's optimization problem in the decentralized equilibrium helps us illustrate the effect of a given level of

9 In a decentralized equilibrium under financial autarky, the substitution effect from a higher wage is exactly compensated by the corresponding wealth effect, thus leaving labor supply constant. With complete asset markets, the substitution effect continues to be present, whereas the wealth effect is not, as a country's consumption is no longer linked to its income.

10 See Cuñat and Fons-Rosen (2013) for a related argument.

foreign liabilities on consumption and labor supply. In the decentralized equilibrium, the representative consumer in country n solves:

$$\max_{\{C_t(n,s_t),L_t(n,s_t)\}_{s_t}} \sum_{t=0}^{\infty} \beta^t \int_{s_t} \pi_t(s_t) U[C_t(n,s_t), L_t(n,s_t)] ds_t \tag{23}$$

subject to

$$\sum_{t=0}^{\infty} \int_{s_t} q_t(s_t) C_t(n,s_t) ds_t \leq \sum_{t=0}^{\infty} \int_{s_t} q_t(s_t) W_t(n,s_t) L_t(n,s_t) ds_t - B_0(n), \tag{24}$$

where $\pi_t(s_t)$ denotes the probability of state of nature s at time t, $q_t(s_t)$ is the price of an Arrow–Debreu security yielding one unit of consumption in state s at time t, and $B_0(n)$ represents country n's net foreign liabilities as of period 0.[11] One can show that the solution of this problem implies:

$$\theta(n) = (1-\beta)\left[\sum_{t=0}^{\infty} \beta^t \int_{s_t} \pi_t(s_t\right) \frac{W_t(n,s_t) L_t(n,s_t)}{Y_t(s_t)} ds_t - \frac{B_0(n)}{Y_0}]. \tag{25}$$

A country's planner weight, $\theta(n)$, thus corresponds to a measure of its initial wealth, consisting of two terms: a first term reflecting the discounted expected share of country n in world GDP going forward, and a second term representing n's initial liabilities relative to initial world GDP. Note that, from equations (16–18), the first term depends implicitly on $\{\theta(n)\}_n$. However, as demonstrated in the Appendix, $\theta(n) < \theta(n')$ implies $B_0(n) > B_0(n')$ for all $n \neq n'$, everything else constant.

Consider now a country with a high initial level of indebtedness, $B_0(n)$. This country will need to run trade surpluses in the future to service its liabilities. Doing so implies foregoing some final consumption and supplying a larger level of labor for the indebted country: a higher initial level of net foreign liabilities lowers $\theta(n)$, thus prompting a lower consumption level, by equation (12), and a larger supply of labor, by equation (14).

However, if other countries with the same specialization pattern also have a low planner weight—also due to a high level of foreign liabilities, say—this will reduce country n's expected share of future incomes, by equations (16) and (17), further lowering $\theta(n)$. Hence, servicing a given amount of initial liabilities under these circumstances will require an increased effort in terms of foregone consumption and leisure.

4 Conclusion

This article draws attention to the importance of countries' specialization patterns in understanding the international transmission of business cycles as well as the cost of servicing a given level of foreign liabilities. It explores a consequence of the increasing vertical disintegration of production structures into global value-added chains in which countries become suppliers of intermediate goods or producers of final goods.

Our empirical evidence distinguishes between intermediate goods producers and final-good producers using a very crude statistic—the intermediate goods content of a country's

11 Note that $\int_0^{2-n^*} B_0(n)dn + B^* = 0$.

sectoral exports. We document that, despite its simplicity, this statistic appears to capture significant differences between countries which affect the international transmission of business cycles. A very simple model of specialization reproduces the main stylized facts featured in the data. The model can also be used to assess the determinants of the utility cost to a country of servicing a given level of foreign liabilities. It highlights the importance of the distribution of foreign assets among the country's trading partners: if many countries with the same specialization pattern are servicing a high level of foreign liabilities, doing so will require all of them to forgo more consumption and leisure.

The evidence and theory presented here suggest a host of questions for future research. For example, it would be important to establish whether the empirical findings presented here are robust to the use of more sophisticated, bilateral measures of vertical integration, and whether there are other key determinants of trade-balance correlations. We plan to address these issues in future work.

Finally, our theory highlights as-yet unexploited avenues for empirical research. The GDP correlations implicit in our model suggest that final goods producers have an incentive to invest foremost in other, economically sizeable final goods producers, as productivity shocks in the latter affect the incomes of the former countries in the opposite direction. A symmetric argument applies to intermediate input-producing countries. In this manner, the theory outlined above could be used to derive, and test, implications for international investment portfolios.

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Appendix A

A.1 Competitive Pricing, Goods Market Clearing, and Labor Demand

Competitive pricing conditions yield

$$P_{Mt}(n) = \frac{W_t(n)}{A_t(n)}, \tag{26}$$

$$P_{Mt}^* = \frac{W_t^*}{A_t^*}, \tag{27}$$

$$P_{Ft}(n) = \left[\frac{W_t(n)}{A_t(n)}\right]^{1-\gamma}\left[\int_1^2 P_{Mt}(n)^{1-\varepsilon}dn\right]^{\frac{\gamma}{1-\varepsilon}}, \tag{28}$$

$$1 = \left[\int_0^1 P_{Ft}(n)^{1-\varepsilon}dn\right]^{\frac{1}{1-\varepsilon}}. \tag{29}$$

Goods market-clearing requires

$$Q_{Ft}(f) = \int_0^{2-n^*} C_t(f,n)dn + C_t^*(f), \tag{30}$$

$$Q_{Mt}(m) = \int_1^2 X_t(m,n)dn. \tag{31}$$

Labor demand is given by the following expressions:

$$L_t(n) = \begin{cases} L_{tF}(n) = Q_{Ft}(n)/A_t(n) & \forall : n \in [0,1] \\ L_{tM}(n) = Q_{Mt}(n)/A_t(n) & \forall : n \in [1, 2-n^*] \end{cases}, \tag{32}$$

$$L_t^* = n^* L_{Mt}^* = Q_{Mt}(n^*)/A_t^*. \tag{33}$$

Combining (26)-(29),

$$1 = \left\{\int_0^1 \left[\frac{W_t(n)}{A_t(n)}\right]^{(1-\gamma)(1-\varepsilon)} dn \left[\int_1^{2-n^*} \left[\frac{W_t(n)}{A_t(n)}\right]^{1-\varepsilon} dn + n^*\left(\frac{W_t^*}{A_t^*}\right)^{1-\varepsilon}\right]^{\gamma}\right\}^{\frac{1}{1-\varepsilon}}. \tag{34}$$

From utility/profit maximization and goods market clearing, we find that

$$W_t(n)L_t(n) = (1-\gamma)\frac{\left[\frac{W_t(n)}{A_t(n)}\right]^{(1-\gamma)(1-\varepsilon)}}{\int_0^1 \left[\frac{W_t(n)}{A_t(n)}\right]^{(1-\gamma)(1-\varepsilon)} dn} Y_t \quad \forall : n \in [0,1], \tag{35}$$

$$W_t(n)L_t(n) = \gamma \frac{\left[\frac{W_t(n)}{A_t(n)}\right]^{1-\varepsilon}}{\int_1^{2-n^*}\left[\frac{W_t(n)}{A_t(n)}\right]^{1-\varepsilon} dn + n^*\left(\frac{W_t^*}{A_t^*}\right)^{1-\varepsilon}} Y_t \quad \forall : n \in [1, 2-n^*], \tag{36}$$

$$W_t^* L_t^* = \gamma \frac{n^*\left(\frac{W_t^*}{A_t^*}\right)^{1-\varepsilon}}{\int_1^{2-n^*}\left[\frac{W_t(n)}{A_t(n)}\right]^{1-\varepsilon} dn + n^*\left(\frac{W_t^*}{A_t^*}\right)^{1-\varepsilon}} Y_t, \tag{37}$$

where $Y_t \equiv \int_0^{2-n^*} W_t(n)L_t(n)dn + W_t^* L_t^*$.

A.2 Financial Autarky: Income Shares

Under financial autarky, and given the preferences we assumed, it is easy to show that labor supply equals 1 in every country-period. This result, combined with equations (35)-(37), yields equations (6)-(9).

A.3 Complete Asset Markets

A.3.1 Consumption and Labor Supply

With complete asset markets and competitive product markets the market equilibrium of the world economy coincides with the solution of the planner problem

$$\max_{\{C_t(n), L_t(n)\}_{n,t}} E_0\{\beta^t \int_0^{2-n^*} \theta(n)U[C_t(n), L_t(n)]dn + \theta^* U(C_t^*, L_t^*)\} \tag{38}$$

subject to

$$\int_0^{2-n^*} C_t(n)dn + C_t^* \le \int_0^{2-n^*} W_t(n)L_t(n)dn + W_t^* L_t^* \equiv Y_t, \tag{39}$$

where $\theta(n) \ge 0$ represents the planner weight on country n (which depends on its expected future income and initial foreign asset position), $\int_0^{2-n^*}\theta(n)dn + \theta^* = 1$, and $\{W_{nt}\}_{n,t}$ are as pinned down by (26)-(29).

The first-order conditions of the planner problem are

$$\beta^t \theta(n)\frac{1}{C_t(n)} - \lambda_t = 0, \tag{40}$$

$$\beta^t \theta^* \frac{1}{C_t^*} - \lambda_t = 0, \tag{41}$$

$$-\beta^t \theta(n)L_t(n)^\eta + \lambda_t \frac{\partial Y_t}{\partial L_t(n)} = 0, \tag{42}$$

$$-\beta^t \theta^* L_t^{*\eta} + \lambda_t \frac{\partial Y_t}{\partial L_t^*} = 0, \tag{43}$$

which yield (12)-(15).

A.3.2 Income Shares

From (36) and (37),

$$\frac{W_t(n)L_t(n)}{W_t^*L_t^*}=\frac{1}{n^*}\left[\frac{A_t^*}{A_t(n)}\frac{W_t(n)}{W_t^*}\right]^{1-\varepsilon}\quad\forall:n\in[1,2-n^*],\tag{44}$$

$$\frac{W_t(n)}{W_t^*}=\left\{\frac{1}{n^*}\left[\frac{A_t^*}{A_t(n)}\right]^{1-\varepsilon}\frac{L_t^*}{L_t(n)}\right\}^{\frac{1}{\varepsilon}}\quad\forall:n\in[1,2-n^*],\tag{45}$$

$$\frac{W_t(n)}{A_t(n)}=\left[\frac{A_t^*L_t^*}{n^*A_t(n)L_t(n)}\right]^{\frac{1}{\varepsilon}}\frac{W_t^*}{A_t^*}\quad\forall:n\in[1,2-n^*].\tag{46}$$

Similarly, from (35),

$$\frac{W_t(n)}{A_t(n)}=\left[\frac{A_t(1)L_t(1)}{A_t(n)L_t(n)}\right]^{\frac{1}{1+(1-\gamma)(\varepsilon-1)}}\frac{W_t(1)}{A_t(1)}\quad\forall:n\in[0,1].\tag{47}$$

Substituting (47) into (37),

$$\frac{W_t^*}{A_t^*}=\gamma\frac{n^*\left(A_t^*L_t^*\right)^{-1}}{\int_1^{2-n^*}\left[\frac{A_t^*L_t^*}{n^*A_t(n)L_t(n)}\right]^{\frac{1-\varepsilon}{\varepsilon}}dn+n^*}Y_t,\tag{48}$$

$$\frac{W_t^*}{A_t^*}=\gamma\frac{\left(\frac{A_t^*L_t^*}{n^*}\right)^{-\frac{1}{\varepsilon}}}{\int_1^{2-n^*}\left[A_t(n)L_t(n)\right]^{\frac{\varepsilon-1}{\varepsilon}}dn+n^*\left(\frac{A_t^*L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}}Y_t.\tag{49}$$

Similarly, substituting (47) into (35),

$$\frac{W_t(1)}{A_t(1)}=(1-\gamma)\frac{\left[A_t(1)L_t(1)\right]^{-\frac{1}{1+(1-\gamma)(\varepsilon-1)}}}{\int_0^1\left[A_t(n)L_t(n)\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}dn}Y_t.\tag{50}$$

From the normalization (29),

$$Y_t=\left\{\frac{\left[\int_0^1\left[A_t(n)L_t(n)\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}dn\right]^{\frac{1+(1-\gamma)(\varepsilon-1)}{(1-\gamma)(\varepsilon-1)}}}{1-\gamma}\right\}^{(1-\gamma)}\times\tag{51}$$

$$\times\left\{\frac{\left[\int_1^{2-n^*}\left[A_t(n)L_t(n)\right]^{\frac{\varepsilon-1}{\varepsilon}}dn+n^*\left(\frac{A_t^*L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\gamma}\right\}^{\gamma}.$$

This gives us

$$\frac{\partial Y_t/\partial L_t(n)}{Y_t}=\frac{A_t(n)^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}L_t(n)^{-\frac{1}{1+(1-\gamma)(\varepsilon-1)}}}{\int_0^1\left[A_t(n)L_t(n)\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}dn}(1-\gamma)\quad\forall:n\in[0,1],\tag{52}$$

$$\frac{\partial Y_t/\partial L_t(n)}{Y_t} = \frac{A_t(n)^{\frac{\varepsilon-1}{\varepsilon}} L_t(n)^{-\frac{1}{\varepsilon}}}{\int_1^{2-n^*} [A_t(n)L_t(n)]^{\frac{\varepsilon-1}{\varepsilon}} dn + n^* \left(\frac{A_t^* L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}} \gamma \quad \forall : n \in [1, 2-n^*], \tag{53}$$

$$\frac{\partial Y_t/\partial L_t^*}{Y_t} = \frac{n^* \left(\frac{A_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}} L_t^{*-\frac{1}{\varepsilon}}}{\int_1^{2-n^*} [A_t(n)L_t(n)]^{\frac{\varepsilon-1}{\varepsilon}} dn + n^* \left(\frac{A_t^* L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}} \gamma \quad \forall : n \in [1, 2-n^*]. \tag{54}$$

Using (14) and (52) implies, after some manipulation,

$$L_t(n) = \left\{ \frac{1-\gamma}{\theta(n)} \frac{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}}}{\int_0^1 \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}} dn} \right\}^{\frac{1}{1+\eta}} \quad \forall : n \in [0,1]. \tag{55}$$

Combining (14) with (53) and (54),

$$L_t(n) = \left[\frac{\theta^*}{n^* \theta(n)}\right]^{\frac{\varepsilon}{1+\eta\varepsilon}} \left[\frac{n^* A_t(n)}{A_t^*}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} L_t^* \quad \forall : n \in [1, 2-n^*]. \tag{56}$$

Substituting (56) into (54),

$$L_t^* = \left\{ \frac{\gamma}{\theta^*} \frac{n^* \left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{\int_1^{2-n^*} \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^* \left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}} \right\}^{\frac{1}{1+\eta}}, \tag{57}$$

which can be used with (56) to obtain

$$L_t(n) = \left\{ \frac{\gamma}{\theta(n)} \frac{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{\int_1^{2-n^*} \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^* \left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}} \right\}^{\frac{1}{1+\eta}} \quad \forall : n \in [1, 2-n^*]. \tag{58}$$

Substituting (47) in (35),

$$\frac{W_t(n)L_t(n)}{Y_t} = (1-\gamma) \frac{[A_t(n)L_t(n)]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}}}{\int_0^1 [A_t(n)L_t(n)]^{\frac{(1-\gamma)(\varepsilon-1)}{1+(1-\gamma)(\varepsilon-1)}} dn} \quad \forall : n \in [0,1], \tag{59}$$

and (46) in (36) and (37),

$$\frac{W_t(n)L_t(n)}{Y_t} = \gamma \frac{[A_t(n)L_t(n)]^{\frac{\varepsilon-1}{\varepsilon}}}{\int_1^{2-n^*} [A_t(n)L_t(n)]^{\frac{\varepsilon-1}{\varepsilon}} dn + n^* \left(\frac{A_t^* L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}} \quad \forall : n \in [1, 2-n^*], \tag{60}$$

$$\frac{W_t^* L_t^*}{Y_t} = \gamma \frac{n^* \left(\frac{A_t^* L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}}{\int_1^{2-n^*} [A_t(n)L_t(n)]^{\frac{\varepsilon-1}{\varepsilon}} dn + n^* \left(\frac{A_t^* L_t^*}{n^*}\right)^{\frac{\varepsilon-1}{\varepsilon}}}. \tag{61}$$

Now, substituting (55) into (59), and (57) and (58) into (60) and (61) yields equations (16)-(18).

A.3.3 Trade Balances

Define $NX_t(n)$ as the trade balance of country n at time t. Then,

$$\frac{NX_t(n)}{Y_t(n)} = 1 - \frac{C_t(n)}{W_t(n)L_t(n)} = 1 - \frac{1}{L_t(n)^{1+\eta}}, \tag{62}$$

$$\frac{NX_t^*}{Y_t^*} = 1 - \frac{C_t^*}{W_t^* L_t^*} = 1 - \frac{1}{L_t^{*1+\eta}}, \tag{63}$$

where the second equality follows from (12)-(15). Substituting in (55), (57) and (58),

$$\frac{NX_t(n)}{Y_t(n)} = 1 - \frac{\theta(n)}{1-\gamma} \frac{\int_0^1 \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}} dn}{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{(1-\gamma)(\varepsilon-1)}{1+\eta+\eta(1-\gamma)(\varepsilon-1)}}} = 1 - \theta(n) \frac{Y_t}{W_t(n)L_t(n)} \quad \forall : n \in [0,1], \tag{64}$$

$$\frac{NX_t(n)}{Y_t(n)} = 1 - \frac{\theta(n)}{\gamma} \frac{\int_1^{2-n^*} \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^* \left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{\left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}}} =$$

$$= 1 - \theta(n) \frac{Y_t}{W_t(n)L_t(n)} \quad \forall : n \in [1, 2-n^*] \tag{65}$$

$$\frac{NX_t^*}{Y_t^*} = 1 - \frac{\theta^*}{\gamma} \frac{\int_1^{2-n^*} \left[\frac{A_t(n)^{1+\eta}}{\theta(n)}\right]^{\frac{\varepsilon-1}{1+\eta\varepsilon}} dn + n^* \left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}}{n^* \left(\frac{A_t^{*1+\eta}}{n^{*\eta}\theta^*}\right)^{\frac{\varepsilon-1}{1+\eta\varepsilon}}} = 1 - \theta^* \frac{Y_t}{W_t^* L_t^*}. \tag{66}$$

Note that this implies that

$$Cov\left[\frac{NX_t(n)}{Y_t(n)}, \frac{NX_t(d)}{Y_t(d)}\right] = \theta(n)\theta(d) Cov\left[\frac{Y_t}{W_t(n)L_t(n)}, \frac{Y_t}{W_t(d)L_t(d)}\right]. \tag{67}$$

A.3.4 Decentralized Equilibrium

Suppose agents can trade a full set of state-contingent Arrow-Debreu securities, with $q_t(s_t)$ denoting the price of security which delivers one unit of final consumption in period t and state s_t. Then the representative consumer in country n solves

$$\max_{\{C_t(n,s_t), L_t(n,s_t)\}_{s_t}} \sum_{t=0}^{\infty} \beta^t \int_{s_t} \pi_t(s_t) U[C_t(n,s_t), L_t(n,s_t)] ds_t \tag{68}$$

subject to

$$\sum_{t=0}^{\infty} \int_{s_t} q_t(s_t) C_t(n,s_t) ds_t \le \sum_{t=0}^{\infty} \int_{s_t} q_t(s_t) W_t(n,s_t) L_t(n,s_t) ds_t - B_0(n), \tag{69}$$

where $U[\cdot,\cdot]$ is still defined as in (1). Note that

$$\int_0^{2-n^*} B_0(n) dn + B^* = 0. \tag{70}$$

The first-order conditions of this problem are

$$\beta^t \pi_t(s_t) \frac{1}{C_t(n, s_t)} - \lambda(n) q_t(s_t) = 0, \tag{71}$$

$$-\beta^t \pi_t(s_t) L_t(n, s_t)^\eta + \lambda(n) q_t(s_t) W_t(n, s_t) = 0, \tag{72}$$

and market clearing requires

$$\int_0^{2-n^*} C_t(n, s_t) dn + C_t^*(s_t) = \int_0^{2-n^*} W_t(n, s_t) L_t(n, s_t) dn + W_t^*(s_t) L_t^*(s_t) \equiv Y_t(s_t). \tag{73}$$

From (71) and (73),

$$\frac{\beta^t \pi_t(s_t)}{q_t(s_t)} \left[\int_0^{2-n^*} \frac{1}{\lambda(n)} dn + \frac{1}{\lambda^*} \right] = Y_t(s_t), \tag{74}$$

so

$$C_t(n, s_t) = \frac{\frac{1}{\lambda(n)}}{\left[\int_0^{2-n^*} \frac{1}{\lambda(n)} dn + \frac{1}{\lambda^*} \right]} Y_t(s_t), \tag{75}$$

and $\frac{1}{\lambda(n)} / \left[\int_0^{2-n^*} \frac{1}{\lambda(n)} dn + \frac{1}{\lambda^*} \right]$ thus corresponds to the 'planner weight' $\theta(n)$ from the planner problem.

Substituting (71) into (69),

$$\frac{1}{\lambda(n)} = (1 - \beta) \left[\sum_{t=0}^{\infty} \int_{s_t} q_t(s_t) W_t(n, s_t) L_t(n, s_t) ds_t - B_0(n) \right]. \tag{76}$$

Now substituting (74) into (76),

$$\theta(n) = (1 - \beta) \left[\sum_{t=0}^{\infty} \beta^t \int_{s_t} \pi_t(s_t) \frac{W_t(n, s_t) L_t(n, s_t)}{Y_t(s_t)} ds_t - \frac{B_0(n)}{Y_0} \right]. \tag{77}$$

Consider two countries n and n' such that $\theta(n) < \theta(n')$. From equation (17), country n's income share will be higher than that of country n', everything else constant. From equation (77), $\theta(n) < \theta(n')$ must therefore imply that $B_0(n) > B_0(n')$.

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The Modality of Fiscal Consolidation and Current Account Adjustment

Abstract

In this paper we argue that supply-side adjustments (i.e. the reallocation of productive resources between the traded and non-traded sectors) can be an important determinant of the output costs of current account adjustment. The argument relies on the fact that tax evasion is more prevalent in the non-traded sector, which is dominated by services and the self-employed. Heavy reliance on tax-based fiscal consolidations induces a reallocation of economic activity towards the non-traded sector, thus requiring a larger decline in domestic absorption (and output) per unit of improvement in the current account balance. Using IMF data for the period 1980-2011 we find that budget consolidations which rely more on tax increases than on spending decreases will be associated with larger output costs per unit of current account improvement.

JEL-Code: E620, F320, F410.

Keywords: current account adjustment, fiscal consolidation, sacrifice ratio, tax evasion.

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1. Introduction

According to the *twin deficits hypothesis* there is a positive relationship between (government) budget deficits and current account deficits (e.g. a lower budget deficit is associated with a lower current account deficit).[1] This suggests that in economies plagued with both budget and current account deficits, domestic policymakers and international authorities charged with enforcing credible adjustment programmes may rest their hopes for addressing both types of deficits by focusing their efforts at budget consolidation. However, these types of adjustments have often consequences for real economic performance. Indeed, the literature on *current account reversals* (defined as a sustained current account improvement of deficit countries) suggests that these often entail substantial output losses, although this is not a unanimous conclusion.[2]

This literature has also studied whether the exchange rate regime affects the extent of output losses during current account reversals. Indeed, Keynes (1931) and Friedman (1953) argued that (nominal) exchange rate flexibility would allow countries to experience a smoother adjustment process by functioning as external shock absorbers.[3] This is because, in practice, both prices and wages are relatively sticky compared to the nominal exchange rate (Mussa, 1986), thus under a fixed exchange rate regime most of the adjustment burden may have to be borne by changes in economic activity, potentially leading to a more pronounced slowdown. Indeed, Edwards (2004a) and Edwards (2004b) found in a sample of mainly developing

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[1] Such a prediction emerges in many models, e.g., in the Mundell-Fleming model under flexible exchange rates and in general equilibrium models with both Ricardian and non-Ricardian features (Obstfeld and Rogoff, 1996; Roubini and Wachtel, 1998). However, the empirical evidence is inconclusive. On the one hand, and on the basis of a historical analysis of documented fiscal policy changes, Bluedorn and Leigh (2011) conclude that the current account responds substantially to fiscal policy—a fiscal consolidation of 1 percent of GDP typically improves an economy's current account balance by about 0.6 percent of GDP. On the other hand, many studies examining the link between fiscal and external deficits have produced very mixed and inconclusive results (e.g., Chinn and Ito, 2007; Kim and Roubini, 2008; Abbas et al, 2010).

[2] Milesi-Ferretti and Razin (2000) did not uncover any *systematic* relationship between current account reversals and economic performance, although output performance was very heterogeneous. Freund (2005 found that reversals in industrial countries are generally accompanied by a decline in GDP growth; this finding emerges also in Freund and Warnock (2007). Debelle and Galati (2005) find that reduction in current account deficits are associated with significantly slower output growth for industrial countries, but argue that current account adjustment likely reflects the outcome of a slowdown in domestic growth rather than vice versa. In contrast, Edwards (2004a, 2004b, 2007) presents results suggesting that current account adjustments do lead to slower output growth for both developing and industrial countries.

[3] However, Chinn and Wei (2013) have disputed the empirical validity of this belief, i.e. they found no evidence In support of the hypothesis that the current account reversion to its long run equilibrium is faster under flexible exchange rate regimes.

economies that current account reversals lead to lower GDP growth only under hard pegged and intermediate exchange rate systems.

In this paper we argue that the modality of budget consolidation (i.e. tax-based versus spending-based) efforts can also be an important determinant for how costly are current account adjustment episodes in terms of output losses.[4] More specifically, we claim that efforts to improve the current account through an improvement in the (government's) budget balance, will cause a larger decline in output per unit of improvement in the current account balance – we call this the *sacrifice ratio* - if they are based more on tax hikes than on spending decreases.

The thrust of our argument is based on noting that tax evasion is more prevalent in the non-traded sector -which in many countries is dominated by the self-employed - than in the traded sector. This implies that the effective after-tax relative price of the traded sector is smaller than what one would surmise by looking simply at the prices of the two sectors, thus attracting fewer resources in the traded sector. It also implies that a given reduction in domestic demand (i.e. absorption) will have a different effect on the current account depending on whether it is achieved through a rise in tax rates or decreases in government spending. This is because, unlike a cut in government spending, a rise in the statutory tax rate(s) - for given rates of tax evasion in the two sectors - increases the relative attractiveness of the non-traded sector, decreases the production of traded goods and, it requires a larger decline in domestic consumption of traded goods and output in order to achieve a given improvement in the current account balance.

In Section 2 we elaborate on our hypothesis that efforts to reduce current account deficits which rely on tax-based budget consolidations will have a larger sacrifice ratio than those relying on spending decreases. We then proceed in Section 3 to explain our method for identifying current account adjustment episodes and of calculating the associated sacrifice ratios. Using IMF data for 161 countries for the period 1980-2012, we identify 82 current account adjustment episodes, for 51 of which we have the necessary data for the fiscal policy

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[4] The modality of budget consolidation efforts has been singled out by many authors as a crucial determinant of their success – and longevity. For example, Alesina and Perotti (1995) and Perroti et al. (1998) have argued that fiscal adjustments that rely too heavily on increasing tax revenue rather than on cutting government spending are less likely to be successful and sustainable. This has recently been challenged by Tsibouris et al (2006), who show that tax-based consolidations can also succeed in countries where the initial tax to GDP ratio is low and where policy changes are implemented gradually (i.e., frontloading should be avoided).

variables required for our investigation. Section 4 explains the main econometric specification and data used for our investigation, and in Section 5 we present the results of our econometric testing which show that the higher is the reliance on tax-based relative to spending-based budget consolidation the higher will be the decline in output per unit of improvement in the current account balance. Extensive robustness tests are carried in Section 6, which confirm the empirical relevance of our main hypothesis. Concluding remarks are offered in Section 7.

2. Theoretical Considerations

Since Frenkel and Razin's (1992) comprehensive analysis of the effects of government spending and tax policies on key macroeconomic aggregates, it is well known that the influence of the government budget on the current account, depends, inter alia, on how (various) taxes and government spending are combined in order to generate a particular budget outcome. To some extent, the features which we wish to highlight in this paper elaborate further on the importance of the modality of budget outcomes for current account adjustment.

One such feature is the existence of differential rates of tax evasion between the traded and non-traded sectors. In most countries, the non-traded sector is dominated by services producers, many of which are self-employed or employ one or two employees (medical and law services, car repairs, haircuts, restaurants, etc.). That tax evasion is higher among the self-employed than amongst employees is a sensible assumption to make for all countries irrespective of how efficient is their tax administration. Indeed, the literature for countries with efficient tax administrations (e.g. Denmark, Sweden, UK, USA) supports the idea that the self-employed – who are mainly operating in the non-traded sector – evade more on their taxes than employees. For example, Kleven et al (2011), on the basis of a randomized tax enforcement experiment in Denmark involving more than 40,000 individual income tax filers and comprehensive administrative tax data found that the tax evasion rate is very small (0.3%) for income subject to third-party reporting (i.e. employees) but substantial (37%) for self-reported income. Engstrom and Holmlund (2009) use income and expenditure data to examine the extent of underreporting of income among self-employed individuals in Sweden, and conclude that households with at least one self-employed member underreport their total incomes by around 30 percent.[5] Pissarides and Weber (1989) compared the relationship between food

[5] Moreover, they find that under-reporting of income appears to be twice as prevalent among self-employed people with unincorporated businesses as among those with incorporated businesses.

expenditure and income in two groups of workers, self-employed and employees in employment, assuming that employees reported income correctly. Pissarides and Weber concluded that the self-employed had actual incomes which were equal 1.55 times their reported income, implying that the self-employed under-reported their actual income by about 33 percent. Finally, using US tax audit data Slemrod and Yitzhaki (2002) calculated that the rate of under-reporting of income from dependent employment was less than 1 percent, whereas the rate at which the self-employed under-reported their income was close to 58 percent. For countries with less efficient tax administration (e.g. Greece), the available evidence (e.g. Artavanis et al., 2012 ; Pappadà and Zylberberg , 2015) reaches the same conclusion, i.e. that tax evasion among the self-employed is much higher than for those subject to third-party reporting.

In addition, it is well known (e.g. de Paula and Scheinkman, 2009), that exporting firms usually transact with other formal-sector firms, like financial intermediaries, and also need the appropriate documentation to export. In contrast, non-traded sector firms usually use too little capital and do not engage in trans-border activities, they rely excessively on cash transactions, thereby avoiding the use of the financial sector. This makes it easier for them to avoid paying taxes as cash transactions leave no paper trail; in contrast, when firms make use of the financial sector, the tax authorities can gain access to their bank records and use this information to enforce the tax law. Eschewing the services provided by the financial sector is more costly for firms engaging in international transactions, thus their ability to evade taxes is smaller than non-traded sector producers. [6]

The implication of the above is that the effective after-tax relative price of the traded sector is smaller than what one would surmise by looking simply at the prices of the two sectors, thus attracting fewer resources in the traded sector. It also implies that a given reduction in domestic demand will have a different effect on the current account depending on whether it is achieved through a rise in tax rates or decreases in government spending. This is because, unlike a cut in government spending, a rise in the statutory tax rate(s) - for given rates of tax evasion in the two sectors - increases the relative attractiveness of the non-traded sector, decreases the production of traded goods and, for a given reduction in domestic absorption, generates a smaller improvement in the current account. As a result, in order to achieve a desired

[6] For some countries, tax evasion will be obviously more prevalent in the traded sector. One such example is the case of countries producing and exporting narcotics.

improvement in the current account, the reduction in domestic absorption (i.e. the dose of fiscal consolidation) must be larger if based on tax increases, thus the output cost per unit of current account improvement (i.e. the sacrifice ratio) will be larger than if based on government spending decreases.

In what follows we assume that there is no tax evasion in the traded sector. (This is an innocuous assumption since the argument goes through as long the incidence of tax evasion is relatively larger in the non-traded sector.) Assuming that the economy we examine is small, the traded good's price is exogenous.[7] We use the traded good as the numeraire. Let v $(0<v<1)$ denote the proportion of value added (or, more generally, of any taxable measure) that is detected by the tax authorities in the non-traded sector. Parameter v thus provides also a measure of the differential rate of tax evasion between the two sectors, with a rise in v implying a reduction in the difference in the rate of tax evasion between the two sectors, i.e. if $v=1$ there is no difference between the two sectors regarding tax evasion. Then, if P is the price of the non-traded good, and t is the (statutory) tax rate which applies in both sectors, the effective, after-tax, relative price of the non-traded good (RP) faced by producers is,

$$RP=P(1-vt)/(1-t). \tag{1}$$

Equation (1) makes clear that the lower is v (i.e. the higher is the effective tax differential between the two sectors) the higher will be RP.

Differentiating equation (1) with respect to the tax rate we find that,

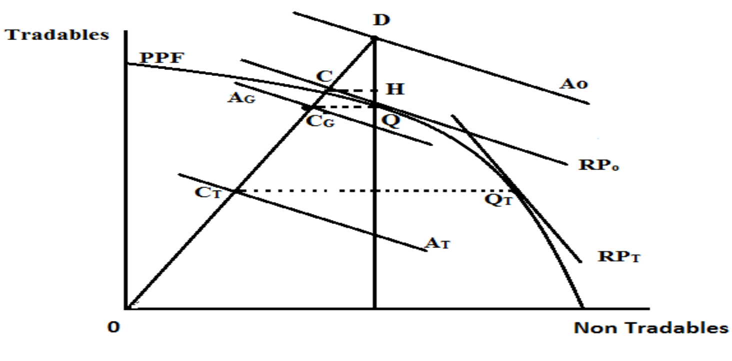
$$\frac{\partial(RP)}{\partial t}=\frac{P(1-v)}{(1-t)^2}>0 \tag{2}$$

Thus, as long as there are differences in the rates of tax evasion across sectors ($v<1$), a rise in the tax rate increases the effective, after-tax, relative price of the non-traded good.

[7] This model is also known as the *dependent economy* model. It assumes a small economy which is a price taker in the world market of both importable and exportable goods. As a result, the country's (external) terms of trade are exogenously given and importables and exportables can be aggregated into a composite commodity - the traded good. Obstfeld and Rogoff (1996) provide a detailed presentation of the model.

In order to illustrate the consequences of differential rates of tax evasion, we refer to Figure 1. The output of tradables is measured on the vertical axis, and that of the non-tradables on the horizontal axis. The initial production point is at point *Q*, where an effective relative price (denoted by RP_0) for the producers is tangent to the production possibilities frontier (PPF). Consumption is at point *D*, where an indifference curve (not shown) is tangent to the absorption[8] line A_0. The position of the absorption line measures the level of domestic spending, whereas its slope reflects the relative price faced by consumers.[9] Market clearing for the non-traded goods under full employment of resources (i.e. internal balance) implies that their consumption will have to be equal to their production, so point *D* lies vertically above point Q. Since the consumption of the traded good is larger than its domestic production, distance *QD* measures the initial trade deficit, which is facilitated by borrowing from abroad. In order to make our case as transparent as possible we assume that the current account deficit is due only to a government budget deficit (i.e. the private sector spends as much as it earns). To further simplify the diagram, we assume that the government returns in a lump-sum fashion to the private sector all tax revenue (so that the private sector's consumption point C is on the PPF), and that the government demands the two goods in the same proportion as the private sector, i.e. the government spends *CH* on non-tradables and *HD* on tradables -in effect, we assume that the government demands the two goods in the same proportion as the private sector, since point *D* is on the extension of the line *OC* (the income-consumption line).

Figure 1: The Modality of Budget Consolidation and the Sacrifice Ratio



[8] As usual, the absorption is equal to domestic spending, with the difference between absorption and income being the external balance.
[9] The relative price faced by consumers will differ from that faced by producers due to the presence of tax evasion.

Consider now that the domestic government engages in contractionary fiscal policy aiming at eliminating the external deficit. Assuming that wages and the price of non-tradables is sticky - otherwise there would be no output costs, to achieve external balance requires cutting the level of absorption to the level depicted by line A_G – so that domestic consumption of tradables at point C_G is equal to domestic production. This would however involve a reduction in demand for non-tradables, reduction in output, and thus unemployment since the production point (at C_G) is inside the PPF.[10]

Alternatively, the government could reduce domestic absorption and eliminate the trade deficit by increasing taxes. With differential rates of tax evasion across sectors, the increase in the tax rate would cause a rise in the effective, after-tax, relative price of the non-traded sector that producers face, resources would be attracted away from the production of traded goods, and, if full employment prevailed, production would shift to point Q_T. To ensure that external balance is achieved, absorption would have to be cut to the level shown by line A_T , so that domestic consumption of tradables at point C_T is equal to domestic production. This would again necessitate a dose of fiscal consolidation which involves a reduction in the demand for non-tradables, reduction in output, and thus unemployment since the production point (at C_T) is inside the PPF.

Comparing the two cases it is clear that the contraction in output is larger if tax increases are used in order to eliminate the external deficit. Accordingly, the sacrifice ratio – defined as the drop in output per unit of improvement of the external deficit – is larger if taxes are raised than if government spending is cut; a corollary of this is that the higher is the reliance on tax increases than on government spending decreases, the higher will be the output costs of any given reduction in the external deficit.

3. Current account adjustment episodes and measurement of the sacrifice ratio

In this section we present our method for identifying current account adjustment episodes as well as the method we use to derive a measurement of the output cost of current account adjustments. We examine data for all countries in the IMF's World Economic Outlook during the 1980-2011 period, except for transition countries, oil-exporting countries, and microstates.

[10] Brecher (1974) provides an early diagrammatic analysis of how the existence of wage rigidity generates unemployment in Heckscher-Ohlin trade models. Other applications of wage rigidity using the PPF apparatus include Krugman (1995) and Davis (1998).

Microstates are defined as countries with a population of less than 2 million (see, Endegnanew et al., 2012), and their current account balances display large variations which are not mainly related to changes in economic policy but to the external environment. This is also true for the oil-exporting countries; such economies generally run large current account surpluses and accumulate foreign assets during the extractive stage in order to smooth consumption once the non-renewable resources have been exhausted. For these economies the evolution of the current account — in addition to being affected by oil prices – may be affected by intended fluctuations in their production in order to stabilize the global oil market rather than any particular concern on their external position (IMF, 2013). We also exclude the transition countries from our study since the collapse of output during the early stages of transition was very large and co-existed with major structural change requiring large current account deficits which were financed by official international assistance and borrowing.

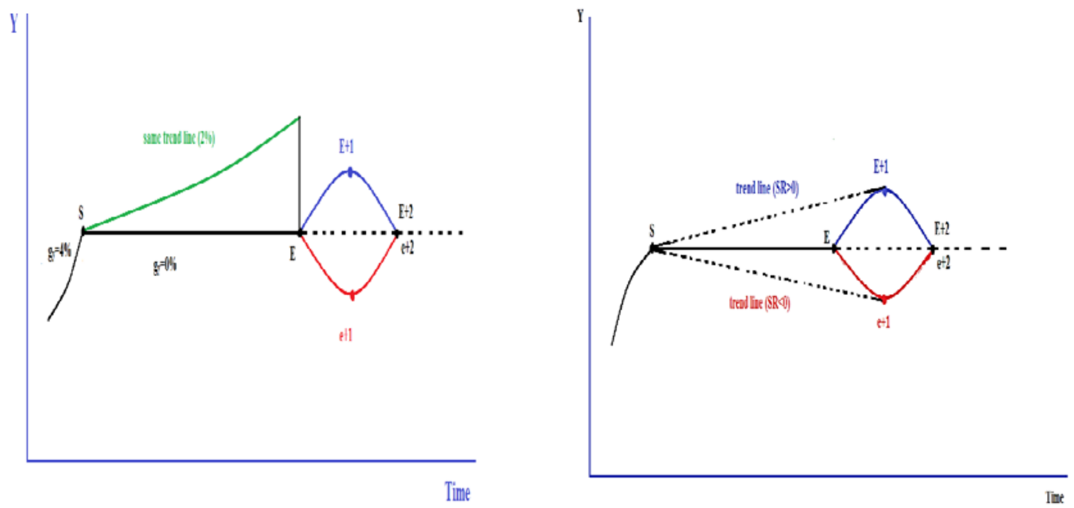
The methods we use have some similarity, but are not identical, to the ones used in the previous literature on current account adjustments and disinflation episodes. The first step is to identify adjustment episodes, i.e. periods where there is significant adjustment in the current account balance. Following on the influential study by Milesi-Ferretti and Razin (1998), current account adjustments have been chosen on the basis of criteria identifying, inter alia, the initial current account balance, the size of the adjustment, and its persistence. Thus, the subsequent literature (e.g. Freund (2005), Croke, Kamin, and Leduc (2005), Freund and Warnock (2007), Debelle and Galati (2007), Adalet and Eichengreen (2007), Algieri and Bracke (2011)) has followed the same general methodology, but has relaxed some of the earlier criteria in order to maximize the number of identified episodes. We adopt a similar strategy in the present paper, and we identify an adjustment episode when all of the following conditions are satisfied (variations of these conditions are also examined):

(i) the current account deficit (CAD) is at the start of the adjustment above 4 percent of GDP
(ii) it drops continuously by at least 2 percentage points of GDP, and remains below 3.5 percent of GDP for at least three years
(iii) there is no adjustment episode in the 3 years before the reversal starts.

We consider the start of the adjustment period to be when the current account deficit as percentage of GDP is at its peak (and above 4 percent), and the end of the adjustment period to take place either after two consecutive years of current account *surpluses*, or after three consecutive years of current account deficits lower than 3.5 percent of GDP.

An important step in our empirical strategy relates to the calculation of the sacrifice ratio. The denominator of the sacrifice ratio is the change in the current account balance (percentage points of GDP) from the beginning of the adjustment period to its end. The numerator of the sacrifice ratio is the cumulative output loss - i.e. the sum of differences between *trend output* and actual output during the period of adjustment. To calculate the trend output series we use a variant of the method followed by Ball (1994).[11] Ball's method of determining trend output in his study of disinflation episodes, was to connect output at the start of the disinflation episode (i.e. when inflation was at its peak), to output one year *after the trough* in inflation. To apply the same method in our case would involve connecting output at the start of the current account adjustment episode to output one year *after the end* of the adjustment. Although Ball's method may be a reasonable approximation for disinflation episodes[12], we demonstrate in Figure 2 that a better approximation to trend output can be used.

Figure 2: An Illustration of the Trend Line and the SR



[11] Another approach to calculate the output cost – used in the disinflation literature – is to estimate a Phillips curve (Okun, 1978; Gordon and King, 1982). A limitation of this approach is that it constrains the output-inflation trade-off to be the same during disinflations as during increases in trend inflation or temporary fluctuations in demand. As argued by Ball (1994), this restriction fails if the sacrifice ratio is influenced by factors specific to disinflations, such as incomes policies or credibility-induced shifts in expectations. Most important, the Phillips-curve approach constrains the sacrifice ratio to be the same for all disinflations within a time series. The procedure followed in this paper allows the calculation of different sacrifice for each adjustment episode.

[12] This is because the change in inflation is zero at a peak, and the natural level of output in (closed-economy) macroeconomics is often defined as the level consistent with stable inflation.

In Figure 2a we demonstrate how much a direct application of Ball's methodology to estimating trend output depends on what happens to output one year after the end of adjustment. At the start of adjustment (denoted by point S), the output path (the solid line) becomes flat until the end of adjustment (denoted by point E). The year after the end of adjustment, output could either rise to point E+1 (and then follow the path following from point E+2 onwards), or it could drop to e+1 (and then follow the path following from point e+2 onwards). Barring any other information, the upper output path is preferable to the lower output path. Yet, the trend output line for the upper path would be the (broken) line connecting points S and E+1, which lies above the actual output path, implying a positive sacrifice ratio (SR); in contrast, the trend output line for the lower path is below the actual output path in this case, implying a negative SR (i.e. that output during the adjustment was higher than "trend" output). This undesirable feature of the method of calculating trend output is clearly due to relying too much on how output evolves just one year after the end of adjustment. To correct for this, we use a different method, which is illustrated in Figure 2b. Our method admits that output growth before the start of the adjustment may have been unsustainable (e.g. due to excessive credit creation), and aims to find the trend output path by averaging[13] between average output growth two years before the adjustment begins and two years after it ends. Thus, if average growth two years before the start of adjustment is 4 percent and average growth two years after the end of the adjustment is 0, the trend output line between S and E would involve a growth rate of 2 percent, and would be (largely) independent of whether the zero (average) growth path two years after the adjustment is the upper or the lower path shown in Figure 2b. As a result, the SR would be (almost) the same for both output paths.

As an illustration of the differences in the SRs resulting from an application of the two methods, we have calculated them for the 82 adjustment episodes we have identified. Using Ball's (1994) methodology to calculate the SR produces a large number of negative SRs (i.e. current account adjustments generate output gains), sometimes as high as -33 (i.e. the cumulative rise in output above its trend is 33 times larger than the percentage point improvement in the current account balance). Given the empirical evidence cited earlier that current account adjustments are more likely to be associated with output costs than output gains, we proceed in our investigation using this paper's method of calculating SRs.

[13] Obviously, output growth before the start of the adjustment may have been sustainable; for example, the occurrence of a large current account deficit could be the result of a rise in the world interest rate, resulting in higher debt service. We present robustness checks for different weighting schemes.

Table 1: Calculated Sacrifice Ratios

	Ball (1994)	This Paper
Average Value of SR	-0.35	1.28
Number of SR<0	29 (of 82)	3(of 82)
Minimum SR	-33.0	-0.25
Maximum SR	3.2	3.12

Due to missing fiscal data for 32 of the adjustment episodes we have identified, our analysis is based on 50 episodes. These are presented in the Appendix, along with the calculated SR in each case. The largest current account deficit (among these episodes) at the beginning of the adjustment was 15.1 percent (of GDP), the smallest 4.1 percent, and the average current account deficit 6.7 percent. At the end of the adjustment, there was, on average, a current account surplus of 0.9 percent, whereas the largest surplus was 15.9 percent and the largest deficit was 3.4 percent. These figures imply that, on average, the improvement was equal to 7.6 percentage points (of GDP). This improvement was a result of an average increase in the exports to GDP ratio by 4.6 percentage points, and a decline in the imports to GDP ratio by 1.1 percentage points. The shortest adjustment episodes took two years to come to an end, the duration of the median episode was 3 years, and the longest episode was 7 years.

4. Econometric Specification and Data

Given our interest on how the modality of fiscal consolidation affects the SR of current account adjustments, we proceed now to specify our main econometric equation. As a first step, we construct the variable which measures the modality of budget consolidation. To do so, we estimate the variables *Cyclically Adjusted Expenditure* (% of GDP) and *Cyclically Adjusted Revenue* (percent of GDP). We use the relevant cyclically adjusted variables since we are interested in the effect of deliberate fiscal policy responses. To this end we take the component of the Expenditure and Revenues (as percent of GDP) which are not explained by the growth rate of the economy or a time trend. These data are obtained from IMF's, World Economic Outlook. Then, the variable measuring the modality of the fiscal adjustment is defined as the ratio of the *Change in Cyclically Adjusted Revenue* (percent of GDP) to the *Change in the Cyclically Adjusted Expenditure (percent of GDP)* during the adjustment period. We denote this variable as $Modality_{i,t}$, and we shall often refer to an increase in it as a "heavier reliance on tax increases".

To control for various changes in domestic and international economic conditions affecting the SR of current account adjustments we use in our baseline specification the following variables:

(i) The Change in the Real Effective Exchange Rate (*DREER*- taken from Darvas, 2012) controls for changes in the price competiveness vis-à-vis the rest of the world (e.g. a depreciation of the REER is expected to improve the external balance without requiring a large drop in domestic output).

(ii) In addition to *DREER,* we allow for the exchange rate regime per se to potentially affect the SR, since a given change in the real exchange rate may have different consequences depending on whether it is brought about through *external* (i.e. through nominal exchange rate adjustment) or *internal* (i.e. domestic wages and prices) devaluation. We thus use the variable *Fixed XR,* which takes the value of 1 if the country has a de-facto fixed exchange rate regime in the beginning of the adjustment. The data for this variable are taken from Levy- Yeyati and Sturzenegger (2003) – which is continuously updated.

(iii) Since it is possible to have a change in the exchange rate regime during an adjustment episode – which may disrupt the adjustment process, we control for this by using the variable *Change in XR regime*, which takes the value of 1 if there is a change in the de-facto exchange rate regime during the adjustment period (the relevant information is drawn from Levy- Yeyati and Sturzenegger, 2003).

(iv) The variable *Length of Adjustment* is introduced in order to control for the possible influence of rapid versus slow adjustments on the SR – possibly capturing political economy issues related to the so-called stabilization fatigue[14] which can introduce uncertainty about the future course of the programme and the economy. This variable is measured as the simple count of the number of years over which the adjustment is completed.

(vi) The variable *% of adj in 1st year* measures the share of current account change that takes place in the first year of the adjustment, and it is meant to capture whether frontloading the adjustment effort can influence the SR. [15] Frontloading can either generate a sense of the eventual success of the programme – thus possibly increasing the political support for it since the adjustment period can be conceived as not being very protracted, or it may be associated with such a large output contraction that decreases political support for the programme and the enactment of the most effective policies – thus increasing the SR.

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[14] The term stabilization fatigue was coined to describe the experience of Latin American countries with long-lasting stabilization programmes.

[15] The data for this and the previous variable are derived by own calculations using the data on the SR as derived in the previous section.

(vii) *Exports at the beginning*, defined as exports over GDP at the beginning of the adjustment period accounts for the ability of more export oriented economies to offset a larger part of the drop in aggregate demand due to fiscal consolidation through a boost in their exports, since a given percentage rise in exports will impact more on countries in which exports are a large percentage of GDP. The data for this variable are drawn from World Bank's (2015) World Development Indicators.

(viii) The variable *Change I/R* measures the change in the US Treasury10-year bond interest rate over the course of the adjustment, which is meant to proxy for the change in the world interest rate, and thus for the burden of servicing the country's external debt. The source of the data is World Bank (2015).

The model we estimate takes the form:

$$SR_{i,t} = \beta_1 Modality_{i,t} + \beta_2 Fixed\_XR_{i,t} + \beta_3 Change\_XR\_regime_{i,t} + \beta_4 Length_{i,t} + \beta_5 Exports_{i,t} + \beta_6 DREER_{i,t} + \beta_7 i/r\_change_t + \beta_4 \%\_of\_adj\_1st\_year_{i,t} + \beta_0 + u_{i,t} \quad (3)$$

where $u_{i,t}$ is the error term.

5. Baseline Results

The results are presented in Table 2. According to column (1), which does not include the main variable of interest (i.e. the relative reliance on tax revenue increases), the only variables that turn out to have a (statistically) significant effect on the SR are the change in the US Treasury10 year bond rate (*i/r change*) and the length of the adjustment episode (*Length*). They both turn out positive, suggesting that an increase in the world interest rate and adjustments that take more time to be completed result into higher output losses per unit of improvement in the current account (i.e. increase the SR). The rest of the variables turn out insignificant at all relevant levels of statistical significance.

Table 2: Main Results									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	No policy	relative pol	frontload	X&M	trade defici	G & T	CA open	labour reg	democracy
Fixed XR	-0.150	-0.336	-0.264	-0.249	-0.253	-0.199	-0.322	-0.245	-0.347
	(-0.59)	(-0.97)	(-0.80)	(-0.76)	(-0.79)	(-0.59)	(-0.84)	(-0.80)	(-0.82)
Change in XR regime	0.003	-0.267	-0.348	-0.335	-0.350	-0.240	-0.318	-0.310	-0.330
	(0.01)	(-0.79)	(-1.17)	(-1.14)	(-1.33)	(-0.80)	(-1.08)	(-1.09)	(-1.10)
Length of adj	0.346**	0.357**	0.506***	0.493***	0.499***	0.519***	0.502***	0.509***	0.509***
	(2.57)	(2.63)	(3.81)	(3.86)	(4.25)	(3.59)	(3.88)	(3.96)	(3.65)
DREER	-0.005	-0.002	-0.005	-0.004	-0.005	-0.003	-0.005		-0.006
	(-1.40)	(-0.51)	(-1.20)	(-0.98)	(-1.24)	(-0.64)	(-1.16)		(-1.12)
X at beginning	-0.001	0.000	-0.000	0.005		-0.002	0.000	0.001	-0.000
	(-0.23)	(0.00)	(-0.01)	(0.44)		(-0.36)	(0.02)	(0.11)	(-0.07)
i/r Change	0.166**	0.236**	0.242**	0.228**	0.233***	0.184	0.247***	0.253**	0.229**
	(2.31)	(2.11)	(2.66)	(2.53)	(2.79)	(1.54)	(2.73)	(2.56)	(2.44)
Modality		0.090***	0.082***	0.082***	0.082***	0.077***	0.082***	0.084***	0.080***
		(2.93)	(3.87)	(4.12)	(4.12)	(3.07)	(3.73)	(3.90)	(3.23)
% of adj in 1st year			0.700***	0.698**	0.698**	0.680**	0.688**	0.654**	0.700**
			(2.70)	(2.59)	(2.65)	(2.53)	(2.53)	(2.36)	(2.47)
M at beginning				-0.006					
				(-0.49)					
Trade deficit					-0.005				
					(-0.48)				
Change in Revenue						-0.017			
						(-1.10)			
Change in Spending						0.001			
						(0.10)			
CA openness							-0.141		
							(-0.33)		
Labor Regulation								-0.006	
								(-0.80)	
Democracy beginning									-0.012
									(-0.39)
Change in Democracy									-0.013
									(-0.29)
Constant	0.393	0.500	-0.486	-0.381	-0.431	-0.461	-0.410	-0.101	-0.449
	(0.87)	(1.10)	(-0.86)	(-0.67)	(-0.91)	(-0.79)	(-0.71)	(-0.14)	(-0.76)
obs	82	50	50	50	50	50	49	50	50
F-test	1.60	4.07	7.65	8.57	9.39	4.89	6.90	7.56	5.08
R2	0.10	0.17	0.31	0.31	0.31	0.33	0.31	0.31	0.31

Notes: Robust t-statistics in the parenthesis. *,**,*** denote statistical significance at the 10%,5%,1% level of statistical significance respectively

In column (2) we introduce the main variable of interest, which turns out positive and statistically significant at the 1% level. This suggests that the modality of budget consolidation crucially affects the output costs of current account adjustments, with those relying more on revenue increases resulting into a higher SR. Quantitatively our results suggest that an adjustment which is based equally on changes in tax increases and spending decreases is expected to have 0.09 lower SR that a budget adjustment which relies two-thirds on revenue increases and one-third on spending decreases. Note also that the introduction of this variable does not impact on the significance of the rest of the variables, even though our sample decreases relative to the one in column (1). The decrease in the number of adjustment episodes considered is due to the fact that the variable measuring the modality of fiscal consolidation cannot be constructed for some adjustment episodes, as the fiscal data for many countries on IMF’s World Economic Outlook are not available before 1990.

The results in column (2) are suggestive in another respect: as the variable *Length* is positive and statistically significant, we can conclude that shorter adjustment episodes typically come with a lower SR. To explore further this idea, in column (3) we introduce the variable *% of adj in 1st year*, which measures the percentage change in the current account balance that is achieved in the first year of the adjustment episode. According to column (3), this variable is positive and significant, suggesting that frontloaded current account adjustments are associated with higher output losses. At first sight this may seem paradoxical since one may assume that the more frontloaded is the adjustment, the shorter will be the length of the adjustment episode. However, there is no necessary (positive) relationship between frontloading and adjustment length. For example, a two-year adjustment episode can be achieved through either an 80% adjustment in the current account balance in the first year and 20% in the second year (frontloaded adjustment), or through 20% in the first and 80% in the second. What our results indicate is that the "policy prescription" should be "keep your adjustment period short, but don't frontload it".[16]

Columns (1) and (2) suggest that neither the exchange rate regime nor changes in the real effective exchange rate have any influence on the *SR*. These results do not necessarily indicate that either the exchange rate regime, or changes in the real exchange rate have no influence on the current account balance – they just indicate that they do not affect the output costs per unit of current account adjustment. In any case, we note that, in principle, we would expect relative price effects to be more relevant for variations in the trade balance rather than the current account. Moreover, and despite the widespread belief that the behaviour of real exchange rates is an important determinant of either the current account or the trade balance, the post-1980s empirical literature has failed to provide ample support that this is indeed the case (see, e.g. Rose, 1991; Chinn and Prasad, 2003).[17]

In the rest of the columns of Table 2, we introduce a series of variables that may be associated with the SR. Specifically we introduce: (i) the share of imports to GDP ratio at the beginning of the adjustment (*M at the beginning*, column (4)) as a way to capture the differential ability of countries to substitute domestic production for imports; (ii) the trade deficit at the beginning

[16] Moreover, the adjustment is not for all episodes monotonic (i.e. there is not always a gradual improvement in the current account balance); an "overshooting" of current account adjustment in the first year may be associated with a large recession which results into a higher SR.
[17] A possible explanation for this is the recent rise in the degree of vertical specialisation and the spread of global supply chains which tends to offset the presumed cost competitiveness benefits of exchange rate changes in the case of inter-firm linkages in the sourcing of intermediate inputs.

of the adjustment (as % of GDP- column (5)) as a way to capture the size of income declines needed to close the trade gap; (iii) the Fernandez et al. (2015) index of capital account openness (column (6)), to capture the possibility that greater capital account openness makes an economy more susceptible to negative financing shocks, which may require sharp output declines during current account reversals which may not be driven by domestic policy developments; (iv) the Heritage index of labour market regulation (column (7)) as a way to capture the ability of the economy to adjust to negative aggregate demand shocks and to the reallocation of economic activity from the non-traded to the traded sector; and (v) the POLITY IV index of democracy (column (8)), since political institutions may influence the ability of the government to enact a host of other reforms (e.g. structural reforms) which can influence the SR. The results of columns (4)-(8) indicate that none of these variables turn out to exert a statistically significant influence on the SR. We note that the variable measuring the modality of fiscal consolidation remains significant in all cases Moreover, the introduction of these variables has no effect on the rest of the variables appearing in column (3) - the only exception being regarding the influence of the world interest rate in column (6). With the above in mind we consider column (3) to be our main specification and in the tables that follow we perform the robustness analysis according to this specification.

6. Robustness Analysis

To examine the robustness of our results to the specification employed, in Table 3 we re-estimate our main model distinguishing further between exchange rate regimes. Starting with column (1), instead of using only a dummy variable for countries classified under a de-facto fixed exchange rate regime, we use separate dummy variables for the de facto- floating and the intermediate exchange rate regimes (Levy-Yeyati and Sturzenegger, 2003). Our initial results remain robust in this specification as well. In column (2) we return to our baseline model, but we now allow for the coefficient of *X at Beginning* variable to vary between fixed and non-fixed exchange rate regimes. We do so since the output losses suffered from an internal devaluation (i.e. under fixed exchange rates) may depend more on the initial exports to GDP ratio than under a flexible exchange rate regime. As the reader can readily verify the effect of *X*

Table 3: Robustness I								
	(1) All XR types	(2) interaction X	(3) Same XR	(4) not fixed	(5) only Fixed	(6) Growth(80%-20%)	(7) Growth(70%-30%)	(8) Growth(60%-40%)
Intermediate XR	0.432							
	(0.89)							
Floating XR	0.269							
	(0.77)							
Change in XR regime	-0.356	-0.337		-0.304	-1.980*	-0.277	-0.301	-0.324
	(-1.02)	(-1.15)		(-0.98)	(-3.41)	(-0.96)	(-1.08)	(-1.15)
X at beginning	0.002	0.001	-0.000	0.001	-0.014	-0.005	-0.004	-0.002
	(0.32)	(0.16)	-0.00)	(0.14)	(-0.77)	(-0.94)	(-0.65)	(-0.33)
Modality	0.081***	0.083***	0.075***	0.075***	0.912*	0.072***	0.075***	0.079***
	(3.51)	(3.72)	(3.26)	(4.04)	(3.19)	(3.30)	(3.56)	(3.75)
DREER	-0.006	-0.005	-0.011	-0.009	-0.001	-0.008*	-0.007*	-0.006
	(-1.27)	(-1.03)	-0.94)	(-1.01)	(-0.11)	(-1.91)	(-1.73)	(-1.48)
Length of adj	0.505***	0.504***	0.640***	0.518***	-1.304	0.473***	0.484***	0.495***
	(3.59)	(3.70)	(2.79)	(3.29)	(-2.21)	(3.58)	(3.74)	(3.82)
% of adj in 1st year	0.635**	0.695**	0.435	0.759***	-3.669*	0.588**	0.626***	0.663***
	(2.28)	(2.66)	(1.04)	(2.94)	(-3.44)	(2.56)	(2.77)	(2.80)
i/r Change	0.238**	0.241**	0.339***	0.222**	-1.325**	0.222**	0.229**	0.235**
	(2.43)	(2.60)	(2.90)	(2.26)	(-5.06)	(2.22)	(2.45)	(2.60)
Fixed XR		-0.098	-0.085			-0.476	-0.405	-0.334
		(-0.17)	(-0.17)			(-1.29)	(-1.22)	(-1.05)
X at beginning*Fixed XR		-0.005						
		(-0.47)						
Constant	-0.783	-0.511	-0.650	-0.646	8.068*	-0.279	-0.348	-0.417
	(-1.18)	(-0.89)	-0.75)	(-1.04)	(3.22)	(-0.51)	(-0.63)	(-0.75)
obs	50	50	33	40	10	50	50	50
F-test	6.39	5.96	5.32	9.09	19.76	7.24	7.79	7.94
R2	0.30	0.31	0.26	0.34	0.83	0.29	0.30	0.31

Notes: Robust t-statistics in the parenthesis. *,**,*** denote statistical significance at the 10%,5%,1% level of statistical significance respectively

at Beginning remains insignificant irrespective of the exchange rate regime. In column (3) we estimate our baseline equation only for the countries that do not change their exchange rate regime during the adjustment episode. A change in exchange rate regime may be, among other things, indicative of the co-existence of currency or banking crises during the adjustment episode, which are well-known to have large output costs (Dornbusch et al., 1995). Dropping the 17 adjustment episodes for which there was a change in the exchange rate regime, the sample size drops to 33 episodes, but still the modality of budget consolidation (as well as the length of adjustment, and the world interest rate) remains a significant influence on the SR. In columns (4) and (5) we split the sample according to the exchange regime. Therefore, instead of assuming that in a fixed exchange rate regime only the constant term changes, we assume that all the coefficients change. When the exchange rate regime is not classified as fixed, there are 40 adjustment episodes, and the previous results regarding our main variable of interest remain intact. When, in column (5), we consider only the episodes involving a fixed exchange rate regime we have only 10 cases, therefore the results in column (5) are derived using a very small sample and thus, although being the same as the previous cases, no confidence can be placed in the results of this column.

In columns (6) to (8) we examine the robustness of our conclusions to changes in the way we calculate the SR. This is essential since our decision to place equal weight on the (two-year) average growth rate before the beginning of adjustment and on the (two-year) average growth rate after the end of adjustment for calculating the trend output path during the adjustment period is obviously open to debate. For example, it could be argued that some current account adjustments follow on periods of unsustainable output growth fuelled by excessive credit expansions, thus placing equal weight on pre-adjustment growth is equivalent to giving undue weight to an unsustainable growth rate. Yet, other adjustment episodes are not associated with any significant (positive) difference between pre-adjustment and post-adjustment growth. To deal with this issue, we have decided to vary the weight placed on pre-adjustment growth rates. Thus, the results in column (6) are based on a SR which is derived from a trend output path that weighs the pre-adjustment, two-year growth average by 20% and the post-adjustment growth by 80%. Similarly, in columns (7) and (8), the weights for calculating the trend output path, are set to 30% and 70% (pre- and post- adjustment) and 40% and 60%, respectively. Again, the results in columns (6) to (8) remain the same irrespective of the weighting used to calculate the trend output path and the SR.

Additional robustness tests are provided in Table 4. An issue which is dealt with in many of the studies on current account adjustment cited in the Introduction, is the threshold initial current account deficit used for defining what constitutes an adjustment episode. In column (1) we assume that a current account adjustment begins when the current account deficit is above 4.5% (of GDP). This reduces the number of adjustment episodes by 9 (to 41), and it has no impact on the results, since the modality of budget consolidation, the length of adjustment, and the world interest rate retain their statistical significance, sign, and magnitude found in the previous Tables. In column (2), the threshold current account deficit is raised to above 5%. This reduces the number of current account episodes to just 35, and still indicates that a heavier relative reliance on tax-based budget consolidation increases the SR (the coefficient is of similar size as in the previous regressions and remains significant at the 1% level of statistical significance). However, the other two variables that appeared to be significant determinants of the SR in the previous regressions (i.e. world interest rate, length of adjustment) are no longer statistically significant even at the 10% of statistical significance.

Table 4: Robustness II

	(1) ca<-4.5	(2) ca<-5	(3) median regression	(4) interaction length	(5) shadow economy	(6) X/M mode of adj
Fixed XR	-0.256	-0.102	-0.372	-0.225	-0.268	-0.252
	(-0.64)	(-0.23)	(-1.59)	(-0.66)	(-0.82)	(-0.76)
Change in XR regime	-0.289	-0.090	-0.129	-0.346	-0.297	-0.341
	(-0.87)	(-0.30)	(-0.43)	(-1.16)	(-0.96)	(-1.28)
X at beginning	0.001	-0.006	0.000	0.001	-0.000	
	(0.18)	(-1.07)	(0.03)	(0.09)	(-0.04)	
Modality	0.083***	0.069***	0.069***	0.209		0.083***
	(4.06)	(4.00)	(4.68)	(1.57)		(3.92)
DREER	-0.006	0.013	-0.006*	-0.004	-0.004	-0.006
	(-0.57)	(1.36)	(-1.72)	(-0.99)	(-0.91)	(-1.21)
Length of adj	0.483***	0.158	0.518***	0.528***	0.533***	0.506***
	(3.18)	(0.69)	(4.16)	(3.96)	(3.96)	(4.09)
% of adj in 1st year	0.676**	-0.137	1.001***	0.689**	0.677**	0.702***
	(2.29)	(-0.36)	(6.65)	(2.63)	(2.62)	(2.77)
i/r Change	0.243**	0.118	0.177***	0.238**	0.239**	0.244***
	(2.49)	(0.92)	(3.25)	(2.65)	(2.65)	(2.78)
Modality*Length				-0.038		
				(-1.02)		
Modality*shadow economy					0.283***	
					(2.77)	
Change X/Change M						-0.004
						(-0.34)
Constant	-0.488	1.072	-1.016*	-0.556	-0.563	-0.492
	(-0.75)	(1.11)	(-1.71)	(-0.99)	(-0.97)	(-1.01)
obs	41	35	50	501	48	50
F-test	7.39	4.94		8.55	7.26	7.42
R2	0.30	0.28		0.32	0.31	0.31

Notes: Robust t-statistics in the parenthesis. *,**,*** denote statistical significance at the 10%,5%,1% level of statistical significance respectively

We now proceed to examine the robustness of our results by checking whether they are driven by individual outliers. Since our sample consists of many heterogeneous countries, a potential source of worry may be the presence of outliers among the identified adjustment episodes. To deal with this, we employ robust regression analysis using the MM- estimator (Yohai, 1987). Following Rousseeuw and Yohai (1987), instead of minimizing the variance of the residuals (as the OLS does) this class of estimators minimizes measures of dispersion of the residuals that are less sensitive to outliers. The results shown in column (3) verify that our empirical findings so far remain highly resilient to robust regression techniques.

The main argument of the paper regarding the effects of the modality of fiscal consolidation on the SR rests on the existence of *differences* in the rates of tax evasion between the traded and the non-traded sectors. Although there is no necessary direct link between the difference in the rates of tax evasion between the two sectors and the size of the shadow economy relative to officially measured GDP, it may be argued that the two variables are positively related. For example, the difference between countries with low and high administrative tax capability in the ability to collect taxes on employees in large firms is probably smaller than the difference in ability (between the two sets of countries) to collect taxes on the self-employed. To make this plain, it may be the case that the rates of tax evasion among employees are of similar magnitude in Denmark and Greece, but differ substantially when it comes to the taxation of the self-employed, with tax evasion among the self-employed being significantly higher in Greece than in Denmark (i.e. the country with an efficient tax administration). This implies that we may expect the influence of the modality of fiscal consolidation on the SR to be higher the higher is the overall rate of tax evasion in the economy. This is explored in column (4), where we control for the possible interaction between the modality variable (i.e. *Change in T/Change in G*) and our proxy for tax evasion; this proxy is share of the shadow economy as percentage of GDP, which we draw from Schneider et al. (2010). This interaction variable is not found to be statistically significant, although the modality of fiscal consolidation remains a significant determinant of the SR on its own.

Finally in column (5) we examine whether the SR is affected by the way trade flows adjust, i.e. whether most of the adjustment comes from a rise in exports or through a reduction in imports. It can be hypothesized that current account adjustments that are achieved through an increase in exports lead to lower output costs than those achieved through a reduction in imports since in the first case aggregate demand for domestically produced goods increases, whereas in the second case lower imports may just be a result of a contraction in economic activity. Although out results do not support this hypothesis, the modality of fiscal consolidation, the length of the adjustment episode, the frontloading of the current account correction, and the world interest rate still remain significant determinants of the SR.

5. Conclusion

The twin deficits hypothesis suggests that an improvement in a country's budget deficit will lead to an improvement in its current account balance. Leaving aside well-known theoretical and empirical objections about the validity of this hypothesis, we have argued that budget consolidations which rely heavily on tax revenue increases will be associated with larger output costs per unit of current account improvement than if they relied on government spending decreases. The empirical evidence presented in this paper supports this hypothesis.

To some extent our results indicate the potential importance of the supply side for current account adjustment. This is, of course, not new; after all, that the supply side, or, more generally, that a country's economic structure exercises large influence on how government policy affects the external balance has been well understood for a long time (e.g. Branson, 1983; Buiter, 1988). In this sense, our results about how differential rates of tax evasion interact with fiscal policy to affect the inter-sectoral allocation of economic activity and the current account provides yet another instance in which a country's economic structure - interpreted in a broad way so as to include political and administrative constraints – is of fundamental importance for understanding why current account adjustments in non-industrial countries have been found to work through distinctly different channels than those in industrial countries (Milesi-Ferretti and Razin, 1998; Chinn and Prasad, 2003). This finding should be contrasted with our finding that neither the exchange rate regime nor changes in the real exchange rate affect the output costs of current account adjustments.

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Appendix

Adjustment Episodes

Country	Start	End	Sacrifice Ratio		Country	Start	End	Sacrifice Ratio
Belgium	1981	1984	1.084		Malaysia	1997	1999	0.3719
Canada	1981	1984	1.546		Paraguay	1997	1999	0.340
Ireland	1981	1988	1.404		Philippines	1997	2000	4.022
Kenya	1981	1984	2.032		Argentina	1998	2002	1.436
Portugal	1981	1986	0.740		Chile	1998	2001	3.121
Colombia	1983	1987	1.122		Ecuador	1998	2000	0.341
New Zealand	1984	1990	1.067		Peru	1998	2001	2.022
Greece	1985	1988	0.294		Venezuela	1998	2000	-0.231
Denmark	1986	1989	1.174		Yemen	1998	2000	0.297
Bangladesh	1988	1992	2.474		New Zealand	1999	2002	1.592
Benin	1988	1991	0.769		Guinea	2000	2003	0.962
El Salvador	1989	1994	1.348		Sri Lanka	2000	2003	1.650
Jamaica	1989	1994	0.141		Brazil	2001	2004	1.048
Finland	1991	1995	0.982		Cameroon	2001	2005	3.235
Burundi	1992	1995	0.834		Eritrea	2001	2003	-0.245
Rwanda	1993	1995	0.701		Tunisia	2001	2004	4.297
Tunisia	1993	1998	2.731		Bolivia	2002	2004	0.535
Jordan	1994	1998	2.212		Syria	2003	2006	0.932
Mexico	1994	1997	1.494		Thailand	2005	2007	0.564
Algeria	1995	1998	0.479		Guatemala	2007	2011	2.468
Cote d'Ivoire	1995	1998	1.720		Ireland	2008	2011	0.683
Thailand	1995	1999	0.715		Pakistan	2008	2012	1.007
Vietnam	1995	2001	1.505		Peru	2008	2011	2.750
Pakistan	1996	2000	1.940		Vietnam	2008	2012	0.444
Colombia	1997	2000	0.981		Zambia	2008	2010	0.797

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CEPII

A European Disease? Non-tradable Inflation and Real Interest Rate Divergence

Sophie Piton

Highlights

- This paper studies the contribution of real interest rate divergence to the dynamics of the relative price of non-tradables within Europe.
- It suggests an extension of the traditional Balassa-Samuelson framework to analyze the impact of the real interest rate on the dynamics of the relative price.
- It documents the expansion of the non-tradable sector in the periphery before the euro crisis.
- It carries out an econometric estimation for 11 EA countries over 1995-2013 and quantifies the contribution of the pure Balassa-Samuelson effect and the impact of the interest rate on non-tradable relative prices.
- In Greece, the fall in the real interest rate over 1995-2008 could explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA.

Abstract

This paper studies the contribution of real interest rate divergence to the dynamics of the relative price of non-tradables within Europe. Based on a model by De Gregorio et al. (1994), it shows that the real interest rate fall in the Euro Area (EA) periphery following the single currency's inception induced an increase in the relative price of non-tradable goods. Using a new dataset, it documents the dynamics of the tradable and the non-tradable sectors over 1995-2013 and the expansion of the non-tradable sector in the periphery before the euro crisis. It then carries out an econometric estimation for 11 EA countries over 1995-2013 and quantifies the contribution of the pure Balassa-Samuelson effect and the impact of the interest rate on non-tradable relative prices. Diverging evolution in the interest rate impacted greatly the evolution of non-tradable relative prices within the euro area over the period. In Greece, the fall in the real interest rate over 1995-2008 could explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA.

Keywords

Non-tradable Prices, Balassa-Samuelson Effect, Real Interest Rate.

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F41, F45, E43.

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RESEARCH AND EXPERTISE
ON THE WORLD ECONOMY

A European Disease?
Non-tradable inflation and real interest rate divergence

Sophie Piton*
This version: October 20, 2016

Contents

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1. Introduction

When the euro was introduced, conditions for economic convergence –the process of narrowing income gaps between lower and higher income countries– seemed to be present.[1] Nominal interest rates between higher and lower income countries had converged rapidly[2] and capital was flowing from the richer (the "core") to the poorer (the "periphery") countries of the area. This convergence process was supposed to be the main reason behind the strong macroeconomic divergence between the core and the periphery, and the imbalances were supposed to be reduced as countries would converge. The 2010 euro crisis has challenged this view, with macroeconomic divergence among countries pointed to as reflecting bad imbalances. In particular, debates have emerged to reassess the mechanisms behind the divergence in inflation rates across countries and behind substantial price differentials between tradable and non-tradable goods in some countries. Even though there is evidence of a convergence of tradable prices across Europe and higher productivity growth in the tradable sectors of catching-up economies, there seems to be a growing consensus that the Balassa-Samuelson (BS) effect[3] cannot be the sole explanation to the steep rise in the non-tradable relative to the tradable price in the Euro Area (EA) periphery before the crisis (Estrada et al., 2013).

This paper further investigates the mechanisms behind the divergence of relative (non-tradable to tradable) prices across Europe. The starting point is Figure 1 which shows the evolution of relative prices and real interest rates in the periphery compared to core countries over 1995-2013. The periphery, facing a steep increase in relative prices, also faced a strong decrease in real interest rates up to 2008. Introducing two factors of production in the BS framework, the paper shows that the real interest rate fall in the EA periphery following the single currency's inception induced an increase in the relative price of non-tradable goods. Using a new dataset, it then documents the dynamics of the tradable relative to the non-tradable sector over 1995-2013 and highlights the expansion of the non-tradable sector in the periphery before the euro crisis. Finally, it carries out an econometric estimation for 11 EA countries over 1995-2013 to quantify the contribution of the pure BS effect and that of the interest rate reduction on non-tradable relative prices.

A growing literature has analyzed the impact of falling interest rates on the increase in relative prices of non-tradables. In 1983 already, Dornbusch (1983) showed how an exogenous disturbance in the real interest rate can affect the price of non-traded goods by fueling a demand boom. This argument has also been suggested more recently by Fagan and Gaspar (2007). Other papers analyze the impact of the interest rate on the supply side rather than on the demand-side of the economy: Reis (2013), studying the case of Portugal, suggests that capital inflows were misallocated within the non-tradable sector due to financial frictions, fueling transitory price increases in this sector. Other authors look at the impact of such misallocation on the sustainability of the current account and the probability of a balance of payment crisis (Giavazzi and Spaventa, 2011; Kalantzis, 2015).

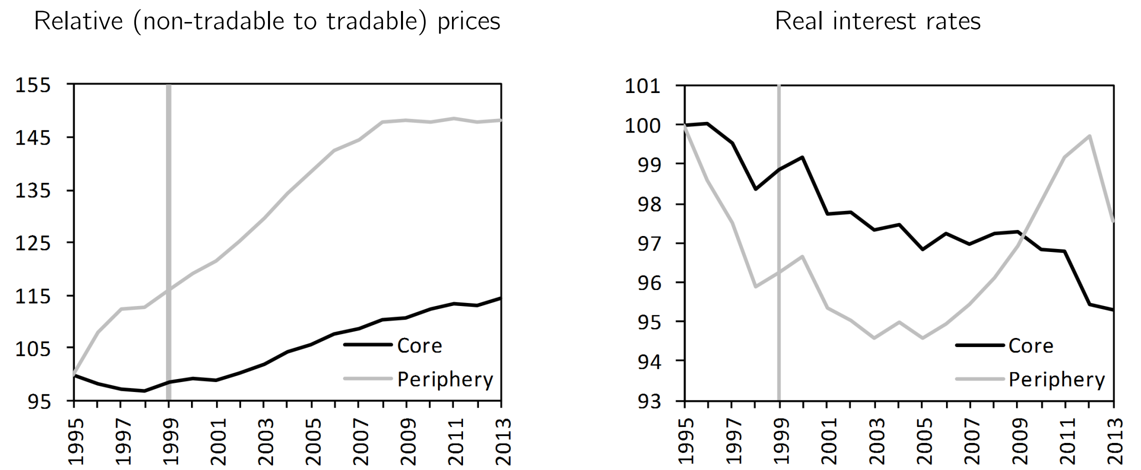
This paper departs from these analyses in the way that it studies the impact of interest rate variations in a BS framework. The BS framework has already been subject to various extensions

[1] Blanchard and Giavazzi (2002) suggested that current account deficits in the periphery after the euro's inception reflected mainly a catch-up and convergence process.

[2] The periphery faced, on average between 2001-2008, a real rate of 0.26% against 1.4% for the rest of the euro area as a whole (Ameco, February 2016.)

[3] Balassa (1964) and Samuelson (1964) suggested that higher inflation rates in catching-up economies could reflect a process of real convergence: assuming the law of one price holds for tradable goods, productivity growth in this sector pushes real wages up both in the tradable sector and the non-tradable one; it results in an increase in the relative price of non-tradable goods and thus in a real exchange rate appreciation in catching-up economies.

Figure 1 – Relative prices and real interest rates in the periphery vs. core countries, 1995-2013
indices 1995=100



Source: author's calculations using Eurostat, BACI and UN ServiceTrade and Ameco.
Note: relative prices are measured using the 10% threshold for tradability and are the ratio of non-tradable prices relative to the tradable price of the EA11. Variables for each group are weighted averages (weight: gross value added at current prices). The real interest rate is deflated by GDP deflators. The periphery includes: Spain, Portugal, Italy, Ireland, Greece. Core countries are: Austria, Belgium, Germany, Finland, France, Netherlands. The grey vertical lines indicate the euro introduction (1999).

to explain the permanent drift in non-tradable prices. Among others, De Gregorio et al. (1994) suggest that it could be explained by an exogenous demand-shift towards non-tradable goods. More recently Bénassy-Quéré and Coulibaly (2014) suggest that inflation differentials in Europe also originate in heterogeneous market regulations. This paper shows that in the long term, a permanent and exogenous decrease in the interest rate will lead to a permanent drift in non-tradable prices as long as the non-tradable sector is labor-intensive. This is, to our knowledge, the first attempt to analyze the impact of the interest rate in a BS framework.

The remainder of the paper is organized as follows. Section 2 extends the usual BS theoretical framework to analyze the impact of a fall in the real interest rate on the non-tradable relative price. Section 3 describes the dataset and the construction of a tradability indicator, and then documents the dynamics of the non-tradable and tradable sectors over 1995-2013 in 11 countries of the EA. Section 4 presents the econometric strategy, reports empirical estimation results and robustness tests. Section 5 concludes.

2. Conceptual framework

The workhorse model to analyze the evolution of non-tradable prices in an open economy is the framework set by Balassa (1964) and by Samuelson (1964). Their model features a small open economy with a perfectly competitive tradable sector (the price being determined by the world market), and a non-tradable sector (the price being determined domestically). Labor is the only factor of production. They show that, assuming the law of one price holds for tradable goods, productivity growth in this sector pushes real wages up both in the tradable sector and in the non-tradable one. This results in an increase in the relative price of non-tradable goods and thus in a real-exchange rate appreciation, which is commonly known as the BS effect. Several theoretical extensions have been proposed in the literature.[4] Some of them consider two factors of production (labor and capital), or examine the implications of incorporating a demand-side in the BS framework (see, among others, De Gregorio et al., 1994; Obstfeld and Rogoff, 1996; Bénassy-Quéré and Coulibaly, 2014).[5] This paper is the first attempt to look at the impact of an exogenous change in the interest rate on the evolution of the non-tradable relative price. It focuses on the supply-side and builds on the framework set by De Gregorio et al. (1994) to show the impact of both faster productivity growth in the tradable sector and an exogenous and permanent fall in the interest rate on the relative price of non-tradable goods.

The model features a small open economy with two goods: a tradable, the numeraire, whose market is perfectly competitive and subject to the law of one price; a non-tradable good, which price is set domestically. Production takes place using two inputs: capital (mobile internationally and between sectors) and labor (mobile between sectors but not internationally). Labor sectoral mobility ensures that workers earn the same wage in either sector whereas capital international mobility ensures that the interest rate is given internationally.

Representative firms in each sector face a Cobb Douglas production function with two factors of production, of the form:

$$Y_T = A_T K_T^{\alpha_T} L_T^{1-\alpha_T} \tag{1}$$
$$Y_N = A_N K_N^{\alpha_N} L_N^{1-\alpha_N} \tag{2}$$

where the subscripts T and N denote the tradable and non-tradable goods, Y denotes real output, L labor inputs and K capital. α_T, α_N represent capital intensity in each sector ($\alpha_T, \alpha_N \in]0,1[$). Given that the tradable good acts as a numeraire, and given that the interest rate r is exogenous, combining first order conditions in the tradable sector yields the equation for the real wage (nominal wage deflated by the numeraire T), ω:

$$\omega = r^{-\frac{\alpha_T}{1-\alpha_T}} A_T^{\frac{1}{1-\alpha_T}} \alpha_T^{\frac{\alpha_T}{1-\alpha_T}} (1-\alpha_T) \tag{3}$$

Combining first order conditions in the non-tradable sector, given r and ω, yields the equation for the non-tradable relative price p:

$$p = \frac{1}{A_N} \left(\frac{\omega}{1-\alpha_N}\right)^{(1-\alpha_N)} \left(\frac{r}{\alpha_N}\right)^{\alpha_N} \tag{4}$$

Plugging (3) into (4), we get that the non-tradable relative price is determined entirely by technological conditions and is independent of demand conditions. The relative price depends on the rate of interest (r) and on the tradable and non-tradable sector productivities (A_T, A_N) and capital intensities (α_T, α_N):

$$p = r^{\frac{\alpha_N-\alpha_T}{1-\alpha_T}} \frac{\left[A_T(1-\alpha_T)^{1-\alpha_T}\alpha_T^{\alpha_T}\right]^{\frac{1-\alpha_N}{1-\alpha_T}}}{A_N(1-\alpha_N)^{1-\alpha_N}\alpha_T^{\alpha_N}} \tag{5}$$

[4] See Bahmani-Oskooee and Nasir (2005) for a review.
[5] In all cases, demand shocks appear unable to move the real exchange rate in the long run.

The BS effect postulating a positive link between faster productivity growth in the tradable sector and the relative price of the non-tradable good is straightforward. Other things constant, a rise in the productivity of the tradable sector (A_T) decreases the price of this sector relative the non-tradable one. This BS effect goes through the impact of A_T on ω:

$$\frac{d\omega}{dA_T} = \frac{1}{1-\alpha_T} A_T^{\frac{\alpha_T}{1-\alpha_T}} r^{-\frac{\alpha_T}{1-\alpha_T}} \alpha_T^{\frac{\alpha_T}{1-\alpha_T}} (1-\alpha_T) > 0$$

This wage increase ensures that the marginal cost of tradables remains constant but it increases the marginal cost, and hence the relative price, of the non-tradable good:

$$\frac{dp}{dA_T} = \frac{1-\alpha_N}{1-\alpha_T} A_T^{\frac{\alpha_T-\alpha_N}{1-\alpha_T}} r^{\frac{\alpha_N-\alpha_T}{1-\alpha_T}} \frac{1}{A_N} \left(\frac{1-\alpha_T}{1-\alpha_N}\right)^{1-\alpha_N} \alpha_T^{\frac{\alpha_T(1-\alpha_N)}{1-\alpha_T}} \alpha_N^{-\alpha_N} > 0$$

In turn, the impact of an exogenous and permanent fall in the interest rate on the relative non-tradable price depends on the capital intensity of the non-tradable relatively to the tradable sector ($\alpha_N - \alpha_T$). Indeed, a fall in the interest rate –all other variables remaining constant– is matched by a wage increase ensuring that the marginal cost of tradables remains constant:

$$\frac{d\omega}{dr} = -\frac{\alpha_T}{1-\alpha_T} r^{\frac{-1}{1-\alpha_T}} A_T^{\frac{1}{1-\alpha_T}} \alpha_T^{\frac{\alpha_T}{1-\alpha_T}} (1-\alpha_T) < 0$$

If the non-tradable sector is relatively more (less) labor intensive, this rise in wages will increase (decrease) the marginal cost, and hence the relative price, of the non-tradable good:

$$\frac{dp}{dr} = \frac{\alpha_N-\alpha_T}{1-\alpha_T} r^{-\frac{1-\alpha_N}{1-\alpha_T}} \frac{A_T^{\frac{1-\alpha_N}{1-\alpha_T}}}{A_N} \left(\frac{1-\alpha_T}{1-\alpha_N}\right)^{1-\alpha_N} \alpha_T^{\frac{\alpha_T(1-\alpha_N)}{1-\alpha_T}} \alpha_N^{-\alpha_N} < 0 \quad \text{if} \quad \alpha_N < \alpha_T$$

Expressing all variables relative to the Euro area (EA) average, assuming the law of one price holds in the tradable sector ($p_T = p_T^{EA}$), and assuming, as in the literature, that productivity grows faster in the tradable sector than in the non-tradable sector, the empirically testable model is given by:

$$\left(\frac{p_N}{p_N^{EA}}\right) = f\left(\left(\frac{A_T}{A_T^{EA}}\right), \left(\frac{r}{r^{EA}}\right)\right) \tag{6}$$

where A_T stands for productivity in the tradable sector, r the real interest rate, and EA subscripts stand for euro area averages. For similar productivity growth in the non-tradable sector, the country should experience a relative increase in its non-tradable price if its productivity growth in the tradable sector is stronger than the average productivity growth of the T sector in the euro area: we expect a positive coefficient on the first variable. Similarly, the country is expected to experience a non-tradable price increase if its real interest rate (expressed in terms of tradables) decreases more than it does, on average, in the EA, given that the non-tradable sector is more labor intensive than the tradable one. There seems to be evidence supporting this assumption that the non-tradable sector is more labor-intensive than the tradable sector. van Riet and Roma (2006) show that services sectors are less capital intensive than the manufacturing sectors in the euro area at the beginning of the 2000s. Moreover, they show that Southern European countries tend to be characterized by a smaller average firm size than the Euro area aggregate, and have a larger share of self-employment in the service sector, making this sector even more labor intensive than in the rest of the EA. This assumption is also confirmed in the dataset used here. These results will be tested empirically after describing the dataset used and documenting patterns in the non-tradable sector inflation across Europe over 1995-2013.

3. Data

3.1. Data sources

Most studies label the manufacturing sector as tradable and consider services sectors as non-tradable. However, services represent an increasing share of advanced economies' exports. To reassess the tradability of both goods and services, one needs to construct a database allowing to compare trade in goods and services, and national accounts data at a sectoral level. Eurostat provides data for national accounts for up to 64 sectors in the NACE revision 2 classification. It provides detailed information on Gross Value Added (GVA) in current and constant prices, production at current and constant prices, employment and labor compensation for European countries. For data on trade in goods, BACI, CEPII's database based on COMTRADE, provides a harmonized world trade matrix for values at the 6-digit level of the Harmonized System of 1992. Data are available from 1989 to 2013 for 253 countries and 5 699 products. Finally, for trade in services, UN ServiceTrade database provides data on services exports and imports in the BPM5 classification over 2000-2013.

All databases are converted into a 21-level NACE revision 2 classification, to get an unbalanced database[6] providing data on gross value added at current and constant prices, production at current and constant prices, labor compensation at current prices, employment and the value of trade in goods and services and goods export for up to 11 EA countries (EA11)[7] over 1995-2013. It is then possible to measure gross value added deflators (chained linked indices, using 1995 as the reference year) and labor apparent productivity (value added in volume per hour worked) as a proxy for total factor productivity. Finally, series on annual real[8] long-term interest rates come from Ameco.

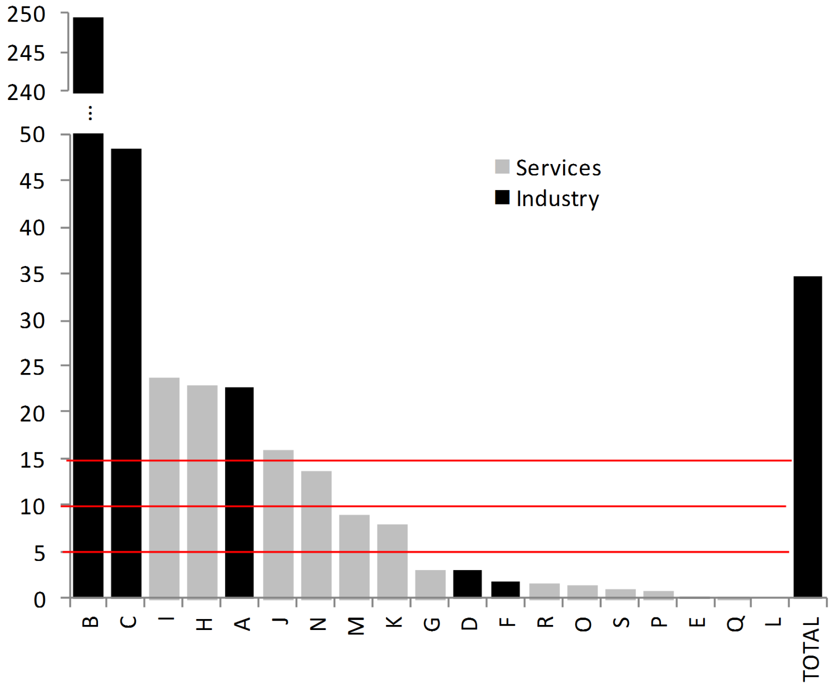
3.2. Defining tradability

The tradability of a good or a service sector is defined as the capacity to trade its output internationally. As in De Gregorio et al. (1994) and most of the empirical literature, the extent to which a good or a service is actually traded with a foreign country is used as a proxy for its tradability. Therefore, the tradability of each sector at the euro area (EA11) level depends on its openness ratio –the ratio of total trade (imports + exports) of the EA11 to total production in the EA11. As in De Gregorio et al. (1994) we use a threshold of 10%, so a sector is considered as being tradable if the average of its openness ratio over 2000-2013 is higher than 10% (the openness ratio for the period 1995-1999 cannot be measured since data on trade in services are not available for this period).

Figure 2 reports the openness ratio by sector on average over 2000-2013 (see Table A.1 in Appendix for more details). Unsurprisingly, agriculture, the manufacturing and mining and quarrying sectors are in the tradable sector. Concerning services, four industries are considered as tradable: accommodation and food service activities; transportation and storage; information and communication, and administrative and support service activities. The tradable sector accounts for 47% of total production, 36% of GVA (both at current prices) and 39% of employment.

[6] Information on disaggregated trade in services is available only for the period 2000-2013.
[7] The 11 EA countries are: AT: Austria; BE: Belgium; DE: Germany; EL: Greece; ES: Spain; FI: Finland; FR: France; IE: Ireland; IT: Italy; NL: Netherlands; PT: Portugal.
[8] Long-term interest rate deflated by GDP deflators.

Figure 2 – Openness ratio and tradability by sector, EA11
Average 2000-2013, in %



Source: author's calculations using Eurostat, BACI and UN ServiceTrade.
Note: the red lines indicate the 15%, 10% and 5% thresholds.
A: Agriculture, forestry and fishing; B: Mining and quarrying; C: Manufacturing; D: Electricity, gas, steam and air conditioning supply; E: Water supply; sewerage, waste management and remediation activities; F: Construction; G: Wholesale and retail trade; repair of motor vehicles and motorcycles; H: Transportation and storage; I: Accommodation and food service activities; J: Information and communication; K: Financial and insurance activities; L: Real estate activities; M: Professional, scientific and technical activities; N: Administrative and support service activities; O: Public administration and defense; compulsory social security; P: Education; Q: Human health and social work activities; R: Arts, entertainment and recreation; S: Other service activities.

Inevitably, the threshold of 10% is arbitrary. One possibility could be to apply different tradability criteria for different countries, but applying the same criterion for all countries leads to more clearcut results.[9] Using a threshold of 15% would exclude administrative and support service activities from the tradable sector. The tradable sector would then account for 43% of total production and 32% of GVA (at current prices), and 33% of employment. Using a threshold of 5% would include 2 other sectors in the tradable sector, and more particularly financial and insurance activities. The tradable sector would then account for 57% of total production and 47% of GVA (at current prices), and 47% of employment (see Figure A.1 in the Appendix).

However, for financial and insurance activities for example, recent empirical work (Jensen and Kletzer, 2005; Gervais and Jensen, 2013) shows that financial and insurance activities are heterogenous

[9] At country-level, tradability could be affected by market regulations or market structure, which should not matter for the EA11 since tradable sectors are well integrated in Europe (Estrada et al., 2013).

and contain both tradable and non-tradable activities.[10] Therefore, labeling this sector as tradable or non-tradable is not straightforward. A few authors show the deep linkages between the non-tradable sector expansion and the banking and financial activity (see, for example, Sy, 2016), supporting the assumption of considering financial and insurance activities as non-tradable. As the choice of a 10% threshold is arbitrary, the 15% and 5% thresholds will be used to check the robustness of the empirical results.

3.3. Stylized facts: the drift from the tradable to the non-tradable sector

Figure 3 describes the evolution of gross value added, employment and prices in the non-tradable sector relative to the tradable sector, for each country of the EA11, for two subperiods: 1995-2008 and 2008-2013.[11] The 10% threshold is used to classify each sector as tradable or not, but similar figures using other thresholds are reported in Appendix. Relative prices are measured as the ratio of non-tradable to the tradable price in the EA11.[12]

Figures 4 and 5 report the contribution of each sector to the average price and employment growth over the two sub-periods: 1995-2008 and 2008-2013. Contributions to price growth are measured as the average inflation over the period in the considered sector weighted by its share in total GVA in volume at the initial year (1995 or 2008). Contributions to employment growth are measured as the average employment growth in the considered sector weighted by its share in total employment in thousands of hours at the initial year (1995 or 2008).

Figure 3, for the first sub-period (1995-2008), highlights the similar pattern in all peripheral countries: the hypertrophy of the non-tradable sector. This pattern is also striking when using other thresholds for the measurement of tradability. Prices in the non-tradable sector relative to the tradable sector rose sharply between 1995 and 2008 in Ireland, Italy, Portugal, Spain and Greece. The rise in relative prices and the growing share of the non-tradable sector led to a strong rise in overall prices and wages. However, some differences remain among the peripheral countries.

As Giavazzi and Spaventa (2011) have noted already, relative employment in Greece rose faster than relative GVA at current prices. The country faced a relatively smaller bubble in the housing sector (F-L) than Spain, with the housing sector contributing to 6p.p. of the average inflation over 1995-2008 (Figure 4). The main contributor to inflation and employment growth over 1995-2008 was the public, education and health sector (O_Q), contributing to respectively 4p.p. of the average employment growth (Figure 5) and 9p.p. of the average GVA deflator growth.

In Portugal, the non-tradable price increase was also led by both the housing and the public, education and health sectors, contributing respectively to 8p.p. and 9p.p. of the average inflation and 1p.p. and 3p.p. of average employment growth over 1995-2008. Employment decreased on

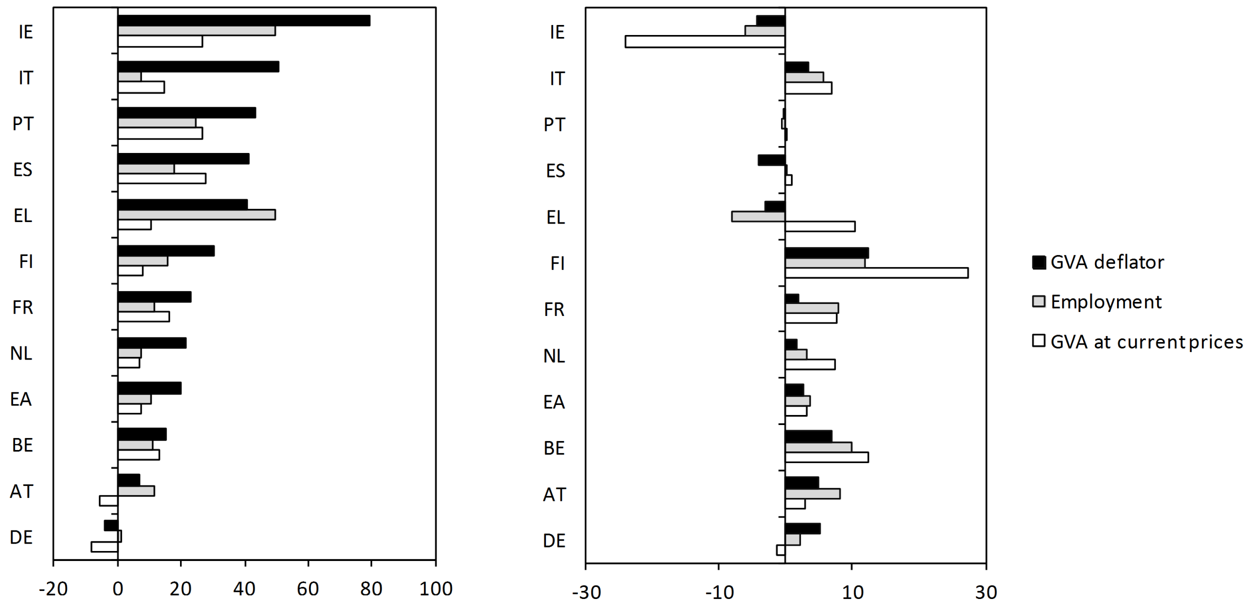
[10]These authors use the geographic concentration of activity as a proxy for the tradability of the industry. The more concentrated the activity, the higher its tradability. Applying this methodology on data on U.S. establishments, Gervais and Jensen show that the financial and business services sector has industries in both the top 5 most concentrated and least concentrated manufacturing and business services industries.

[11]As seen on Figure 1, the trends of relative prices and real interest rates started to reverse after the 2008-crisis. We thus use the year 2008 as a break point for the stylized facts presented in this section.

[12]Like in the model and the following empirical analysis, the law of one price is assumed to hold in the tradable sector of the EA and the same tradable EA price is used as the numeraire for the 11 countries. The database used does not inform on price levels, but recent work show empirical evidence of a substantial convergence in price levels in the case of tradable goods (see Estrada et al., 2013). As the main focus of the paper is on the dynamics of the non-tradable sector, we assume the LOP holds and exclude from the analysis the dynamics specific to the tradable sectors.

Figure 3 – Evolution of the non-tradable relative to the tradable sector, %

(a) 2008/1995 **(b)** 2013/2008

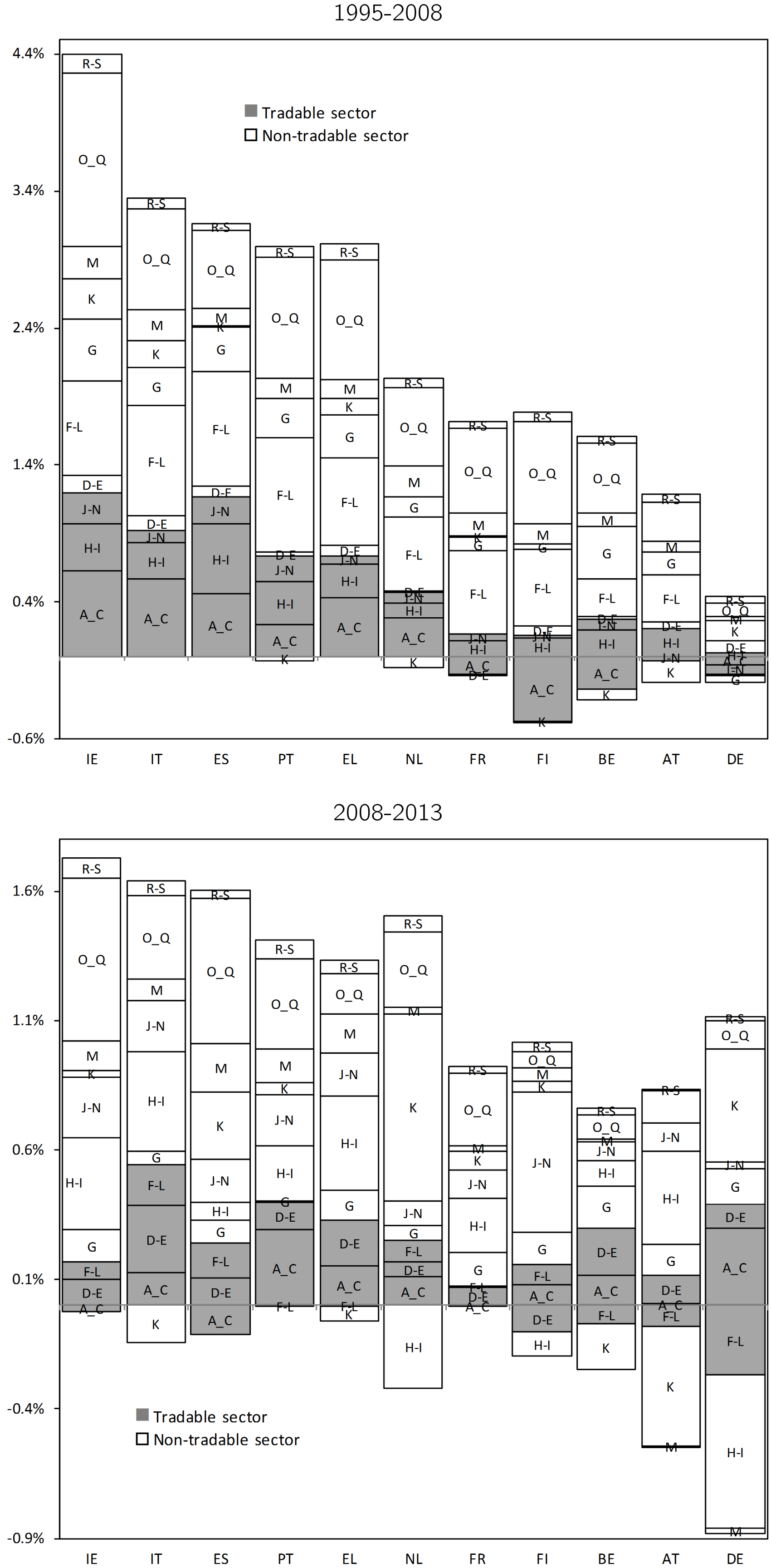


Source: author's calculations using Eurostat, BACI and UN ServiceTrade.
Note: relative prices are measured using the 10% threshold for tradability and are the ratio of non-tradable prices relative to the tradable price of the EA11. Employment is measured in thousands of hours worked.

average in the tradable sector –and especially for the industrial and agricultural activities (A_C) which had a negative contribution of -6p.p. to total employment growth.

Ireland and Spain were the two countries with the fastest employment growth over 1995-2008, both experiencing a housing bubble: the housing sector contribution to the average growth employment over the period reached 5p.p. and 6p.p. respectively. In Ireland, employment growth was also led by the expansion of the public, education and health sector. In Spain, the housing sector also contributed to a 8p.p. increase in the average inflation, and was by far the main contributor to price growth over 1995-2008.

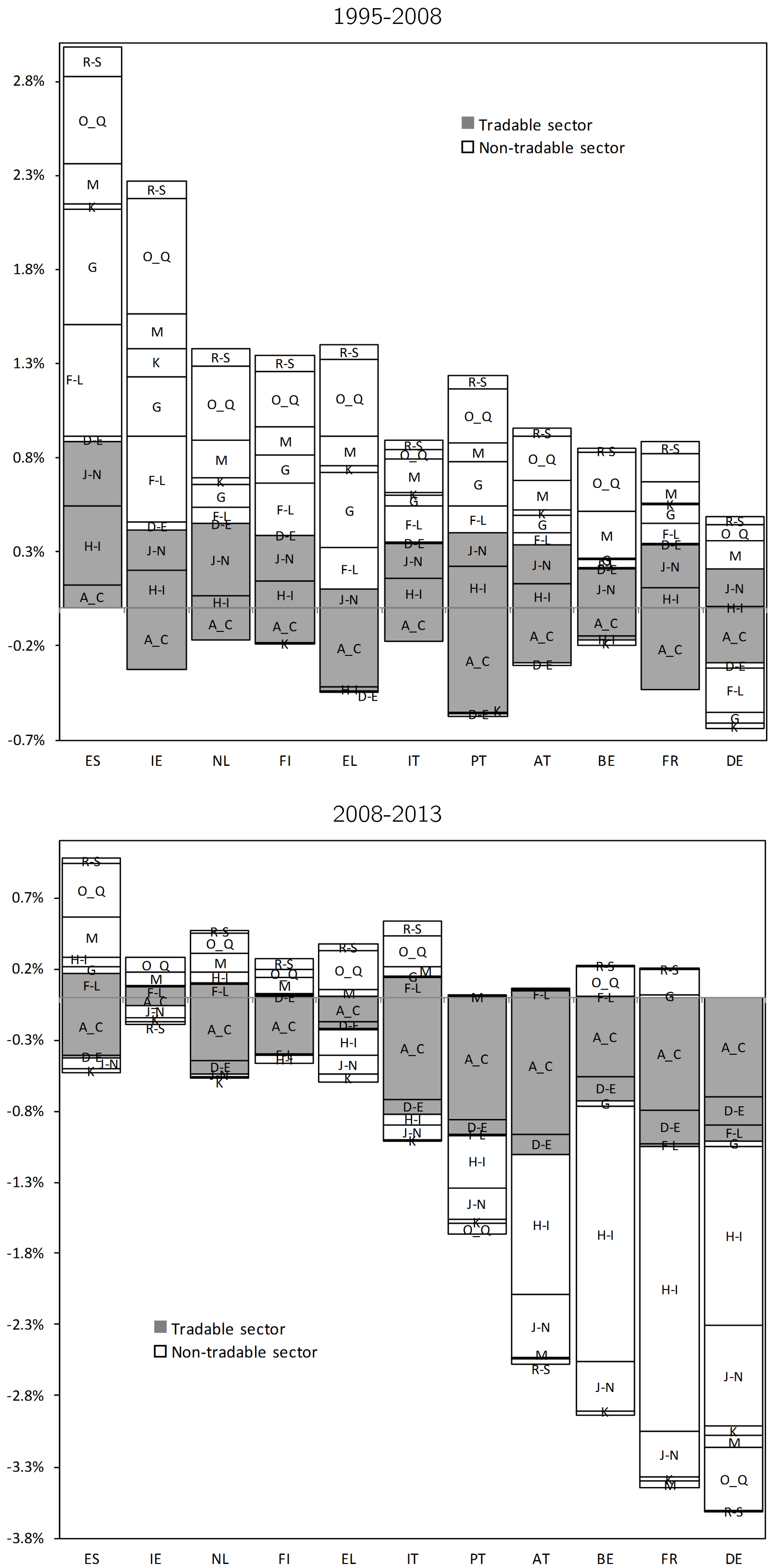
Figure 4 – GVA deflators: contributions of each sector to average growth over 1995-2008 and 2008-2013, by country



Source: author's calculations using Eurostat, BACI, UN ServiceTrade. Note: chained-linked indices, reference year: 1995. For the measurement of the tradability of each sector, the 10% threshold is used.

A_C: tradable industry; H-I: transportation, accommodation & food service activities; J-N: other tradable service activities; D-E: non-tradable industry; F-L: construction & real estate; G: wholesale and retail trade; K: finance & insurance services; M: other non-tradable business services; O_Q: public administration, education, health and social work activities; R-S: other non-tradable services.

Figure 5 – Employment: contributions of each sector to average growth over 1995-2008 and 2008-2013, by country



Source: author's calculations using Eurostat, BACI, UN ServiceTrade. Note: thousands of hours worked. For the measurement of the tradability of each sector, the 10% threshold is used.
A_C: tradable industry; H-I: transportation, accommodation & food service activities; J-N: other tradable service activities; D-E: non-tradable industry; F-L: construction & real estate; G: wholesale and retail trade; K: finance & insurance services; M: other non-tradable business services; O_Q: public administration, education, health and social work activities; R-S: other non-tradable services.

The evolution of the relative price of non-tradables seems to be well correlated to current account deficits: countries facing the steepest increase in prices have the largest deficits over 1995-2008. Since capital inflows did not serve to expand the tradable sector, however, when facing sudden stops, countries were forced to readjust and reallocate their factors of production to the tradable sector in order to produce the tradable surplus necessary to reimburse foreign liabilities previously accumulated. As we see in Figure 3, relative prices decreased in the peripheral countries relatively more than in the rest of the EA11 over 2008-2013. These adjustments happened at a high social cost. In Spain and Greece, in particular, the readjustment resulted in a steep increase in unemployment. Wages fell by 16% in Greece, 5% in Ireland, remained stable in Portugal and slowed down in Spain between 2008 and 2013.

4. Determinants of the relative price of non-tradables

This section presents empirical evidence supporting the theoretical result that the real interest rate, together with the traditional BS effect, impact the evolution of non-tradable prices. To do so, it uses the data gathered on the evolution of non-tradable relative prices, apparent labor productivity in the tradable sector and real interest rates.[13] All variables are expressed in deviations from the EA11 average. The choice of a reference here is neutral since all estimations are performed in logarithms.

The sample ranges from 1995 to 2013 and covers $N = 11$ EA countries, which amounts to $T = 19$ observations per country. In terms of size, the sample is close to previous studies of the BS effect, for instance De Gregorio et al. (1994) use data for 14 OECD countries over 1970-1985 (16 observations per country), or Bénassy-Quéré and Coulibaly (2014) use a dataset including 12 European countries over 1985-2006 (21 observations per country).

Figure 6 displays non-tradable prices, real interest rates and apparent labor productivity in the tradable sector, over 1995-2013, in core and periphery countries (weighted averages; the figures for each countries are presented in Appendix). The figures highlight both the BS effect and the real interest rate effects analyzed earlier: in the periphery for example, real interest rates declined by about 1.0% over 1995-2008 compared to the EA average, while non-tradable relative prices increase by 12.2% and productivity in the tradable sector increased (25.0%) compared to the EA average. In core countries, real interest rates increased by 0.3% over 1995-2008 relatively to the EA average, while non-tradable prices and tradable productivity decreased by 17.6% and 13.3% respectively, relatively to the EA average (numbers are also given in Table 5).

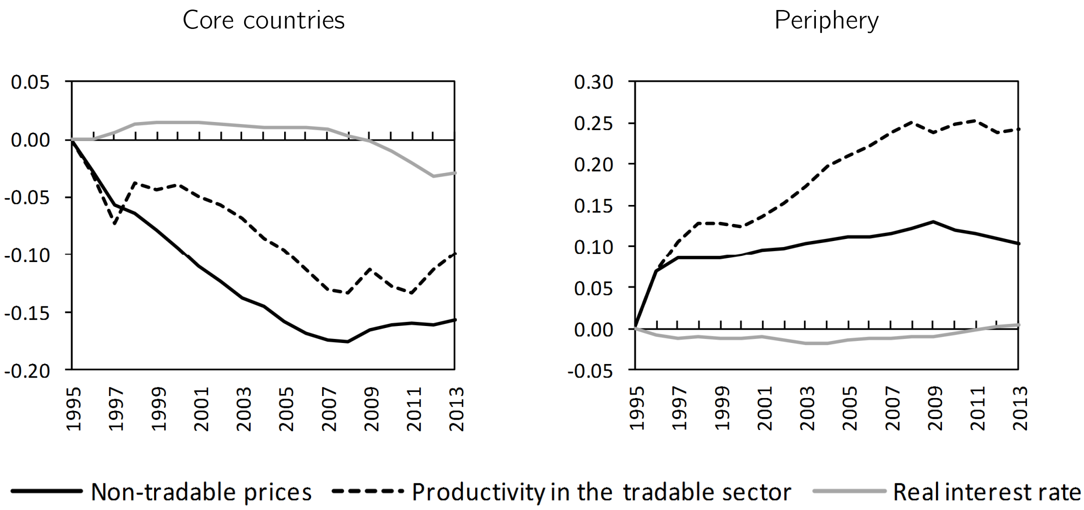
To deal with data limitations, panel techniques are used to estimate equation (6). With nonstationary series, equation (6) needs to be a cointegration relationship, as is usually the case in the BS framework. Therefore, before estimating equation (6), panel unit root tests and tests for the existence of a cointegration relationship are performed.[14] The presence of structural breaks will be tested, as the sample covers both the adoption of the common currency and the 2010 euro crisis.

For robustness, all tests and estimations are performed using the 5% and 15% thresholds value for the measure of tradability. Estimates will also be provided for a sample excluding the real estate

[13] A 2-year moving average (average of the value in t and $t-1$) for the interest rate is used to capture the inertia of capital adjustment and its consecutive effect on the relative price.

[14] The tests are performed with GAUSS, using the codes provided by J. Westerlund, J.L. Carrion-i-Silvestre and N.C. Mark & D. Sul.

Figure 6 – Non-tradable prices, productivity in the tradable sector and long-term real interest rate in core and periphery countries
1995-2013, log deviations from the EA11 average



Source: author's calculations using Eurostat, BACI and UN ServiceTrade and Ameco.
Note: non-tradable prices and productivity in the tradable sector are measured using the 10% threshold for tradability. The real interest rate is a 2-year moving average. Variables for each group are weighted averages (weight: gross value added at current prices).

and construction sectors, to check if results do not reflecting only the specificity of the housing sector. To be sure that demand factors play a limited role in the long-run, we also control for demand effects. Finally, estimates are provided for a sample covering the shorter period 1995-2009 to see if results are relevant when not taking into account the 2010 euro crisis.

4.1. Panel unit root and cointegration tests

The presence of unit roots in the series is studied using the third generation panel unit root test of Bai and Carrion-i-Silvestre (2009), allowing for heterogeneous panels with cross-section dependence and multiple structural breaks. The case for cross-section dependence is especially relevant here since real interest rate divergence resulted from nominal interest rate convergence in the euro area around the euro's inception. This test allows also the presence of multiple structural breaks, which number and dates are unknown and heterogeneous across countries. These shifts can affect both the level and the slope of each time series. Allowing for structural breaks is important in the analysis since the sample covers both the adoption of the common currency and the 2010 euro crisis.

This test has a null hypothesis of a unit root. More precisely, after identifying and taking into account the number and locations of structural breaks for each series (identified using the sequential procedure in Bai and Perron, 1998) and the common factors (estimated using the BIC criterion), this test pools modified Sargan-Bhargava (MSB) tests for individuals series. Three different pooling methods are used resulting in three different test statistics: Z, a standardization of individual statistics, and P and P_m combining their *p-values*. When shifts in trends are present, a simplified MSB test is also performed on individual series, adding three other pooled statistics : Z^*, P^* and

P_m^*. Monte Carlo simulations confirm the good performance of the tests in finite samples (see Bai and Carrion-i-Silvestre, 2009).

Up to two structural breaks are found for each country time series, and one on average for each of the 3 variables (relative price, productivity in the tradable sector and real interest rate).[15] Results are presented in Table 1. It can be concluded that at conventional levels of significance, all series are non-stationary.

Cointegration tests are then performed. We use the third generation test proposed by Westerlund and Edgerton (2008), which allows for heterogeneous specifications in both the long and short run parts of the error correction model, based on the data. It also takes into account cross-section dependence and unknown structural breaks in both the mean and slope of the cointegrated regression. The authors suggest two simple tests for the null hypothesis of no cointegration derived from the Lagrange multiplier (LM) based unit root tests: the coefficient version (ϕ_N) and the t-test version (τ_N). Three different options are presented: the case with no break, the case with a shift in level only, and the case with a shift in level and trend. The tests generally perform well even in small samples.

Table 2 give the results of the tests: the two statistics reject the null hypothesis of no cointegration at the 10% level of significance in every case, aside from the τ_N statistic in the model with no shift.

4.2. Estimation of the long-run relationship

The long-run relationship is estimated using panel Dynamic OLS (DOLS) techniques. Two main approaches have been proposed in the literature that both deal with serial correlation and the endogeneity of the regressors: the fulled modified ordinary least squares (FMOLS) and the dynamic ordinary least squares (DOLS). The DOLS procedure consists in estimating a long-run relationship by instrumental variables using leads and lags of the differenced endogenous variables as instruments. Kao and Chiang (2001) show that DOLS outperform both OLS and FMOLS estimators in estimating cointegrated panel regressions. We use the extension to the DOLS framework suggested by Mark and Sul (2003), which allows for individual heterogeneity through different short-run dynamics, individual-specific fixed effects and individual-specific time trends.

The empirical model corresponding to equation (6) is:

$$ln(\frac{p_{N,i,t}}{p_{N,EA,t}}) = \eta_i + \gamma_i t + \mu_t + \beta_1 ln(\frac{A_{T,i,t}}{A_{T,EA,t}}) + \beta_2 ln(\frac{1 + r_{i,t}}{1 + r_{EA,t}}) + \varepsilon_{i,t} \quad (7)$$

where η_i and $\gamma_i t$ are country-specific fixed effects and trends, μ_t is a common-time effect, and $\varepsilon_{i,t}$ is the idiosyncratic error.

Table 3 report the estimation for the single BS effect (columns 1 and 3), and of the BS and real interest rate effects (columns 2 and 4). For robustness, a first estimation is implemented with country-specific fixed effects and trends (columns 1 and 2), while the second also includes a common-time effect (columns 3 and 4).

[15] The break is most recurrent in 2010 for the relative price, 1998 for the productivity in the tradable sector and 2007 for the real interest rate.

Table 1 – Third generation panel unit root tests

	$ln(\frac{p_N}{p_{N,EA}})$	$ln(\frac{A_T}{A_{T,EA}})$	$ln(\frac{1+r}{1+r_{EA}})$
Constant and trend (no break)			
Z	-1.370	-0.689	-0.367
P_m	0.247	0.749	-1.163
P	23.640	26.967	14.286
Trend shifts			
Z	0.758	0.157	0.058
P_m	-0.818	-0.002	-1.460
P	16.572	21.99	12.313
$Z*$	2.152	0.996	0.051
P_m*	-1.429	-0.028	-0.985
$P*$	12.522	21.815	15.465

Note: the test has a null hypothesis of a unit root. Country-specific intercepts and trends are included (model 2). See Bai and Carrion-i-Silvestre (2009) for a description of the tests. The 1%, 5% and 10% critical values for the absolute value of the standard normal distributed Z and P_m statistics are 2.326, 1.645 and 1.282, while the critical values for the chi-squared distributed P statistic are 40.289, 33.924 and 30.813, respectively. The number of common factors are estimated using the panel Bayesian information criterion proposed by Bai and Ng (2002), and the test was estimated with a maximum number of breaks of 3.
Source: author's calculations.

Table 2 – Third generation panel cointegration test of Westerlund and Edgerton (2008)

	τ_N		ϕ_N	
	value	*p-value*	value	*p-value*
No shift	-1.373	0.085	-0.673	0.250
Level shift	-4.137	0.000	-2.422	0.008
Regime shift	-6.99	0.000	-4.358	0.000

Note: the test has the null hypothesis of no-cointegration. The breaks are determined by grid search at the minimum of the sum of squared residuals. The *p-values* are for one-sided test based on the normal distribution.
Source: author's calculations.

Table 3 – Panel cointegration estimates of the Balassa-Samuelson and real interest rate effects

Dependent variable : $ln(\frac{p_N}{p_{N,EA}})$, 1995-2013

	No common time effect (μ_t)		Common time effect (μ_t)	
	(1)	(2)	(3)	(4)
$ln(\frac{A_T}{A_{T,EA}})$	0.611***	0.360***	0.659***	0.410***
	(0.126)	(0.130)	(0.132)	(0.135)
$ln(\frac{1+r}{1+r_{EA}})$		-1.287***		-1.186***
		(0.360)		(0.376)

Note: standard errors, in parentheses, are based on Andrews and Monathan (1992) pre-whitening method. *, ** and *** denote significance at 10%, 5% and 1% levels respectively.
Source: author's calculations.

It appears that both explanatory variables (tradable productivity and real interest rate, in deviations from the EA average) are significant at the 1% level and have the expected sign. A +1% differential in the tradable sector productivity raises the non-tradable price by 0.36% to 0.66% relative to the EA average. Introducing the real interest rate tends to depress the coefficient of the BS effect using the samples covering the 1995-2013 period.

A +1% differential in the real interest rate reduces the non-tradable price by 1.19% to 1.29% relative to the EA average. It thus seems that diverging evolution in the interest rate impacted greatly the evolution of non-tradable relative prices within the euro area over the period.

4.3. Robustness tests

Different thresholds for the measure of tradability For robustness, all tests and estimations are now performed using the 5% and 15% thresholds value for the measure of tradability. We first test for the presence of unit roots in the series using the third generation panel unit root test of Bai and Carrion-i-Silvestre (2009). Structural breaks are found again for every variable. There are up to two structural breaks for each time series, and one on average. Results for the tests are presented in Appendix (Table A.2). It can be concluded that at conventional levels of significance, all series are non-stationary.[16]

Cointegration tests are then performed for series that are non-stationary using test proposed by Westerlund and Edgerton (2008). Three different options are presented: the case with no break, the case with a shift in level only, and the case with a shift in level and trend. Table A.3 in the Appendix gives the results of the tests: the two statistics reject the null hypothesis of no cointegration at the 10% level of significance in every case, expect the τ_N statistic in the model with a regime shift for the 5% threshold, and with no shift for the 15% threshold.

As all three series, measured using different thresholds (5% and 15%), are non-stationary and cointegrated, panel DOLS estimations of equation are performed to estimate equation (6). Table 4a reports the estimation for the single BS effect (columns 1 and 3), and of the BS and real interest

[16]Only the Z statistic for the tests driven for non-tradable prices present mixed results.

rate effects (columns 2 and 4). For robustness, a first estimation is implemented with country-specific fixed effects and trends (columns 1 and 2), while the second also includes a common-time effect (columns 3 and 4). It appears that both explanatory variables (tradable productivity and real interest rate, in deviations from the EA average) are significant at the 1% level and have the expected sign using the two samples with different thresholds for the measure of tradability (5% and 15%).

Excluding the housing sector All tests and estimations are also performed excluding the housing sector (Nace codes C and L) from the dataset. In this case also it can be concluded that at conventional levels of significance, all series are non-stationary and cointegrated (see Table A.3 in Appendix).[17] Panel DOLS estimates are very close to the case where the housing sector is included (Table 4b).

Controlling for demand effects Demand booms and busts could have lasting effects on relative prices. To control for these effects, we include real domestic consumption (in deviations from the EA average, measured using data from Ameco) in the previous tests and estimations. At conventional levels of significance, real domestic consumption is non-stationary. However, when including it in the cointegration analysis, the four series are no longer cointegrated (see Table A.3 in Appendix)[18]. Panel DOLS estimates confirm the fact that demand factors do not play a significant role in the long-run: when including real domestic demand in the equation, this variable is not significant. Tradable productivity and real interest rate are still significant at the 1% level and have the expected sign, their coefficients are slightly reduced (see Table 4c). Demand effects should thus play mainly in the short-run dynamics of relative prices.

Excluding the Euro crisis Estimates are also provided for a sample covering the shorter period 1995-2009 to see if results are relevant when not taking into account the 2010 euro crisis (see Table 4d).

In this sample covering a shorter time period, tradable productivity is not significant when introduced alone. We can see that the impact of a +1% differential in the tradable sector productivity raises the non-tradable price by 0.26% to 0.72% relative to the EA average. Introducing the real interest rate tends to depress the coefficient of the BS effect using the samples covering the 1995-2013 period, but increase the coefficient using the sample covering the 1995-2009 period. A +1% real interest rate differential reduces the non-tradable price by 0.99% to 1.52% relative to the EA average.

Overall, the impact of a +1% differential in the real interest rate reduces the non-tradable price by 0.86% to 1.52% relative to the EA. It thus seems that diverging evolution in the interest rate impacted greatly the evolution of non-tradable relative prices within the euro area over the period. In periphery countries, over 1995-2008, changes in the interest rate could explain up to 13% of the changes in relative prices. In Greece, the fall in the real interest rate over 1995-2008 could

[17]When taking into account the existence of a trend shift, results are weaker when testing the non-stationarity of non-tradable prices.

[18]Real consumption, tradable productivity, and relative prices are not cointegrated either when excluding the real interest rate. Results are not reported for this case.

Table 4 – Panel cointegration estimates: robustness tests

Dependent variable : $ln(\frac{p_N}{p_{N,EA}})$

(a) using different measures of tradability

	No common time effect (μ_t) (1)	(2)	Common time effect (μ_t) (3)	(4)
5% threshold				
$ln(\frac{A_T}{A_{T,EA}})$	0.650***	0.404***	0.722***	0.458***
	(0.125)	(0.106)	(0.137)	(0.113)
$ln(\frac{1+r}{1+r_{EA}})$		-1.181***		-0.994***
		(0.353)		(0.360)
15% threshold				
$ln(\frac{A_T}{A_{T,EA}})$	0.550***	0.406***	0.605***	0.461***
	(0.179)	(0.130)	(0.195)	(0.138)
$ln(\frac{1+r}{1+r_{EA}})$		-1.260***		-1.135***
		(0.357)		(0.373)

(b) excluding the housing sector

	No common time effect (μ_t) (1)	(2)	Common time effect (μ_t) (3)	(4)
$ln(\frac{A_T}{A_{T,EA}})$	0.717***	0.511***	0.769***	0.569***
	(0.156)	(0.185)	(0.169)	(0.191)
$ln(\frac{1+r}{1+r_{EA}})$		-1.192***		-1.093**
		(0.495)		(0.517)

(c) controlling for demand

	No common time effect (μ_t) (1)	(2)	(3)	Common time effect (μ_t) (4)	(5)	(6)
$ln(\frac{A_T}{A_{T,EA}})$	0.611***	0.360***	0.340***	0.659***	0.410***	0.347***
	(0.126)	(0.130)	(0.034)	(0.132)	(0.135)	(0.036)
$ln(\frac{1+r}{1+r_{EA}})$		-1.287***	-0.945***		-1.186***	-0.863***
		(0.360)	(0.123)		(0.376)	(0.128)
$ln(\frac{C}{C_{EA}})$			0.060			0.073
			(0.058)			(0.057)

(d) using a shorter period: 1995-2009

	No common time effect (μ_t) (1)	(2)	Common time effect (μ_t) (3)	(4)
$ln(\frac{A_T}{A_{T,EA}})$	0.127	0.259***	0.147	0.284***
	(0.162)	(0.054)	(0.189)	(0.054)
$ln(\frac{1+r}{1+r_{EA}})$		-1.521***		-1.494***
		(0.282)		(0.271)

Note: standard errors, in parentheses, are based on Andrews and Monathan (1992) pre-whitening method. *, ** and *** denote significance at 10%, 5% and 1% levels respectively.
Source: author's calculations.

explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA (Table 5).

Table 5 – Contributions of the Balassa Samuelson (BS) and the real interest rate effects to the non-tradable price growth
1995-2008, deviations from the EA average

	Growth			Contributions to non-tradable price growth	
	Non-tradable prices	Productivity in the tradable sector	Real interest rates	BS effect	Real interest rate effect
AT	-20.2%	-15.3%	0.4%	-4.0%	-0.6%
BE	-12.4%	-7.3%	-0.4%	-1.9%	0.6%
DE	-30.9%	-21.9%	1.4%	-5.7%	-2.1%
EL	7.6%	9.3%	-2.3%	2.4%	3.5%
ES	7.6%	31.5%	-1.0%	8.1%	1.5%
FI	-0.4%	-21.0%	0.3%	-5.4%	-0.5%
FR	-6.0%	-4.7%	-1.1%	-1.2%	1.7%
IE	31.7%	-23.6%	3.4%	-6.1%	-5.2%
IT	14.1%	27.4%	-1.4%	7.1%	2.1%
NL	-7.3%	0.9%	0.6%	0.2%	-0.9%
PT	9.2%	22.0%	0.0%	5.7%	0.0%
Core*	-17.6%	-13.3%	0.3%	-3.4%	-0.5%
Periphery*	12.2%	25.0%	-1.0%	6.5%	1.6%

*weighted averages, weight: gross value added at current prices.
Source: author's calculations.
Note: contributions are measured using the coefficients resulting from panel DOLS estimates with no common time effect on the sample covering the 1995-2009 periods and using the 10% threshold for the measure of tradability, see Table 4d, 3rd estimate, column (2). For example, in Greece (EL), the real interest rate contribution to the non-tradable price increase is: (-2.3)*(-1.521) = 3.5%. Therefore, the real interest rate fall in Greece could explain 3.5/7.6 = 46% of the non-tradable price increase over 1995-2008 relative to the EA11.

5. Concluding Remarks

This paper has analyzed how the real interest rate influences the dynamics of non-tradable relative prices. The theoretical framework, incorporating two factors of production in the traditional Balassa-Samuelson model, shows that the real interest rate fall in the euro area periphery following the single currency's inception induced an increase in the relative price of non-tradable goods. The paper then documents the dynamics of the tradable to the non-tradable sector over 1995-2013 using a new dataset and carries out an econometric estimation for 11 EA countries to quantify the contribution of the pure Balassa-Samuelson effect and the impact of the interest rate on non-tradable relative prices.

The results confirm that, together with the traditional BS effect, diverging evolutions in real interest rates seem to have contributed to the evolution of non-tradable relative prices within the euro area over the period. In Greece, the fall in the real interest rate over 1995-2008 could explain almost half of the non-tradable price increase relative to the EA average, while in Germany the increase in the real interest rate might have contributed up to 7% of the decrease of the non-tradable price relative to the average of the EA.

This result is especially important in the context of the debate on the relative price adjustment and the subsequent surveillance within Europe. Divergence across euro area members challenges greatly the efficiency of a single monetary policy. This divergence was translated, before the crisis, in strong inflation differentials as we have seen. While the introduction of the euro should have fostered a real convergence as capital flew towards so-called "catching-up" economies, these capital flows were indeed mainly allocated in the less innovative non-tradable sectors and fueled strong price increases. Since the 2008 financial crisis, in the EA periphery, increased interest rates may have contributed to internal rebalancing but labor reallocation happens at a high social cost as the non-tradable sector is more labor-intensive than the tradable sector. The divergence thus now takes the form of strong heterogeneities in how economies reacted to the financial crisis, and through high differentials in unemployment rates across countries.

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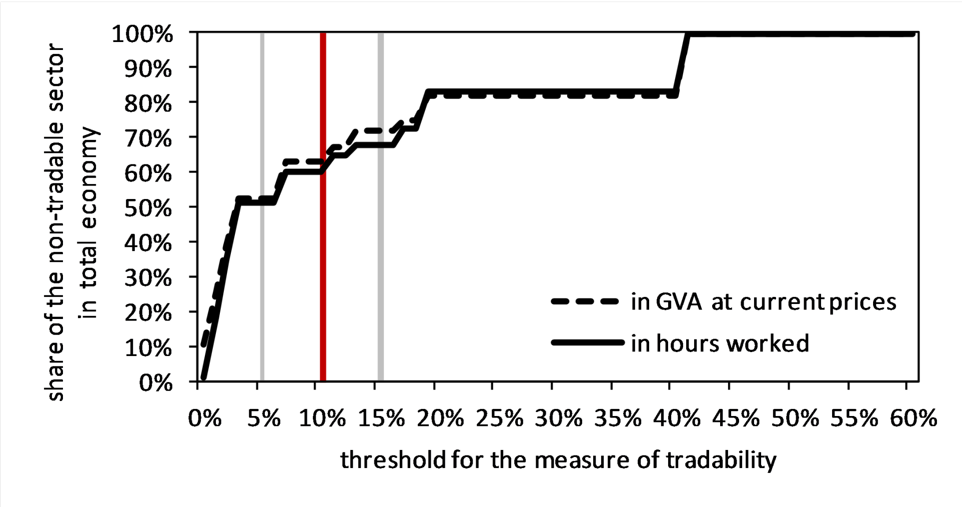
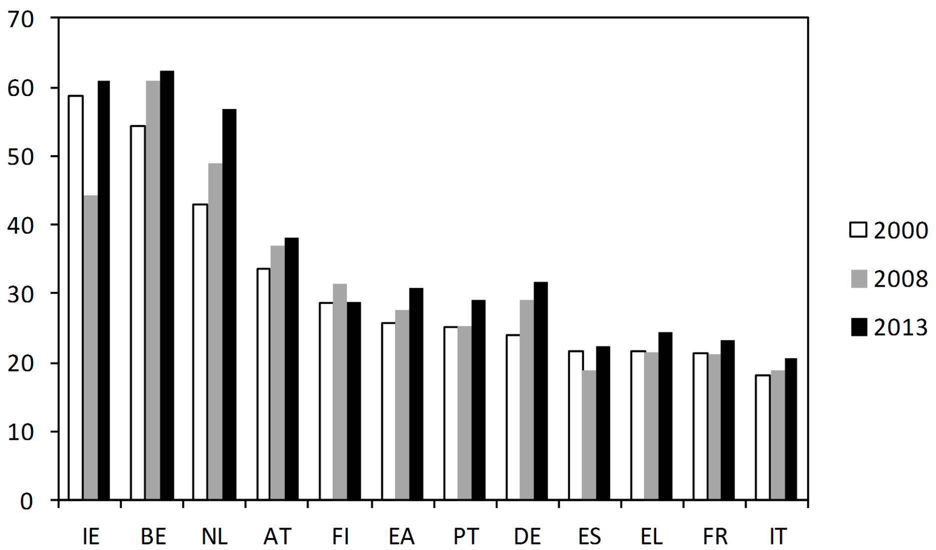
Appendix

Figure A.1 – Share of the non-tradable sector by threshold for the measure of tradability
EA11, average over 2000-2013



Source: author's calculations using Eurostat, BACI and UN ServiceTrade.
Note: the openness ratio is the ratio of total trade (imports+exports) to total production. The red line indicates the 10% threshold used here, the grey lines indicate the 5% and 15% thresholds used for the robustness tests.

Figure A.2 – Openness ratio by country
2000, 2008 and 2013, in %



Source: author's calculations using Eurostat, BACI and UN ServiceTrade.
Note: the openness ratio is the ratio of total trade (imports+exports) to total production.

Table A.1 – Openness ratio by sector, EA11
2000 and 2000-2013 average in %, 2013/2000 growth in p.p.

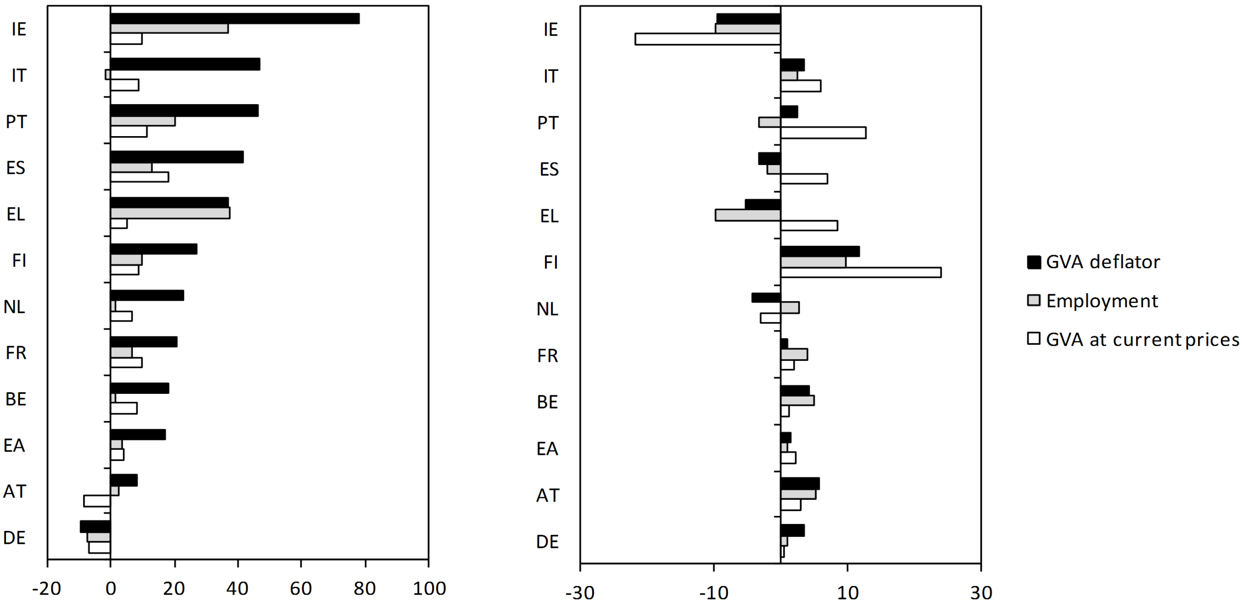
Sector		2000 (%)	growth (%) 2013-2000	average (p.p.) 2000-2013
B	Mining and quarrying	184.1	179.0	249.4
C	Manufacturing	44.0	10.1	48.4
I	Accommodation and food service activities	9.4	17.4	23.7
H	Transportation and storage	26.1	-4.1	22.8
A	Agriculture, forestry and fishing	19.0	8.2	22.8
J	Information and communication	12.5	10.3	15.8
N	Administrative and support service activities	11.0	6.3	13.7
M	Professional, scientific and technical activities	9.0	3.7	9.0
K	Financial and insurance activities	6.8	2.2	7.8
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	3.0	0.4	3.1
D	Electricity, gas, steam and air conditioning supply	1.5	1.9	3.0
F	Construction	1.9	0.0	1.7
R	Arts, entertainment and recreation	2.1	-0.5	1.5
O	Public administration and defence; compulsory social security	1.9	-0.8	1.4
S	Other service activities	0.5	1.1	0.9
P	Education	0.3	0.5	0.7
E	Water supply; sewerage, waste management and remediation activities	0.0	0.2	0.2
Q	Human health and social work activities	0.0	0.1	0.2
L	Real estate activities	0.0	0.0	0.0
TOTAL		33.1	6.3	34.8

Source: author's calculations using Eurostat, BACI and UN ServiceTrade.
Note: the red lines indicate the 15%, 10% and 5% thresholds. The openness ratio is the ratio of total trade (imports+exports) to total production.

Figure A.3 – Evolution of the non-tradable relative to the tradable sector

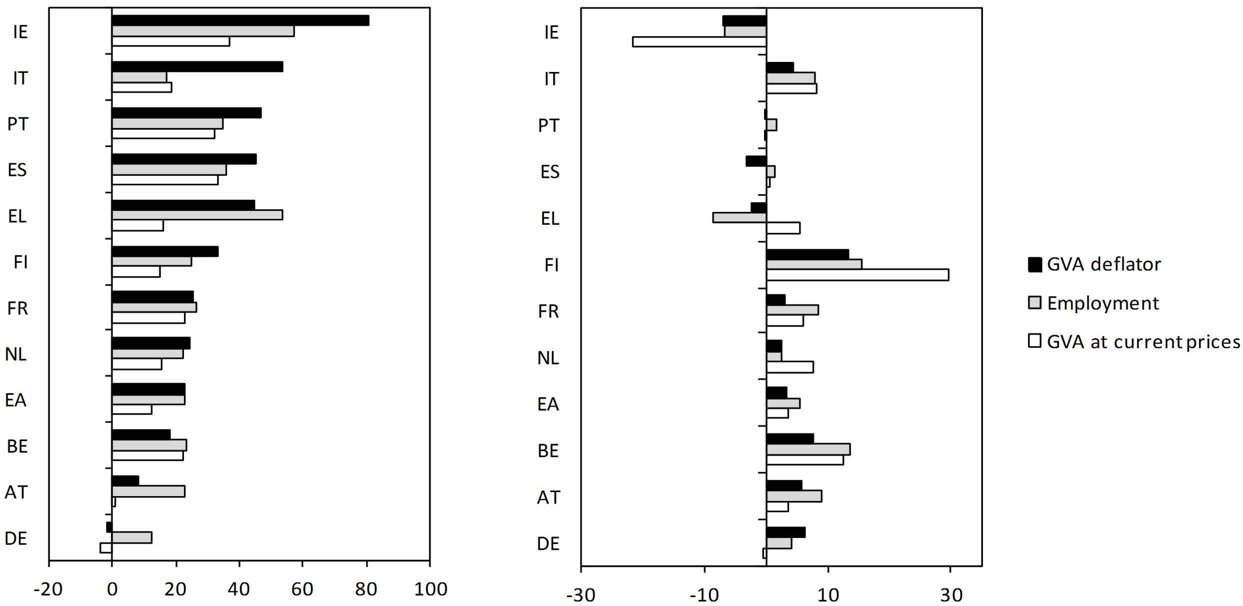
5% threshold for the measurement of tradability.

(a) 2008/1995 **(b)** 2013/2008



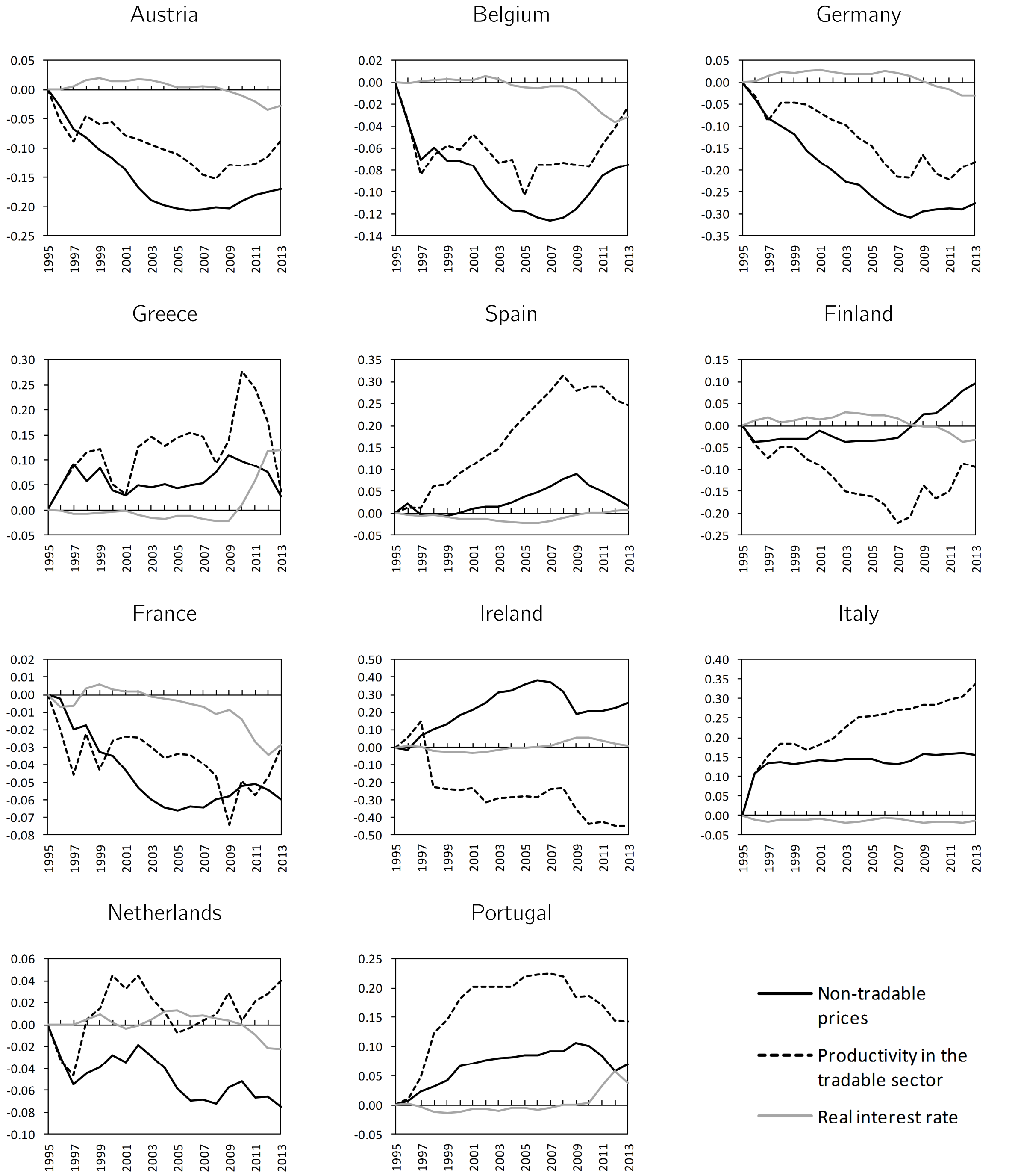
15% threshold for the measurement of tradability.

(c) 2008/1995 **(d)** 2013/2008



Source: author's calculations using Eurostat, BACI and UN ServiceTrade.
Note: relative prices are the ratio of non-tradable prices relative to the tradable price of the EA11. Employment is measured in thousands of hours worked.

Figure A.4 – Non-tradable prices, productivity in the tradable sector and long-term real interest rate
1995-2013, log deviations from the EA11 average



Source: author's calculations using Eurostat, BACI and UN ServiceTrade and Ameco.
Note: non-tradable prices and productivity in the tradable sector are measured using the 10% threshold for tradability. The real interest rate is a 2-year moving average.

Table A.2 – Third generation panel unit root tests

	5% threshold		15% threshold		10% threshold excl. the housing sector		10% threshold
	$ln(\frac{p_N}{p_{N,EA}})$	$ln(\frac{A_T}{A_{T,EA}})$	$ln(\frac{p_N}{p_{N,EA}})$	$ln(\frac{A_T}{A_{T,EA}})$	$ln(\frac{p_N}{p_{N,EA}})$	$ln(\frac{A_T}{A_{T,EA}})$	$ln(\frac{C}{C_{EA}})$
Constant and trend (no break)							
Z	-1.463	-0.008	-1.191	-1.177	-0.951	-0.689	-1.499
P_m	2.154	-0.867	-0.112	0.951	-0.205	0.749	0.827
P	36.285	16.251	21.257	28.310	20.643	26.967	27.484
Trend shifts							
Z	*3.094**	1.349	0.587	0.458	*7.817**	0.157	0.825
P_m	-1.564	-2.016	-0.075	-0.985	*-2.542**	-0.002	-0.911
P	11.628	8.63	21.504	15.465	5.135	21.989	15.959
$Z*$	*9.523**	1.986	*4.424**	*24.443**	24.444	0.996	0.995
P_m*	-1.758	-1.817	-0.538	-1.478	*-2.968**	-0.028	-1.322
$P*$	10.336	9.951	18.432	12.596	2.309	21.845	13.231

* the test statistics reject the null hypothesis of a unit root.
Note: Country-specific intercepts and trends are included (model 2). See Bai and Carrion-i-Silvestre (2009) for a description of the tests. The 1%, 5% and 10% critical values for the absolute value of the standard normal distributed Z and P_m statistics are 2.326, 1.645 and 1.282, while the critical values for the chi-squared distributed P statistic are 40.289, 33.924 and 30.813, respectively. The number of common factors are estimated using the panel Bayesian information criterion proposed by Bai and Ng (2002), and the test was estimated with a maximum number of breaks of 3.
Source: author's calculations.

Table A.3 – Third generation panel cointegration test of Westerlund and Edgerton (2008)

	τ_N		ϕ_N	
	value	*p-value*	value	*p-value*
5% threshold				
No shift	-2.006	0.022	-2.008	0.022
Level shift	-4.46	0.000	-4.673	0.000
Regime shift	-2.156	0.016	-0.093	0.463
10% threshold, 1995-2009				
No shift	-1.295	0.098	-0.670	0.252
Level shift	-3.045	0.001	-2.318	0.010
Regime shift	-5.227	0.000	-2.603	0.000
10% threshold, excl. the housing sector				
No shift	-1.952	0.025	-1.186	0.118
Level shift	-2.190	0.014	-1.366	0.086
Regime shift	3.251	0.001	-1.612	0.054
10% threshold, incl. real consumption				
No shift	-1.956	0.025	0.374	0.646
Level shift	-1.515	0.065	0.072	0.529
Regime shift	0.710	0.761	0.518	0.698

Note: the test has the null hypothesis of no-cointegration. The breaks are determined by grid search at the minimum of the sum of squared residuals. The *p-values* are for one-sided test based on the normal distribution.
Source: author's calculations.

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Stabilisation and rebalancing with fiscal or monetary devaluation: a model-based comparison

Lukas Vogel

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Stabilisation and rebalancing with fiscal or monetary devaluation

A model-based comparison

Lukas Vogel

Abstract

The paper uses a small open economy general-equilibrium model to compare fiscal and nominal exchange rate devaluation with respect to their impact on economic activity and the current account. In particular, it investigates the extent to which fiscal devaluation mimics nominal exchange rate adjustment and mitigates the output loss associated with demand rebalancing and external adjustment. The results suggest that internal or external devaluation can support external adjustment and mitigate its impact on economic activity, without leading to lasting adjustment themselves. However, the quantitative contribution of a tax shift from labour to consumption, the standard example of fiscal devaluation, remains moderate.

JEL Classification: E52, F41, F47.
Keywords: devaluation, exchange rate, tax shift, recession, rebalancing.

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1. INTRODUCTION

The experience of the euro area (EA) illustrates that price dynamics and real exchange rates can diverge greatly between countries that share a nominal exchange rate (EXR) or even a common currency. Much of the external adjustment (trade balance improvement) in countries at the EA periphery in recent years occurred through import contraction rather than export growth, i.e. it has been driven by week domestic demand rather than competitiveness gains (Kang and Shambaugh 2014, Tressel and Wang 2014, Tressel et al. 2014).

Against this background, the concept of internal (fiscal) devaluation has gained particular attention in the rebalancing debate, which refers to real EXR adjustment under fixed nominal EXRs. The idea of fiscal devaluation is that fiscal tools can be used to support and accelerate real EXR adjustment, improve price competitiveness, reduce external imbalances and support domestic economic activity in the absence of flexible nominal EXRs and monetary policy independence.

As long as wages and prices are somewhat flexible on the downside, wage and price adjustment should eventually produce internal devaluation also in the absence of supportive policies. In particular, downward pressure on wages and prices should increase price competitiveness and strengthen net trade in an economy characterised by contracting demand. Sluggish price and wage adjustment can imply substantial economic costs in terms of declining economic activity and employment in the transition period, however. In the presence of downward nominal rigidity, real wage and price adjustment becomes particularly muted in an environment of globally low aggregate inflation. Therefore, the costs and limits of purely market-based adjustment have motivated the search for policies to support real devaluation.

This paper addresses the question of whether fiscal devaluation measures can support external rebalancing and mitigate the costs in terms of falling domestic economic activity by shifting adjustment from domestic demand contraction towards net export growth. The paper uses the European Commission's QUEST macroeconomic model (Ratto et al. 2009) to provide a quantitative general-equilibrium analysis of two sets of measures, i.e. (i) a government revenue shift from employer social security contributions (SSC) to the consumption tax (VAT), and (ii) an import tax-export subsidy combination. The tax shift from labour to consumption corresponds to the general use of "fiscal devaluation" in the current literature (e.g., Burgert and Roeger 2014, de Mooij and Keen 2013, Engler et al. 2014, Koske 2013, Puglisi 2014), whereas import taxes and export subsidies are conceptually close substitutes to nominal EXR adjustment as they directly affect the net price of exports and imports, as stressed by Keynes (1981).

The paper by Farhi et al. (2015) derives exact conditions for the equivalence of fiscal (in the form of a tax shift from labour to consumption or a combination of import tax and export subsidy) and monetary devaluation (nominal EXR re-pegging) in a simple New-Keynesian open economy model. The comparison becomes more complex in QUEST and other large-scale models that add, e.g., different household types, trade in intermediate inputs, and a broader set of adjustment frictions. This paper does not aim at extending the equivalence results to a more complex model environment, but considers fiscal measures of a simple form and compares numerical outcomes instead. The comparison focuses on the ability of fiscal devaluation to support rebalancing and stabilise economic activity in a demand-driven recession. The inclusion in the model of different types of households also allows for a discussion of distributional effects of the different policy measures.

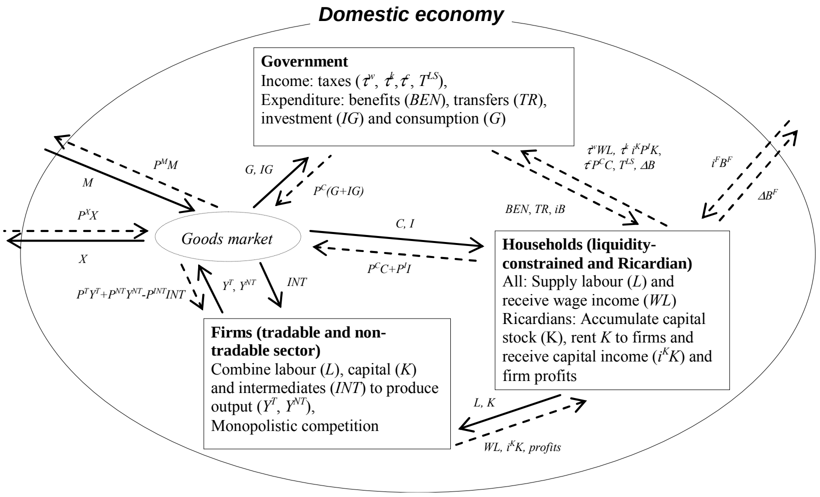
The optimal policy perspective in Langot et al. (2012) analyses the welfare implications of the tax shift from labour to consumption based on household utility and stresses the existence of a trade-off between lower labour market distortions and the decline of agents' purchasing power on the import side. The present paper with its perspective on rebalancing relates to situations in which domestic demand and external deficits are unsustainably high, so that falling import demand is part of the rebalancing rather than a negative side effect. Instead of utility-based welfare comparison, the policy measures are compared according to their impact on external accounts and domestic economic activity.

A further aspect of fiscal devaluation is the question of cross-border spillovers, i.e. whether fiscal devaluation benefits neighbouring countries by strengthening activity and import demand in the reforming economy, or whether it leads to a deterioration of price competitive-ness and activity elsewhere. Lipinska and von Thadden (2012) argue that there is little spillover from fiscal devaluation between countries in a monetary union. This paper excludes the question of spillover and the question of potential foreign "retaliation" on the basis of our small-economy assumption for the reforming country.

2. ANALYTICAL FRAMEWORK

The analysis uses a QUEST version for a small open economy with two production sectors (tradable and non-tradable goods) and international trade in final goods and intermediate inputs. Graph 1 summarises the main model blocks. A detailed model description is provided in the appendix.

Graph 1: Basic structure of QUEST with tradable and nontradable sectors



The household sector of the model includes two types of households, namely intertemporally optimising households (60% of the population) and liquidity-constrained ones (40%). Inter-temporally optimising households have access to financial markets to smooth consumption over time and invest in different assets, namely productive capital, government bonds, and foreign assets. Liquidity-constrained households simply consume their current disposable wage and transfer income in every period.

The production sector of the model features monopolistic competition in labour and goods markets. Labour unions set wages; monopolistically competitive firms set prices. The wages and prices adjust sluggishly to demand and supply shocks. Besides nominal price and wage stickiness, the model also includes real rigidities such as labour and capital adjustment costs and inertia in the response of trade to changes in relative prices, which gives rise to a J-curve effect in the trade balance. The model includes trade in final and intermediate goods. The inclusion of trade in intermediates accounts for the importance of global value chains in the production process and the significant import content of exports. The share of imported value added in gross exports has reached 20-30% in the large EU Member States in recent years and is substantially higher for smaller and more open economies (Ollivaud et al. 2015).

The government consumes, invests in public infrastructure, and pays benefits and transfers to households. Government spending on consumption and investment are kept constant in real terms. The government levies taxes on consumption, labour and corporate income, and issues debt to finance the expenditures. A budget-closure rule based on lump-sum taxes is in place to ensure the stability of government debt in the long term. The fiscal devaluation measures in the simulations are ex-ante (i.e. all else equal) budgetary neutral, but ex-post tax revenue may be affected through tax-base effects.

The nominal EXR of the domestic economy is fixed. The nominal short-term interest rate in the domestic economy equals the foreign rate plus an endogenous country-specific risk premium that depends on the net foreign asset (NFA) position of the domestic economy. Negative NFA positions, i.e. net foreign indebtedness, imply a positive risk premium.

Following the standard notion of fiscal devaluation, the simulations consider a reduction in labour and production costs by shifting government revenue collection from employer SSC to the VAT. As theoretical benchmark the subsequent section also depicts a hypothetical combination of an import tax and an export subsidy, i.e. a combination that directly changes the price of tradables and improves trade competitiveness.

The import tax-export subsidy combination seems closest to nominal EXR depreciation. The import tax increases the price of imported goods, while the export subsidy reduces the price of exports. Hence, both measures improve the price competitiveness of domestic tradable goods in domestic and foreign markets and imply expenditure switching towards goods produced in the domestic economy. The share of domestically produced goods in domestic demand increases (fewer imports); the share of domestic exports in foreign demand increases (more exports). With trade in intermediate goods, however, import taxes and export subsidies that apply to final goods and intermediates alike mitigate the competitiveness gain. Like nominal EXR depreciation, an import tax on intermediates also raises domestic production costs through higher prices of imported intermediaries, whereas export subsidies subsidise not only foreign final demand but also production abroad.

In addition to the immediate impact on relative prices, fiscal measures also have second round effects. In particular, import taxes create upward pressure on domestic prices via growing wage claims and production costs if labour supply is sensitive to the real purchasing power of wages. Such pass-through into domestic prices raises inflation expectations and reduces real interest rates in the adjustment process, which strengthens domestic and import demand.

The import tax-export subsidy combination is an interesting benchmark as its transmission is very similar to the transmission of EXR devaluation into prices and real variables. In practice, international trade rules preclude such scenario, whereas taxes on product categories that are predominantly imported or temporary support to export-oriented industries can replicate (only) some of the effects. As previously mentioned, the theoretical import tax-export subsidy scenario also excludes retaliation by trading partners that otherwise offsets competitiveness gains for the domestic economy.

The tax shift from labour to consumption as standard internal devaluation scenario replicates the effects of external devaluation in so far as it makes domestic consumption more and domestic production less expensive due to the reduction in domestic labour costs. Higher after-tax consumption prices and lower production costs now apply to all goods and services, how-ever, and not only to imported and exported ones.

Based on data for 2007, Boscá et al. (2013) show that EMU member states with a high levels of SSC used to tax consumption relatively lightly, which suggests space for a tax shift from labour to consumption. They also depict a negative correlation between a high tax burden on labour relative to consumption taxation and current account positions, suggesting that the tax mix affects net trade and the current account.

The following section will presents simulation results for the impact of fiscal devaluation on economic activity, relative prices and the external position and compares these results to the impact of nominal EXR adjustment. The measures are implemented on the baseline of an economy in recession characterised by a strong contraction in domestic private consumption and investment demand.

3. SIMULATION RESULTS

This section compares fiscal devaluation with nominal EXR adjustment for an economy in recession. More specifically, the economy is subject to negative shocks to domestic demand which lead to a domestic demand contraction by 10% on impact, i.e. a contraction of domestic demand in the order of magnitude experienced by several European economies in recent years. The fall in domestic demand is spread proportionally across private consumption and investment in the example.

The panels of the following figures show five different policy settings (summarised in Table 1): First, the domestic economy with fixed nominal EXR and without fiscal devaluation (FIX). Second, the domestic economy with fixed nominal EXR and a large ex-ante budgetary neutral (permanent) tax shift from labour to consumption that reduces the SSC rate by ten percentage points and increases the VAT rate by seven percentage points (SSC).[1] Third, the domestic economy with fixed nominal EXR with the theoretical case of a budgetary neutral (permanent) export subsidy of ten percent financed by import taxation of the same level (XSU).[2] Fourth, the domestic economy keeps a nominal peg, but the peg is adjusted (permanently) in the direction of ten percent depreciation of the domestic currency (REP); obviously re-pegging is possible only with a domestic currency, not within monetary union. Fifth, the same contractionary demand shocks in an otherwise identical economy with flexible nominal EXR (FXR) in which monetary policy follows the instrument rule $i_t = \rho i_{t-1} + (1-\rho)\alpha E_t \sum_{i=1}^{4} 0.25\pi_{t+i}^{C}$ with interest rates and CPI inflation defined in deviations from theirs long-term trends, and with $\rho=0.7$ and $\alpha=1.5$.[3]

Table 1: Different monetary and fiscal policy settings in the simulations

Label	Nominal exchange rate	Fiscal measures
FIX	Fix	-
SSC	Fix	10pp SSC reduction; 7pp VAT increase
XSU	Fix	10% export subsidy and import tax
REP	10% devaluation	-
FXR	Flexible	-

Graph 2 present the responses of main macroeconomic variables to the 10% domestic demand contraction under the five alternative policy settings summarised in Table 1. The scenario assumes that the economy enters recession with a balanced net foreign asset position; an alternative scenario in which the economy enters the recession with high levels of foreign indebtedness can be found further below.

The contraction of domestic demand pushes domestic wages and prices downwards. Given the exogenous nominal interest rate in the fixed EXR setting (FIX) the real interest rate increases on impact, which reinforces the decline in interest-sensitive domestic demand. The real effective EXR (REER) depreciates, which leads to an improvement in the trade balance (TB) and the current account (CA). The persistent CA improvement translates into a persistent improvement in the net foreign asset (NFA) position. Government debt rises due to a sharp deterioration in the primary budget balance (shrinking tax bases, higher expenditure on unemployment benefits) until the budget-closure rule offsets the negative tax base effect.

Comparing the different scenarios, the initial contraction of economic activity as measured by the drop in real GDP and employment is strongest in the setting with fixed EXR and unchanged fiscal policy (FIX) in which domestic demand contracts strongly due to the sharp increase in the real interest rate (4pp on impact) associated with gradual price adjustment. Export volumes improve moderately and gradually (peaking at 6% improvement after 5 years) due to the sluggish REER depreciation under the fixed nominal EXR. The FIX scenario displays sizable improvement in the CA position. However, this improvement is driven mainly by the contraction of domestic and import demand rather than by export growth.

Adjusting the EXR peg to devalue the domestic currency (REP) dampens the contraction of economic activity substantially compared to FIX. The 10% devaluation in Graph 2 almost offsets the decline in economic activity associated with the contraction of domestic demand. REP limits the trough in real GDP (employment) to -2% (-1%) compared to the -8% (-6%) contraction in FIX, i.e. it offsets ¾ of the initial contraction in economic activity. In particular, REP strengthens net exports, so that the improvement in net trade is driven predominantly by export growth. The EXR devaluation implies upward pressure on prices as imports become more expensive, which

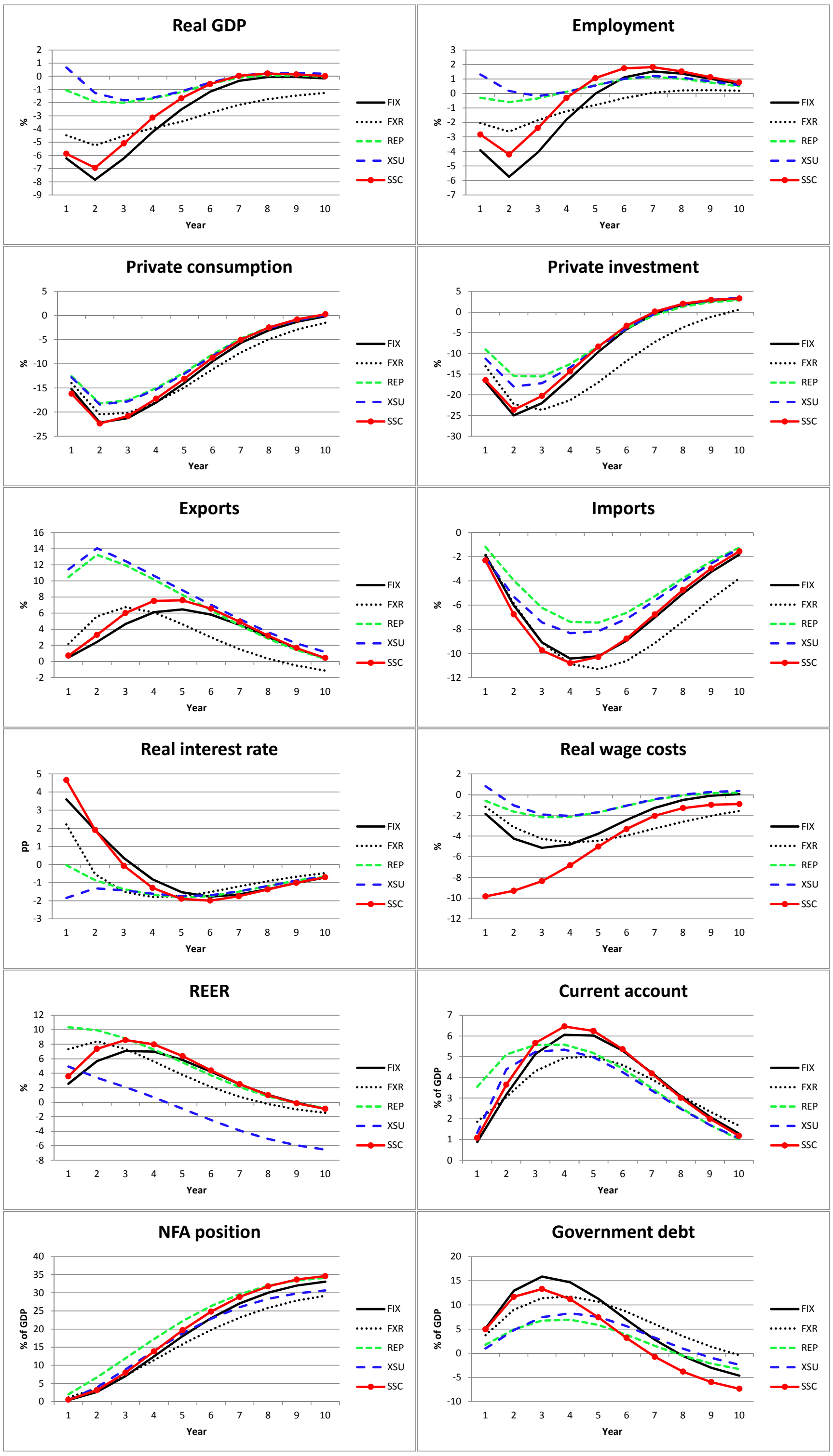
[1] The level of employer SSC in EU countries is within the range of 10-40 per cent of labour costs, but the tax shifts that have been implemented in selected EU Member States in recent years have been much smaller (Bernoth et al. 2014).

[2] Export subsidies imply a transfer of wealth to foreigners, leading to deterioration of the trade balance and the NFA position at given trade volumes. The import tax does not affect foreign prices and has no direct wealth effect under the small-country assumption. A demand shift towards domestic output in response to an import tax may raise domestic wages and prices, however, and increase export prices unless compensated by export subsidies. The latter would imply an income transfer from foreigners to the domestic households if domestic and foreign goods are imperfect substitutes, i.e. if domestic households have some price setting power.

[3] The monetary policy rule implements CPI inflation targeting at a one-year horizon and includes interest rate persistence that generates a 2-quarter half-life of past interest rate decisions. The parameters are in the range of parameter estimates and calibrations in the literature, but remain purely illustrative. Alternative monetary policy rules with other parameter values or additional arguments would lead to quantitatively different FXR results.

increases the real interest rate. The decline in the real interest rate and the stabilisation of output and employment stabilise domestic and particularly investment demand. By stabilising economic activity, REP also limits the deterioration in the primary government balance and the rise in government debt. The rise in government debt to GDP peaks at 7pp compared to 16pp under the unchanged EXR peg (FIX).

Graph 2: Fiscal and exchange rate devaluation with initially balanced NFA position



Note: An increase in the REER represents real effective exchange rate depreciation.

The nominal and real EXR adjustment and the degree of stabilisation in the REP scenario of 10% EXR devaluation is stronger than the scenario with flexible EXR and independent monetary policy (FXR), due to gradual adjustment of the policy rate in response to price developments. The gradual adjustment leads to an initial increase in the real interest rate, which dampens interest-sensitive domestic demand. Consequently, the CA improvement is driven more by contracting imports rather than increasing exports compared to the REP scenario. A more aggressive and immediate monetary policy response to output contraction and below-target inflation would improve the stabilising impact of monetary policy in FXR in the short term. Such aggressive response may not be feasible when monetary policy reaches the zero bound (ZLB) in the recession, a situation in which alternative (fiscal) measures gain relevance also in economies with flexible EXR and independent monetary policy; see, e.g., Correia et al. (2013) on fiscal policy options at the ZLB.[4]

The theoretical case of a joint import tax and export subsidy of 10% each (XSU) has very similar effects to the 10% EXR devaluation (REP) in Graph 2. The increase in import prices leads to a temporary decline in the real interest rate, which mitigates the fall in domestic demand. Subsidised exports increase strongly, while the decline in import demand is mitigated by the stabilisation of domestic demand. Real GDP and employment even increase on impact for the 10% tax and subsidy combination; smaller policy changes would imply less positive GDP effects. The CA improvement is driven by strong export growth rather than falling import demand. Similarly to the impact of EXR devaluation on relative prices, the CA improvement is mitigated by the wealth transfer to foreign households and firms that the export subsidy implies.

The tax shift from labour (10pp SSC reduction) to consumption (7pp VAT increase) in Graph 2 (SSC) finally implies a very limited degree of output stabilisation compared to EXR devaluation (REP) or the export subsidy-import tax combination (XSU). Despite of the quantitatively large tax shift the drop in real GDP is reduced only by 1pp from -8% to -7%. The mitigating impact on the fall in employment is larger, 2pp from -6% to -4%, due to the substitution effect associated with falling labour costs. REER depreciation is gradual due to price stickiness that implies an initial feeding of SSC reduction into firm profits rather than lower goods prices. The gradual improvement in price competitiveness translates into only gradual improvement in export performance. Export growth is weaker than the decline in import demand, pointing to an improvement in the external position that is mainly driven by the contraction of domestic demand.

The fact that the labour-consumption tax shift in Graph 2 is very large compared to historic experience in OECD countries and compared to the revenues (6-7% of GDP on average) from employer social security contributions and the VAT in OECD economies (Koske 2013) underlines the modest contribution of the tax shift to economic stabilisation and external rebalancing in the short and medium term.

Other than the limited stabilising impact in the short run, the permanent SSC-VAT tax shift implies positive employment effects in the long run, which are absent in the case of nominal EXR adjustment. The positive employment effect derives from the implied shift in the tax burden from labour to all kinds of income (see, e.g., Burgert and Roeger 2014, Koske 2013). Nominal wage claims adjust to the higher VAT rate, i.e. the decline in purchasing power. But as long as the VAT base is larger than the SSC base, the VAT increase is smaller than the SSC rate reduction in the ex-ante budgetary neutral scenario, which leads to a lasting decline in labour costs. Hence, if workers or unions bargain for the real consumption wage, positive employment effects derive from a broadening of the tax base, so that the SSC rate falls by more than the VAT increase. The latter is the case in the SSC scenario underlying Graph 2, in which the VAT increase spreads the tax burden more widely from workers towards capital income earners and benefit and transfer, notably pension, recipients. Long-run employment and output gains are higher if higher ex-post tax revenue from an ex-ante revenue-neutral tax shift leads to a reduction in distortionary taxes on production as opposed to (as here) a reduction in the lump-sum tax. The negative wealth effect associated with the export subsidy in the export subsidy-import tax scenario (XSU) also has a positive impact on employment in the long term.

[4] In fact, the monetary policy rule in the FXR scenario of Figure 2 lowers the nominal short-term rate by almost 4pp in the short run. Interest rate cuts of this size are precluded by the ZLB in most advanced economies at the current juncture. The relative performance of fiscal devaluation may appear more favourable against this background. An alternative is the adoption of non-standard monetary policy tools that can provide monetary accommodation when short-term policy rates are hitting the ZLB.

In sum, the results in Graph 2 suggests that the tax shift from labour to consumption has rather moderate impact on output and employment stabilisation during recessions. The 10pp SSC cut together with 7pp VAT increase dampens real GDP and employment contraction by 1pp and 2pp respectively and improves export performance by up to 2pp compared to the no-policy-change scenario. Nominal EXR devaluation and (unilateral) trade taxes and subsidies of similar size imply much stronger stabilisation of economic activity in the short term and lead to more export-driven TB and CA adjustment.

The SSC-VAT tax shift in Graph 2, which implies a shift in government revenue of 5% of GDP, improves the TB and the CA by up to 0.5% of GDP. Results reported in Engler et al. (2014), namely 0.2% of GDP TB improvement for 1% of GDP fiscal devaluation, are slightly higher, but in the same order of magnitude. The impact on real GDP, i.e. a dampening of the output contraction by up to 1 pp for 5% of GDP SSC-VAT tax shift in Graph 2, is smaller than the 1.2% output gain associated with 1% of GDP fiscal devaluation in Engler et al. (2014). Gomes et al. (2014) find medium-term real GDP gains of up to 0.5% and TB improvement of 0.5% of GDP for fiscal devaluation of 1% of GDP. The model comparison in ECB (2012) reports peak effects for the real GDP increase of 0.2-0.5% for fiscal devaluation of 1% of GDP that correspond at the lower bound to the result in Graph 2.[5]

Compared to Engler et al. (2014), the version of the QUEST model used in this paper includes additional elements that dampen the impact of fiscal devaluation, notably the distinction between tradable (T) and non-tradable (NT) goods. An economy-wide fiscal devaluation of a given size implies less competitiveness improvement when the NT share in total output is high, which is the case in our example where non-tradables account on average for circa 60% of output. Similarly, the inclusion in QUEST of trade in intermediate inputs mitigates the impact of falling labour costs on product prices. The EAGLE model used by Gomes et al. (2014) and ECB (2012) also includes the T-NT distinction and trade in intermediate products. The EAGLE simulations adopt comparatively high values for the elasticity of labour supply and the price elasticity of trade, however, which strengthens the employment and competitiveness effects of the tax shift.

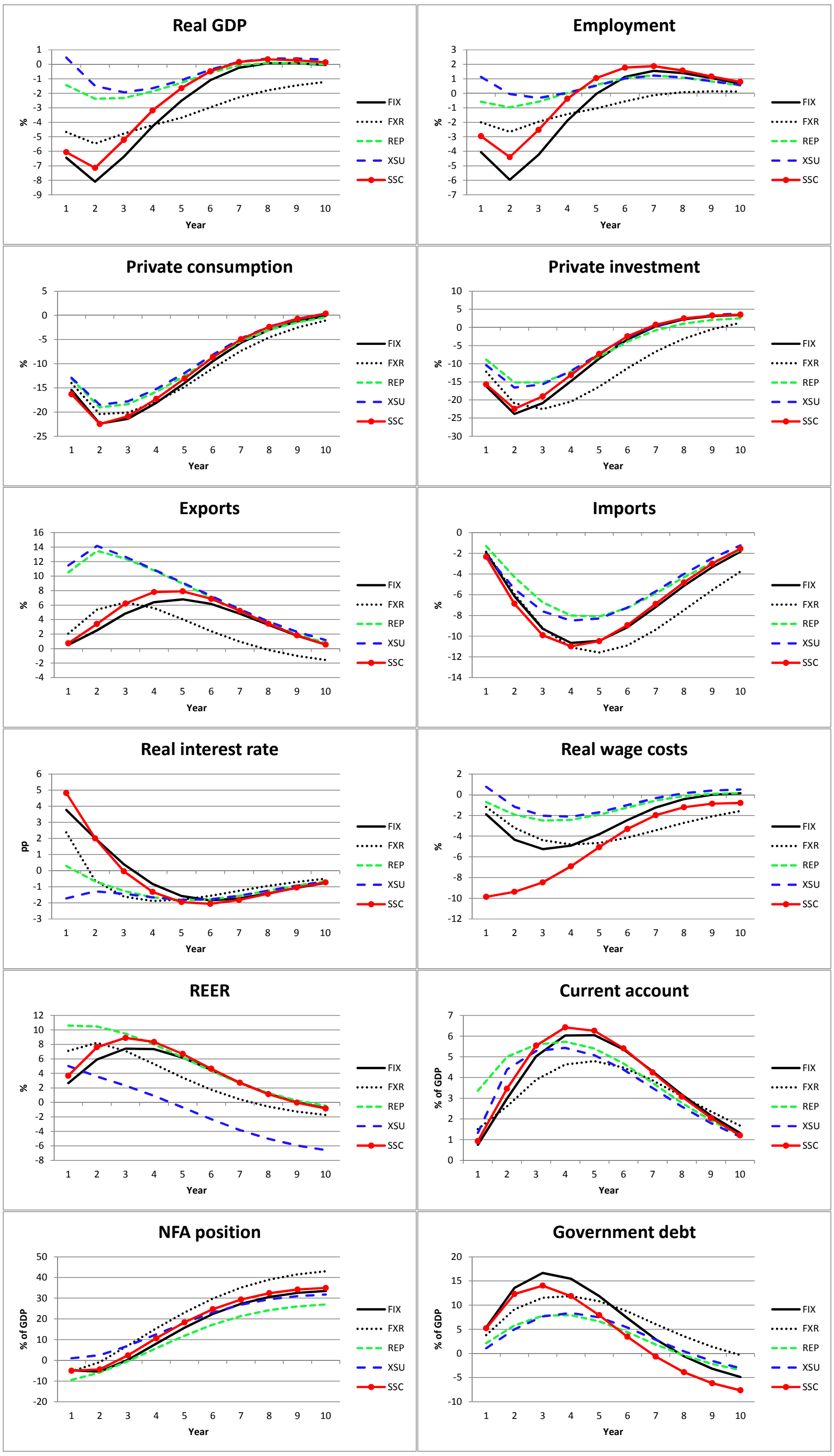
Gomes et al. (2014) also stress the importance of price and wage stickiness for the effective-ness of the SSC-VAT tax shift in the short run. Price stickiness slows decelerates the pass-through of lower labour costs into lower product prices and price competitiveness gains, which mitigates positive output and TB effects; wage stickiness mitigates the pass-through of higher consumption taxes into higher nominal wage claims and strengthens the positive GDP and TB effects in the short term.

An additional factor that affects the effectiveness of the SSC-VAT tax shift is the indexation of benefits and transfers paid by the government sector. The results in Graph 2 are for a mod-el setting in which unemployment benefits correspond to the replacement rate times the wage level and where transfers are indexed to the general price level, but not to the VAT increase. Non-indexation of benefits and transfers to the VAT hike implies that recipients of benefits and transfers also face a reduction in their real consumption income on impact. The disposable income of benefit recipients increases gradually as wages rise. In fact, the reform without indexation of benefits and transfers to the VAT increase amounts to a combination of tax reform and social security reform, with real income losses for transfer recipients. The positive GDP impact of the SSC-VAT tax shift in QUEST would be smaller if nominal benefits and transfers were indexed to the VAT increase as indexation would imply an (immediate) increase in the reservation wage and reduce labour supply.

The general performance of monetary and fiscal devaluation remains very similar if the economy in recession is characterised by high levels of external foreign-currency debt. Graph 3 shows impulse responses for the adjustment path when the domestic economy enters recession with net foreign debt of 100% of GDP. The main difference is the initial deterioration of the NFA-to-GDP ratio that derives from the denominator effect of nominal GDP decline which initially more than offsets the gradual improvement in the CA position. Only the combination of 10% import tax and export subsidy (XSU) avoids further deterioration of the NFA position on impact by achieving a high degree of GDP stabilisation. Nominal exchange rate devaluation by 10% (REP) achieves similar GDP stabilisation. The devaluation increases the value of foreign-currency debt in domestic-price terms, however, which is the effect stressed, e.g., by Keynes (1981).

[5] See Koske (2013) and Puglisi (2014) for comprehensive surveys of the econometric and model-based evidence on the impact of the labour-consumption tax shift.

Graph 3: Fiscal and exchange rate devaluation with foreign debt



Note: An increase in the REER represents real effective exchange rate depreciation.

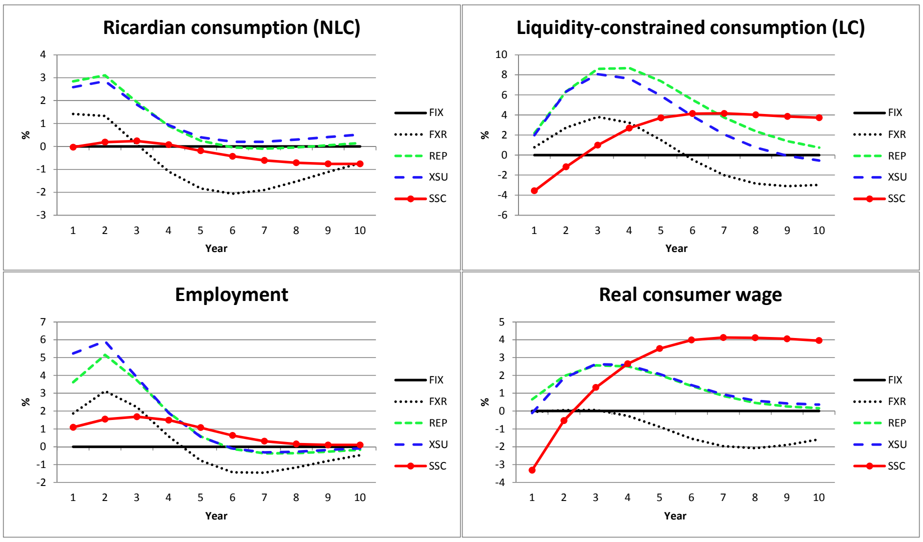
The simulation results also show that neither fiscal nor monetary devaluation as such generate permanent improvements in the external position. The current account position improves temporarily due to competitiveness gains, but converges towards the path under fixed nominal exchange rates without fiscal devaluation in the longer term and eventually returns to the baseline level. While the improvement of the NFA stock is more persistent, CA adjustment remains temporary if not accompanied by a lasting rebalancing of demand in line with the economies output potential (Vogel 2012, 2013).

An important aspect of fiscal devaluation measures is their potential distributional implications. A common argument states that the SSC-VAT tax shift is regressive as poorer households have a higher propensity to consume out of their income, so that their tax payments will increase more than proportionally. Burgert and Roeger (2014), however, show that the SSC-VAT tax shift is progressive insofar as it shifts taxation from labour to all sorts of income, in particular to capital and rental income which predominantly goes to richer households.

This paper does not provide a detailed discussion of the distributional effects of fiscal devaluation, for which readers should turn to Burgert and Roeger (2014) instead. An approximate answer can focus on the consumption pattern of the two household groups in the model, i.e. the richer Ricardian (NLC) households that are the owners of the economy's wealth and receive related income, and the poorer liquidity-constrained (LC) consumers who only receive wages, benefit and transfer income. A tax shift that penalised the poorer LC households on the income side should translate into a decline in LC real consumption.

Graph 4, which is based on the simulations displayed in Graph 2, reports NLC and LC consumption along with employment and the real consumer wage. The real consumer wage accounts for changes in the CPI deflator and particularly for the VAT increase in the SSC-VAT tax shift scenario (SSC). The variables are plotted relative to the economy with fixed nominal EXR and without further policy action (FIX).

Graph 4: F Ricardian and liquidity-constrained households' consumption



Note: Impulse responses show the percentage-point deviation from responses in the FIX scenario.

Graph 4 shows that the SSC-VAT tax shift (SSC) leads to an initial decline in LC real consumption due to the loss in purchasing power associated with the VAT increase. LC consumption raises above the FIX level in year 3, however, and remains above the FIX level thereafter. The medium- and long-term increase in LC consumption in SSC derives from the employment gain compared to FIX and the catch-up of nominal wage claims with the VAT increase in the medium term. Given the broader VAT tax base and, hence, the smaller VAT increase under an ex-ante budgetary neutral scheme, real wage costs remain below the FIX case in response to the SSC reduction even after the adjustment of nominal wage claims. Therefore, Graph 4 does not support the view that the SSC-VAT tax shift would be regressive for lower-income groups in the medium and longer term.

Indexation of benefits and transfers to the VAT increase would dampen the loss in purchasing power for recipients, but also weaken the positive long-run effect of a permanent tax shift by increasing the reservation wage. The non-indexation scenario in Graph 4 is in line with benefit systems in most EU and OECD countries that do not comprise an automatic indexation of unemployment benefits to changes in the VAT (Koske 2013).

4. CONCLUSIONS

This paper has compared the contribution of nominal exchange rate (external) and fiscal (internal) devaluation to macroeconomic stabilisation and current account rebalancing based on a small open economy version of the QUEST macroeconomic general-equilibrium model. In particular, starting from a domestic demand contraction in the order of magnitude experienced by several European economies periphery in recent years it has analysed whether fiscal tools such as a combination of (measures mimicking) import taxes and export subsidies or a tax shift from labour to consumption can reproduce the impact of nominal exchange rate adjustment in an economy with fixed nominal exchange rate and accelerate external rebalancing and mitigates the domestic costs in terms of economic activity by shifting current account adjustment from import-demand contraction to export growth. In other words, how much does fiscal devaluation help limiting the output contraction associated with domestic demand contraction by strengthening price competitiveness and net exports a time when domestic demand is contracting?

Among the fiscal measures included, the hypothetical import tax/export subsidy combination performs very similar to nominal exchange rate re-pegging. Both measures with the illustrative size of 10% used in the simulations imply an almost full offsetting of the real output con-traction of 8% associated with the contraction of domestic demand by 10%. The stabilising impact on economic activity of a tax shift from labour (10% SSC reduction) to consumption (7% VAT increase), which corresponds to a revenue shift of around 5% of GDP, remains comparably modest, dampening initial real GDP contraction from -8% to -7% and the drop in employment from -6% to -4%. Compared to the trade tax/subsidy and the re-pegging case, current account adjustment under the labour-consumption tax shift relies more on import con-traction than on export growth.

The fact that the labour-consumption tax shift analysed in this paper is very large compared to historic experience in OECD countries and compared to revenues from employer social security contributions and the VAT in OECD economies underlines the modest contribution of the tax shift to economic stabilisation and external rebalancing in the short and medium term. A permanent labour-consumption tax shift has positive employment effects in the long term, however, that derive from a broadening of the tax base towards other types of income and an associated reduction of labour costs. This positive long-run effect is larger if fiscal space from additional tax revenue associated with positive employment and output effects is used for a (further) reduction of distortionary taxes on the production side.

Despite the moderate performance of the standard fiscal devaluation package, i.e. the labour-consumption tax shift, adjustment would not necessarily be smoother in an economy with flexible exchange rate in which the central bank sets policy rates following a policy rule with a high weight on inflation. This holds even more if monetary policy is operating close to the zero bound and could, hence, not react with strong policy rate reduction during a recession.

Even if the fiscal measures are permanent, their impact on external variables remains temporary. The same holds for nominal exchange rate devaluation. In the presence of price and wage stickiness, the real effects of nominal exchange rate movements persist until relative prices have adjusted to the underlying demand and supply conditions. Several channels inter-act in the transmission: the competitiveness gain that improves the trade balance due to expenditure switching abroad and domestically towards domestically produced goods; the real interest channel, following which higher expected (imported) inflation would raise real interest rates and total and import demand; the positive income effect of policy measures with positive long-term impact on economic activity, which imply a more positive response of domestic and import demand.

The simulation results show that neither fiscal nor monetary devaluation as such generate permanent improvements in the external position. The current account position improves temporarily due to competitiveness gains, but converges towards the path under fixed nominal exchange rates without fiscal devaluation in the longer term and eventually returns to the baseline level. While the improvement of the net foreign asset stock is more persistent, current account adjustment remains temporary if not accompanied by a lasting rebalancing of demand in line with the economies output potential.

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APPENDIX: MODEL DESCRIPTION

The analysis in this paper uses the QUEST III model (Ratto et al., 2009). QUEST III is a quarterly macroeconomic model and a member of the class of New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) models. The model has rigorous microeconomic foundations derived from utility and profit maximization and includes frictions in goods, labour and financial markets.

The model version used here is a small open economy version with two production sectors that, respectively, produce tradable (T) and non-tradable (NT) goods. There are two types of households: liquidity-constrained households (l), and intertemporally optimising Ricardian households (r). All households consume and supply labour. In addition, Ricardian households invest into domestic productive capital, domestic government bonds and a foreign bond, they own the firms, and they obtain the firms' profits. There is no cross-border mobility of labour. The government levies taxes and spends its revenue on consumption, public investment, social benefits, transfers, and debt service. Short-term interest rates are set by the national central bank in the case of nominal exchange rate (EXR) flexibility and monetary independence, or determined by foreign interest rates in the case of a fixed EXR regime.

A.1. PRODUCTION

The domestic economy is home to firms j operating in the T and NT sectors. Individual firms in T and NT are indexed by the superscript j=(t, nt). Each firm produces a variety of the T or NT good that is an imperfect substitute for varieties produced by other firms. Sectoral output O_t^J with J=(T, NT) is a CES aggregate of the varieties O_t^j:

(1) $$O_t^J \equiv \left[\int_0^1 (O_t^j)^{(\sigma_j - 1)/\sigma_j} dj \right]^{\sigma_j/(\sigma_j - 1)}$$

where σ_j is the elasticity of substitution between varieties j in sector J. The elasticity value can differ between T and NT, implying sector-specific price mark-ups. Given the imperfect substitutability, firms are monopolistically competitive in the goods market and face a demand function for their output:

(2) $$O_t^j = (P_t^j / P_t^J)^{-\sigma_j} O_t^J$$

The firms in sector T sell consumption and investment goods and intermediate inputs to domestic private households and firms, the domestic government and the rest of the world (RoW). The NT sector sells consumption goods to domestic households, consumption and investment goods to the domestic government, and intermediate inputs to domestic firms. All private investment in physical capital consists of T goods.

Output is produced with a CES technology that combines value-added (Y_t^j) and intermediate inputs (INT_t^j). It nests a Cobb-Douglas technology with capital (K_t^j), production workers ($L_t^j - LO_t^j$) and public infrastructure (KG_t) for the production of Y_t^j:

(3) $$O_t^j = [(1 - \sin^j)^{1/\sigma_{in}} (Y_t^j)^{(\sigma_{in}-1)/\sigma_{in}} + (\sin^j)^{1/\sigma_{in}} (INT_t^j)^{(\sigma_{in}-1)/\sigma_{in}}]^{\sigma_{in}/(\sigma_{in}-1)}$$

(4) $$Y_t^j = A_t^j (ucap_t^j K_t^j)^{1-\alpha} (L_t^j - LO_t^j)^{\alpha} KG_t^{\alpha_g} - FCY_t^j$$

where $\sin^j$ and σ_{in} are, respectively, the steady-state share of intermediates in output and the elasticity of substitution between intermediates and value-added, and $A_t^j, ucap_t^j$, LO_t^j and FCY_t^j are total factor productivity (TFP), capacity utilisation, overhead labour and fixed costs of producing.[6]

Firm-level employment L_t^j is a CES aggregate of the labour services supplied by individual households i:

(5) $$L_t^j \equiv \left[\int_0^1 L_t^{i,j(\theta-1)/\theta} di \right]^{\theta/(\theta-1)}$$

where θ indicates the degree of substitutability between the different types of labour i.

The objective of the firm is to maximise real profits ($\Pr_t^j$):

(6) $$\Pr_t^j = p_t^j O_t^j - p_t^{INT,j} INT_t^j - (1+ssc_t^J) w_t L_t^j - p_t^I I_t^j - (adj_t^{P,j} + adj_t^{L,j} + adj_t^{ucap,j})$$

where ssc_t^J , w_t , i_t^J and p_t^I are the employer social security contributions, the real wage, the rental rate of capital, and the price of capital. The firms are owned by the intertemporally optimising households that receive the firms' profits.

The firms face technology and regulatory constraints that restrict their capacity to adjust. These constraints are modelled as adjustment costs with the following convex functional forms:

(7a) $$adj_t^{L,j} \equiv \gamma_L w_t (\Delta L_t^j)^2 / 2$$

(7b) $$adj_t^{P,j} \equiv \gamma_P (\pi_t^j)^2 Y_t^j / 2 \text{ with } \pi_t^j \equiv P_t^j \big/ P_{t-1}^j - 1$$

(7c) $$adj_t^{ucap,j} \equiv p_t^I K_t^j [\gamma_{ucap,1}(ucap_t^j - 1) + \gamma_{ucap,2}(ucap_t^j - 1)^2] / 2$$

The firms choose labour input, capital services, capacity utilisation, the price of output j, and the volume of output j given the demand function (2), the production technology (3) and (4), and the adjustment costs (7). The first-order conditions (FOC) are:

(8a) $$\frac{\partial \Pr_t^j}{\partial L_t^j} => \frac{\partial O_t^j}{\partial L_t^j} \eta_t^j - \gamma_L w_t \Delta L_t^j + \gamma_L \beta E_t (\lambda_{t+1}^r \big/ \lambda_t^r \, w_{t+1} \Delta L_{t+1}^j) = (1+ssc_t^J) w_t$$

(8b) $$\frac{\partial \Pr_t^j}{\partial K_t^j} => \frac{\partial O_t^j}{\partial K_t^j} \eta_t^j = i_t^J p_t^I$$

(8c) $$\frac{\partial \Pr_t^j}{\partial ucap_t^j} => \frac{\partial O_t^j}{\partial ucap_t^j} \eta_t^j = p_t^I K_t^j [\gamma_{ucap,1} + \gamma_{ucap,2}(ucap_t^j - 1)]$$

[6] Lower case letters denote ratios and rates. In particular, $p_t^j \equiv P_t^j / P_t$ is the price of good *j* relative to the GDP deflator, $w_t \equiv W_t / P_t$ is the real wage, $ucap_t^j$ is actual relative to steady-state (full) capital utilisation, and e_t is the nominal exchange rate defined as the price of foreign in domestic currency.

(8d) $$\frac{\partial \Pr_t^j}{\partial O_t^j} \Rightarrow \eta_t^j = 1 - 1/\sigma^j - \varepsilon_t^J - \gamma_P \left[\beta E_t (\lambda_{t+1}^r / \lambda_t^r \, \pi_{t+1}^j) - \pi_t^j \right]$$

where η_t^j is the Lagrange multiplier associated with the production technology, λ_t^r the marginal value of wealth in consumption terms as defined by equation (13) below, and ε_t^J is a sector-specific shock to the price mark-up.

Equation (8a) implies that optimising firms equate the marginal product of labour net of adjustment costs to wage costs. Equations (8b-c) jointly determine the optimal capital stock and capacity utilisation by equating the marginal value product of capital to the rental price and the marginal product of capital services to the marginal cost of increasing capacity. Equation (8d) defines the price mark-up factor as function of the elasticity of substitution and price adjustment costs. QUEST follows the empirical literature and allows for backward-looking elements in price setting by assuming that the fraction *1-sfp* of firms indexes prices to past inflation, which leads to the specification:

(8d') $$\eta_t^j = 1 - 1/\sigma^j - \varepsilon_t^J - \gamma_P \left[\beta E_t (\lambda_{t+1}^r / \lambda_t^r)(sfp E_t \pi_{t+1}^j + (1-sfp)\pi_{t-1}^j) - \pi_t^j \right] \text{ with } 0 \le sfp \le 1$$

for the inverse of the price mark-ups in the T and NT sectors. Given the symmetry of objectives and constraints across firms j in sector J, the superscript j for individual firms can be dropped to obtain aggregate sectoral equations for T and NT. The price setting decision establishes a link between output and inflation dynamics in the economy. For constant technology, factor demand and/or capacity utilisation increase (decline) with increasing (declining) demand for output, which leads to an increase (decline) in factor and production costs and, hence, an increase (decline) in the price level of domestic output.

A.2. HOUSEHOLDS

The household sector consists of a continuum of households $i \in [0,1]$. There are $0 \le s^l \le 1$ households that are liquidity constrained and indexed by the superscript l. These households do not invest or trade on asset markets and consume their disposable income at each period in time. The fraction $1-s^l$ of households is Ricardian and indexed by the superscript r. The period utility function is identical for each household type. It is separable in consumption (C_t^i) and leisure ($1-L_t^i$), allows for habit persistence in consumption (h) and is given by:

(9) $$U(C_t^i, 1-L_t^i) = (1-h)/(1-\sigma_c)(C_t^i - hC_{t-1})^{1-\sigma_c} + \omega/(1-\kappa)(1-L_t^i)^{1-\kappa}$$

where ω is the weight of the utility of leisure in total period utility, and κ is the inverse of the elasticity of labour supply.

Both types of households supply differentiated labour services to unions that maximise a joint utility function for each type of labour i. It is assumed that types of labour are distributed equally across both household types. Nominal wage rigidity is introduced through adjustment costs for changing wages. These adjustment costs are borne by the households.

A.2.1. Ricardian households

Ricardian households have full access to financial markets. They hold domestic government bonds (B_t^G), foreign bonds (B_t^F) and the real capital stock (K_t^j) of the T and NT sectors. Ricardian households receive labour income, returns on financial assets, rental income from lending capital to firms, and the profit income from firm ownership. Domestic firms are owned by domestic Ricardian households. Income from labour is taxed at rate t^w, corporate income at rate t^k and consumption at rate t^c. In addition, there is a lump-sum tax T^{LS}.

Income from financial assets is subject to different types of risk. Domestic bonds yield a risk-free nominal return of i_t, but returns on foreign bonds (i_t^F) are subject to a risk premium $(rprem_t)$ linked to the country's net foreign indebtedness. An equity premium ($i_t^K - i_t$) on productive capital arises due to the uncertainty about the future value of the capital stock. The Lagrangian of the maximisation problem is:

$$Max \quad V_0^r = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t^r, 1 - L_t^r)$$

(10) $$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^t \begin{pmatrix} (1+t_t^c) p_t^C C_t^r + \sum_J p_t^{I,J} I_t^J + \frac{B_t^G}{P_t} + e_t \frac{B_t^F}{P_t} - (1+i_{t-1}) \frac{B_{t-1}^G}{P_t} \\ -(1+i_{t-1}^F + rprem_t) e_t \frac{B_{t-1}^F}{P_t} - \sum_J ((1-t_t^k) i_{t-1}^{K,J} + t_t^k \delta^{k,J}) p_{t-1}^{I,J} K_{t-1}^J \\ -(1-t_t^W) w_t L_t^r + \frac{\gamma_W}{2} (\Delta W_t / W_{t-1})^2 L_t - \sum_J \mathrm{Pr}_t^J - \frac{T_t^{LS,r}}{P_t} \\ -\frac{BEN_t}{P_t}(1 - NPART_t - L_t^r) - \frac{TR_t^r}{P_t} + \sum_J adj_t^{K,J} + \sum_J adj_t^{I,J} + adj_t^W \end{pmatrix}$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^t \left(\sum_J \xi_t^j (K_t^J - J_t^J - (1-\delta^{K,J}) K_{t-1}^J) \right)$$

where the adjustment costs have the functional forms:

(11a) $$adj_t^{K,J} \equiv \gamma_{K,J} (I_t^J / K_{t-1}^J - \delta^J)^2 K_{t-1}^J / 2$$

(11b) $$adj_t^{I,J} \equiv \gamma_{I,J} (\Delta I_t^J)^2 / 2$$

(11c) $$adj_t^W \equiv \gamma_W (\pi_t^W)^2 L_t / 2$$

and where p_t^C and p_t^I are the consumption and investment price deflators relative to the GDP deflator.

The FOCs of the optimisation problem provide the intertemporal consumption rule, where the ratio of the marginal utility of consumption in periods t and t+1 is equated to the real interest rate adjusted for the rate of time preference:

(12) $$\beta E_t (\lambda_{t+1}^r / \lambda_t^r) = 1/(1+r_t)$$

(13) $$\lambda_t^r = 1 / [(1+t_t^c) p_t^c (C_t^r - h C_{t-1}^r)]$$

with the real interest rate here defined as $r_t = i_t - E_t \pi_{t+1}$, i.e. the nominal rate minus the expected per-cent change in GDP deflator.

The FOC for investment provides an investment rule linking capital formation to the shadow price of capital:

(14) $$\gamma_{K,J} \left(\frac{I_t^{K,J}}{K_{t-1}^J} - \delta^{K,J} \right) + \gamma_{I,J} \Delta I_t^J - \gamma_{I,J} \beta E_t \left(\frac{\lambda_{t+1}^r}{\lambda_t^r} \frac{p_{t+1}^{I,J}}{p_t^{I,J}} \Delta I_{t+1}^{K,j} \right) = q_t^J - 1$$

and q_t^J corresponds to the present discounted value of the rental income from physical capital:

(15)
$$q_t^J = (1-\sin)(O_t^J / Y_t^J)^{1/\sigma_{in}} \eta_t^J P_t^J / P_t^I (1-t_t^K)(1-\alpha)(Y_t^J - A_t^J FCY_t^J)/K_t^J$$
$$+t_t^k \delta^J - \gamma_{ucap1,J}(ucap_t - 1) - \gamma_{ucap2,J}(ucap_t - 1)^2 / 2 + (1 - i_t^J - \delta^J)\mathrm{E}_t q_{t+1}^J$$

The FOC for investment in foreign bonds gives the UIP condition:

(16) $$i_t = i_t^* + (E_t \Delta e_{t+1})/e_t + rprem_t$$

which determines the nominal exchange rate vis-à-vis the RoW. There are no capital controls that would insulate domestic from international capital markets and separate domestic monetary from exchange rate policy.

A.2.2. Liquidity-constrained households

Liquidity-constrained households do not optimise the intertemporal consumption path, but simply consume their entire disposable income at each date. Real consumption of household l is thus determined by the net wage and transfer income minus the lump-sum tax:

(17) $$(1+t_t^c)P_t^c C_t^l = (1-t_t^w)W_t L_t^l + TR_t^l + BEN_t(1-NPART_t - L_t^l) - T_t^{LS,l}$$

The labour supply behaviour of liquidity-constrained households is determined by the utility function (9) which also applies to Ricardian households and is described next.

A.2.3. Wage setting

A trade union is maximising a joint utility function for each type of labour i. It is assumed that types of labour are distributed equally over Ricardian and liquidity-constrained households with their respective population weights. The trade union sets wages by maximising a weighted average of the utility functions of these households. The wage rule is obtained by equating a weighted average of the marginal utility of leisure to a weighted average of the marginal utility of consumption times the real consumption wage of both household types, adjusted for a wage mark-up ($1/\eta_t^W$):

(18) $$\frac{(1-s^l)U_{1-L,t}^r + s^l U_{1-L,t}^l}{(1-s^l)U_{c,t}^r + s^l U_{c,t}^l} = \frac{(1-t_t^W)W_t - BEN_t}{(1+t_t^C)P_t^C}\eta_t^W$$

The wage mark-up fluctuates around 1/*θ*, which is the inverse of the elasticity of substitution between different varieties of labour services. Fluctuations arise from wage stickiness and shocks to the wage mark-up (ε_t^W). In the presence of wage stickiness, the fraction *1-sfw* of workers ($0 \le sfw \le 1$) indexes wage growth π_t^W to price inflation in the previous period:

(19) $$\eta_t^W = 1 - 1/\theta - \varepsilon_t^W - \beta\gamma_W / \theta E_t[\lambda_{t+1}^r / \lambda_t^r (\pi_{t+1}^W - (1-sfw)\pi_t) - (\pi_t^W - (1-sfw)\pi_{t-1})]$$

The (semi-)elasticity of wage inflation with respect to employment is given by κ / γ_W, i.e. it is positively related to the inverse of the elasticity of labour supply and inversely related to wage adjustment costs.

A.2.3. Aggregation

The aggregate value of any household-specific variable X_t^i in per-capita terms is given by $X_t \equiv \int_0^1 X_t^i di = (1-s^l)X_t^r + s^l X_t^l$ since the households within each group are identical with respect to their consumption and labour supply decisions. Hence, aggregate consumption is given by:

(20a) $$C_t = (1-s^l)C_t^r + s^l C_t^l$$

and aggregate employment by:

(20b) $$L_t = (1-s^l)L_t^r + s^l L_t^l \text{ with } L_t^r = L_t^l.$$

A.3. FISCAL AND MONETARY POLICY

Real government purchases (G_t) and investment (IG_t) are kept constant in real terms. The stock of public infrastructure that enters the production function (4) develops according to:

(21) $$KG_t = IG_t + (1-\delta^g)KG_{t-1}$$

Nominal transfers (TR_t) are indexed to consumer prices:

(22) $$TR_t = \overline{tr}P_t^C$$

The nominal benefits paid to the non-employed part of the labour force correspond to the exogenous replacement rate (*benr*) times the nominal wage:

(23) $$BEN_t = \overline{benr}W_t$$

The government receives consumption tax, labour tax, corporate tax and lump-sum tax revenue as well as social security contributions. Nominal government debt (B_t) evolves according to:

(24) $$\begin{aligned} B_t &= (1+i_{t-1})B_{t-1} + P_t^C(G_t + IG_t) + TR_t + BEN_t(1 - NPART_t - L_t) - T_t^{LS} - t_t^c P_t^c C_t \\ &- \sum_J (t_t^w + ssc_t^J)W_t L_t^J - \sum_J t_t^k (P_t^J O_t^J - P_t^{INT,J} INT_t^J - (1+ssc_t^J)W_t L_t^J - \delta P_t^I K_{t-1}^J) \\ &- t_t^M e_t P_t^M M_t - t_t^X P_t^X X_t \end{aligned}$$

where t_t^M is an tax on the domestic-currency value of imports, $e_t P_t^M$, and t_t^X is a tax on exports, i.e. $t_t^X < 0$ is an export subsidy. Both t_t^M and t_t^X are zero in the baseline calibration of the model.

The lump-sum tax is used to stabilise the debt-to-GDP ratio:

(25) $$\Delta T_t^{LS} = \tau^b\left(B_{t-1}/(P_{t-1}Y_{t-1}) - btar\right) + \tau^{def}\Delta\left(B_t/(Y_t P_t)\right)$$

with btar being the target level of government debt to GDP. The consumption tax, the labour income tax, the corporate income tax, the rate of social security contributions, the import tax and the export subsidy are exogenous and adjusted in the fiscal devaluation scenarios as described in the main text.

When the exchange rate is fixed, short-term interest rates in the small open economy are determined by the foreign level of interest rates. In the case of a monetary union, the policy rate is set on the basis of union-wide aggregates. In the case of independent monetary policy, domestic short-term rates follow a Taylor-type monetary policy rule in which the policy rate responds to CPI inflation and the output gap:

$$(26) \qquad i_t = \rho_i i_{t-1} + (1-\rho_i)\left(\bar{r} + \pi^{tar} + \tau_\pi \sum_{i=0}^{n} \tfrac{1}{n}(\mathrm{E}_t\,\pi_{t+i}^{C} - \pi^{tar}) + \tau_y ygap_t\right)$$

The central bank has an inflation target π^{tar}, adjusts its policy rate when actual or expected CPI inflation deviate from the target and may also responds to the output gap (*ygap*). The output gap is not calculated as the difference between actual and efficient output, but derived from a production function framework, which is the standard practice of output gap calculation for fiscal surveillance and monetary policy. More precisely, the output gap is defined as deviation of factor utilisation from its long-run trend:

$$(27) \qquad ygap_t \equiv \alpha \ln(L_t / L_t^{ss}) + (1-\alpha)\ln(ucap_t / ucap_t^{ss})$$

where $L_t^{ss} \equiv \rho^L L_{t-1}^{ss} + (1-\rho^L)L_t$ and $ucap_t^{ss} \equiv \rho^{ucap} ucap_{t-1}^{ss} + (1-\rho^{ucap})ucap_t^j$ are moving averages of employment and capacity utilisation rates.

A.4. TRADE AND FINANCIAL LINKAGES

This sub-section describes the key relationships for the dynamics of the trade balance, the current account and the net foreign asset position in response to relative price and demand adjustment. Previous sub-sections have determined aggregate domestic consumption, investment and government expenditure, but not the allocation of demand between T versus NT output and domestically produced versus imported T goods.

In order to facilitate aggregation, private households and the government are assumed to have identical preferences across goods used for private and government consumption and public investment. Let Z=C+G+IG be the demand by private households and the government, and let their preferences for T and NT goods be given by the CES functions:

$$(28) \qquad Z_t = \left[(1-s_{tnt})^{\frac{1}{\sigma_{tnt}}} (Z_t^{NT})^{\frac{\sigma_{tnt}-1}{\sigma_{tnt}}} + s_{tnt}^{\frac{1}{\sigma_{tnt}}} (Z_t^{TT})^{\frac{\sigma_{tnt}-1}{\sigma_{tnt}}} \right]^{\frac{\sigma_{tnt}}{\sigma_{tnt}-1}}$$

where Z^{NT} is an index of demand across the NT varieties, and Z^{TT} is a bundle of domestically produced (Z^T) and imported (Z^M) T goods:

$$(29) \qquad Z_t^{TT} = \left[(1-s_m)^{\frac{1}{\sigma_x}} (Z_t^{T})^{\frac{\sigma_x-1}{\sigma_x}} + s_m^{\frac{1}{\sigma_x}} (Z_t^{M})^{\frac{\sigma_x-1}{\sigma_x}} \right]^{\frac{\sigma_x}{\sigma_x-1}}$$

The elasticity of substitution between the bundles of NT and T goods is σ_{tnt}. The elasticity of substitution between the bundles of domestically produced and imported T goods is σ_x. The steady-state shares of T goods in Z_t and of imports Z_t^{TT} are s_{tnt} and s_m, respectively. All investment in physical capital in the T and NT sectors consists of T goods.

The CES aggregate (28) combining T and NT goods gives the following demand functions:

(30a) $Z_t^T = s_{tnt}(P_t^T / P_t^C)^{-\sigma_{tnt}}(C_t + G_t + IG_t)$

(30b) $Z_t^{NT} = (1 - s_{tnt})(P_t^{NT} / P_t^C)^{-\sigma_{tnt}}(C_t + G_t + IG_t)$

The intermediate inputs in sector J=(T, NT) are also composites of T and NT analogously to equations (29) and (30) with T either domestically produced or imported:

(31) $$INT_t^J = \left[(1 - \sin_{tnt}^J)^{\frac{1}{\sigma_{tnt}}}(INT_t^{NT,J})^{\frac{\sigma_{tnt}-1}{\sigma_{tnt}}} + (\sin_{tnt}^J)^{\frac{1}{\sigma_{tnt}}}(INT_t^{T,J})^{\frac{\sigma_{tnt}-1}{\sigma_{tnt}}}\right]^{\frac{\sigma_{tnt}}{\sigma_{tnt}-1}}$$

(32) $$INT_t^{TT,J} = \left[(1 - s_m)^{\frac{1}{\sigma_x}}(INT_t^{T,J})^{\frac{\sigma_x-1}{\sigma_x}} + s_m(INT_t^{M,J})^{\frac{\sigma_x-1}{\sigma_x}}\right]^{\frac{\sigma_x}{\sigma_x-1}}$$

This gives demand functions for T and NT intermediates analogously to (31):

(33a) $INT_t^{T,J} = \sin_{tnt}^J(P_t^T / P_t^{INT,J})^{-\sigma_{tnt}} INT_t^J$

(33b) $INT_t^{NT,J} = (1 - \sin_{tnt}^J)(P_t^{NT} / P_t^{INT,J})^{-\sigma_{tnt}} INT_t^J$

Combining the demand functions corresponding to (29) and (32) and allowing for sluggish volume responses to price changes (ρ_m) gives the import demand equation:

(34) $$M_t = \rho_m M_{t-1} + (1 - \rho_m)s_m\left(\frac{(1 + t_t^M)e_t P_t^M}{P_t^T}\right)^{-\sigma_x}(Z_t^T + \sum_J I_t^j + \sum_J INT_t^{T,J})$$

with t_t^M as the import tax, P_t^M as the import price in foreign currency and e_t as the nominal (effective) exchange rate. Analogous assumptions for demand in the rest of the world give the export demand equation:

(35) $$X_t = \rho_X X_{t-1} + (1 - \rho_X)s_m^F\left(\frac{(1 + t_t^X)P_t^X}{e_t P_t^{T*}}\right)^{-\sigma_x}(Z_t^{T*} + \sum_J I_t^{J*} + \sum_J INT_t^{T,J*})$$

Equations (34-35) incorporate a sluggish response (ρ_M and ρ_X) of trade volumes to relative prices, which can replicate the J-curve effect of exchange rate depreciation. The export price is augmented in (35) by an export tax t_t^X that becomes an export subsidy for $t_t^X < 0$.

Exporters sell domestically produced tradables in the world market. The export price (P_t^X) depends on the price of tradable output and, capturing an element of pricing to market, the lagged export price adjusted by changes in the nominal exchange rate:

(36) $$P_t^X = (1 - \rho_{PX})P_t^T + \rho_{PX} \, {}^{e_t}\!/_{e_{t-1}} \, P_{t-1}^X$$

The trade balance of the domestic economy is net trade in value terms:

(37) $$TB_t \equiv (1+t_t^X)P_t^X X_t - e_t P_t^M M_t$$

Adding interest income on the net foreign asset (NFA) position gives the current account:

(38) $$CA_t \equiv i_{t-1}^* e_t B_{t-1}^* + (1+t_t^X)P_t^X X_t - e_t P_t^F M_t$$

The law of motion for the NFA position is:

(39) $$e_t B_t^* = (1+i_{t-1}^*)e_t B_{t-1}^* + (1+t_t^X)P_t^X X_t - e_t P_t^M M_t$$

The focus on the NFA position abstracts from valuation effects on the gross asset or liability side.

The model requires an external closure to rule out explosive NFA dynamics as illustrated by Schmitt-Grohé and Uribe (2003). The model uses a closure rule that relates the external risk premium in (16) to the NFA position of the domestic economy relative to the baseline (target) position bwy^T:

(40) $$rprem_t = -rprem(e_t B_t^* / (4P_t Y_t) - bwy^T)$$

An increase (decline) in the NFA position of the domestic economy increases (reduces) the risk on foreign relative to domestic bonds. An increase in the relative risk of domestic assets in response to a fall in the domestic NFA position reduces domestic consumption and investment demand, which improves the trade balance and stabilises the NFA position.

A.5. PARAMETERISATION

The parameter and baseline values of the model reflect data for a small open European economy such as Sweden. Following standard practice, the big real ratios, notably trade openness, consumption and investment shares, government size, and the wage share, are set on the basis of national accounts data. The sectoral disaggregation (tradables versus non-tradables) and the share of intermediates are based on input-output tables from the GTAP (Global Trade Analysis Project) database.

Fluctuations around the long-term growth path are governed by nominal and real rigidities in conjunction with exogenous shocks. The parameters of nominal price and wage rigidity are set to generate average wage and price durations of 3 and 5 quarters respectively. The price elasticity of trade is in the range of average aggregate time series estimates in Imbs and Méjean (2010). Evidence for the sluggish adjustment of import and export demand and the gradual pass-through of exchange rate movements to import and export prices is provided, e.g., by Bussière et al. (2014). The chosen parameter are summarised in Table A.1.

Table A.1: Model parameters and steady-state ratios

Name	Value	Name	Value
Frictions:		Fix costs of production (FCY) to GDP	0.13
Price adjustment costs (γ_P)	20	Overhead labour (LO) to total employment	0.04
Wage adjustment costs (γ_W)	120	Elasticity of substitution between value added and intermediates (σ_{in})	0.5
Import price stickiness (ρ_{pm})	0.8	Intermediate share T (sin^T)	0.68
Export price stickiness (ρ_{px})	0.8	Intermediate share NT (sin^{NT})	0.50
Labour adjustment cost (γ_L)	25	T intermediate share in T (sin_{tnt}^T)	0.62
Capital adjustment cost (γ_K)	20	T intermediate share in NT (sin_{tnt}^{NT})	0.42
Investment adjustment cost (γ_I)	75	Substitutability between types of labour (θ)	6
Linear capacity-utilisation adjustment cost ($\gamma_{ucap,1}$)	0.04	Depreciation rate T capital stock (δ^T)	0.02
Quadratic capacity-utilisation adjustment cost	0.05	Depreciation rate NT capital stock (δ^{NT})	0.01

($\gamma_{ucap,2}$)			
Share of forward-looking price setters (sfp)	0.9	Depreciation rate public capital stock (δ^g)	0.01
Share of forward-looking wage setters (sfw)	0.9	Equity premium (i^K-i)	0.01
Preferences:		Persistence of potential employment (ρ^L)	0.95
Share of LC households (s^l)	0.4	Persistence of potential capacity (ρ^{ucap})	0.99
Discount factor (β)	0.997	Fiscal policy:	
Habit persistence (h)	0.7	Corporate profit tax (t^k)	0.35
Intertemporal elasticity of substitution ($1/\sigma_c$)	1	Consumption tax (t^c)	0.27
Inverse of elasticity of labour supply (κ)	-5	Labour income tax (t^w)	0.39
Utility weight of leisure (ω)	0.0005	Social security contributions (ssc)	0.15
Labour force (1-NPART) to population	0.71	Transfer share (try)	0.16
Employment (L) to population in steady state	0.66	Benefit replacement rate (benr)	0.40
Elasticity of substitution T varieties (σ_T)	8	Baseline government debt to GDP (btar)	0.4
Elasticity of substitution NT varieties (σ_{NT})	6	Parameter debt (τ^b)	0.01
Elasticity of substitution T-NT (σ_{tnt})	0.5	Parameter deficit (τ^{def})	0.10
Elasticity of substitution in trade (σ_x)	1.5	Risk premium (risk)	0.001
Consumption share of T (s_{tnt})	0.4	National accounts (share of GDP):	
Consumption share of imports (s_m)	0.4	Private consumption	0.59
Persistence in import demand (ρ_m)	0.9	Private non-construction investment	0.09
Persistence in export demand (ρ_x)	0.6	Government purchases	0.28
Production:		Government investment	0.04
Labour parameter (α)	0.65	Imports	0.44
Public capital stock parameter (α_g)	0.09	Exports	0.44

A.6. REFERENCES

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