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HOW SUPPLY-SIDE CHANGES AFFECT AN EXCHANGE RATE ADJUSTMENT

by Philipp Engler,
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In 2007 all ECB publications feature a motif taken from the €20 banknote.

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Abstract

The influential work of Obstfeld and Rogoff argues that a closing-up of the US current account deficit involves a large exchange rate adjustment. However, the Obstfeld-Rogoff model works exclusively via demand-side channels and abstracts from possible supply-side changes. We extend the framework to allow for endogenous supply-side changes and show that this fundamentally alters the mechanism of the adjustment process. Allowing for such an extension attenuates quite significantly the implied exchange rate adjustment. The paper also provides some empirical evidence of variations in the supply-side structure and correlations with the exchange rate and the current account. The policy implications are that measures to foster a supply-side reaction would facilitate the external adjustment by alleviating an exclusive reliance on demand and exchange rate changes, with the latter being potentially destabilising for the global financial system.

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Non-technical summary

How are the external imbalances of the US likely to adjust? The literature has typically looked into the adjustment from a demand side angle, considering that it would primarily be global demand that would shift away from foreign goods to US tradable goods and US demand shifting from tradable goods to non-tradable goods. These studies have also provided conclusions on the exchange rate change entailed in this process. Among the most prominent authors, Obstfeld and Rogoff examine various constellations of the demand shift and conclude that the depreciation of the dollar would be substantial and comparable to the post 1985 decline of the dollar – 30% in real effective terms between March 1985 and April 1988 – that was enrobed in one of the largest efforts of international monetary cooperation centred on the Plaza-Louvre accords.

However, the existing literature focuses exclusively on demand-side channels and abstracts from possible supply-side changes that are likely to take place over the medium and long term. This paper tries to fill this gap by taking a longer term view and focusing on the role of the supply-side in the adjustment process. It underscores that a turnaround in the external balance requires not only a demand shift away from imported goods to domestically produced goods but also almost mechanically involves a change on the supply side towards higher production of tradables. The latter supply side adjustment has a significant bearing on the exchange rate variation in the overall current account adjustment. Specifically, a supply side reaction is likely to attenuate the exchange rate change implied in models purely based on shifts in demand.

In order to highlight the impact of supply side changes, we present a modified version of the model developed by Obstfeld and Rogoff. The supply-shift is introduced by transformation curves between tradable and non-tradable goods produced in the US and the rest of the world respectively. Hence any change in the relative price of non-tradables relative to domestically produced tradables will incur a shift in production from one sector to the other. A rise in the relative price of tradables will hence not only imply a shift in demand from tradables to non-tradables, it will, in addition, increase the relative supply of tradable output. Accordingly, these two effects will help improve the trade balance. We find that for the most "alarmist" scenarios, the exchange rate change entailed in a rebalancing of the current account is halved when allowing for endogenous supply side changes as compared to an entirely demand driven adjustment. Furthermore, we find that, in the most benign case, there is virtually no exchange rate change involved in the adjustment process. Our extension appears to be supported by actual developments showing that the sectoral supply of tradables and non-tradables varies quite significantly with relative prices and the current account. Of course, the sectoral change is likely to be stretched over time depending inter alia on the overall flexibility of the economy to adjust.

However, a certain supply driven adjustment channel is likely to be present in any current account reversal.

Therefore, our angle of analysis provides for a refinement to the well-know policy paradigm relating to global imbalances: the US current account deficit is unlikely to close up without a substantial change in its own and its trading partners' industrial structure. Measures that go beyond demand policy management – i.e. through fiscal or monetary policy – but that also include areas of structural change, education, training, productive capacity in export sectors, infrastructure, as well as a different macroeconomic policy stance, would facilitate an orderly adjustment of the US current account deficit and hence of global imbalances.

1 The US current account deficit and its adjustment

The question "is the US current account deficit sustainable?" yields over one million hits in Google, but gets essentially only one answer: no, it isn't, at least not over the longer term. The domestic economic imbalances in the US, especially the fall in national savings and the accumulation of domestic and external debt are too severe for the US and the rest of the world to consider these trends going forward for good.

Over the short and medium-term, however, many economists consider the US current account deficit to be sustainable. Reserve accumulation by the emerging Asian economies, whose currencies closely follow the dollar, and the elevated oil price, which has transferred wealth to a few oil exporting countries with often still underdeveloped financial systems, leads to a steady flow of purchases of US dollar denominated financial assets.[1] This process also contributes to keeping bond yields low. Economists vary in their assessment of this situation, ranging from "temporarily stable disequilibrium" to "an equilibrium of global imbalances and low interest rates" (Caballero, Farhi and Gourinchas, 2006), but all concur that short-run sustainability is not an issue.[2]

Over the longer term things are looked at differently. In this perspective, stocks of assets and liabilities rather than flows, and the real side of the economy move into the forefront. Total US debt that now exceeds world GDP and three times US GDP has risen to levels surpassing those seen in the context of the Great Depression. In external trade, US imports have been soaring, while the US has been losing export market shares not only to China but also to key industrial competitors. Within the US the supply side has been strongly geared towards non-traded goods in recent years: housing, for example, a non-tradable par excellence, has been absorbing unprecedented shares of production factors. In 2005 the share of construction workers in payroll employment, a figure historically closely correlated with the current account, was the highest since 1959, and residential investment accounted for the biggest share in GDP in over 50 years. These are all developments suggesting non-sustainability in the long run. The cooling off of the housing market of 2006 and 2007 has so far attenuated the trend but not reversed it.

How are the external imbalances of the US likely to adjust? Several papers have looked into the adjustment from a demand side angle, considering that it would primarily be global demand that would shift away from foreign tradable goods to US tradable goods and US demand

[1] The Bretton Woods II paradigm refers to a dollar-standard with Asia now being the main counterpart region. Dooley, Folkerts-Landau and Garber (2003, 2004a and 2004b) have developed this eye-opening view by casting current developments into an institutional perspective for the international monetary system. The view is also shared by McKinnon (2006) who labels it the "East Asian Dollar Standard".

[2] There are a few contributions also aiming at justifying the low level of US savings, either because expenditure for education and research and development should enter the national accounts as savings (Cooper, 2005) or because higher future income growth will make up for it (Engel and Rogers, 2006).

shifting from (imported or domestically produced) traded goods to (domestically-produced) non-traded goods. These studies have also provided conclusions on the exchange rate change entailed in this process. The most famous of these papers are those by Obstfeld and Rogoff (2001, 2005, 2006) who examine various constellations of the demand shift and quantify the exchange rate implication. Many other prominent authors have pointed to the exchange rate implication of an adjustment in the US current account, including Feldstein (2006), Blanchard, Giavazzi and Sa (2005), Freund and Warnock (2006) or Roubini and Setser (2005).[3]

Obstfeld and Rogoff (2005 and 2006) develop a stylised general equilibrium framework in order to illustrate the "mechanics" of a current account rebalancing based on changes in the relative prices between traded and non-traded goods and eventually the terms of trade and the real exchange rate. They use this model to examine the implications of a closing up of the US current account deficit. In their analysis, the output of tradable and non-tradable goods is kept fixed and the entire adjustment is achieved through relative price and demand shifts. The key policy question in this analysis is the following: what is the rate of depreciation of the US dollar that would accompany such a scenario? In Obstfeld and Rogoff (2006) – which is used as the main reference point for our paper – the authors come to the conclusion that the real effective depreciation of the dollar would be substantial and comparable to the post 1985 decline of the dollar – 30% in real effective terms between March 1985 and April 1988 – that was enrobed in one of the largest efforts of international monetary cooperation centred on the Plaza-Louvre accords. The authors give as their "preferred scenario" that of a real effective dollar decline of 32%, although they also emphasise the possibility of a much larger depreciation of up to 64%.

This paper takes a long term view. It does not look at the question of sustainability itself but at the question of adjustment, focusing on the role of the exchange rate change and the supply-side change in the adjustment process. It tries to underscore the case that a turnaround in the external balance requires not only a demand shift away from imported goods to domestically produced goods but also a change on the supply side towards higher production of tradables. The latter supply side adjustment has a significant bearing on the exchange rate variation in the overall current account adjustment. Specifically, a supply side reaction is likely to attenuate the exchange rate change implied in models purely based on shifts in demand.

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[3] Feldstein (2006) calls for a "more competitive dollar". He even argues that this should occur "relative to the other major currencies of the world", thereby distancing himself from the view advocated by the G7 and others that focuses on exchange rate adjustment by the emerging economies. Blanchard, Giavazzi and Sa (2005) foresee a large dollar drop when foreigners stop financing the US, and Freund and Warnock (2006) as well as Roubini and Setser (2005) foresee an exchange rate adjustment in combination with a recession. However, it should be borne in mind that international linkages in models are mostly concentrating on exchange rates hence compared to the real world overstating the importance of the exchange rate in external adjustment.

We are particularly interested in whether and to which extent the exclusive focus on a price adjustment biases the findings of Obstfeld and Rogoff towards a higher depreciation than when allowing for endogenous production. We therefore challenge the assumption of an endowment economy and the entire adjustment being driven by changes of demand, and we extend their model to include also endogenous supply-side changes. Such an extension appears supported by actual developments showing that the sectoral supply of tradables and non-tradables varies quite significantly with the current account. Of course, the sectoral change is likely to be stretched over time depending inter alia on the overall flexibility of the economy to adjust. However, a certain supply driven adjustment channel is likely to be present in any current account reversal.

In order to highlight the impact of supply side changes, we present a modified version of the model in Obstfeld and Rogoff (2006). The supply-shift is introduced by transformation curves between tradable and non-tradable goods produced in the US and the rest of the world respectively. Hence any change in the relative price of non-tradables relative to domestically produced tradables will incur a shift in production from one sector to the other. A fall in this price will then not only imply a shift in demand from tradables to non-tradables, it will, in addition, increase the relative supply of tradable output. Accordingly, these two effects will help improve the trade balance, defined as output of tradable goods net of consumption of tradable goods. Because both effects work in the same direction, the necessary depreciation implied by a reduction of the current account deficit is smaller than in the case in which the entire adjustment rests solely on demand adjustments.

This extension has an important implication for the main conclusion of the paper regarding the exchange rate adjustment. We find that a supply side reaction would attenuate the exchange rate response, and under various scenarios significantly so. The reason is that the shift in supply towards tradable production would by itself contribute to narrowing the external deficit. The exact magnitude of the dampening of the exchange rate effect depends, like in Obstfeld and Rogoff, upon the parameters of substitution between foreign and domestic tradable goods, as well as domestic tradable and non-tradable goods. In what corresponds to their preferred scenario, we find that the effective exchange rate depreciation is reduced by a quarter to 24% in Obstfeld and Rogoff's preferred specification, but more importantly the implied depreciation is halved in the more "alarmist" scenario from 64% to 32%. In the most benign case, however, the implied depreciation drops from 18% to 5%.

The exchange rate dimension is not only relevant for global financial stability; it also bears an important welfare implication. The most immediate channel is that of valuation effects. There is strong evidence that a dollar decline would favour the US, given that its debt is denominated almost exclusively in dollars, while its assets are to a significant degree denominated in foreign currency (Tille, 2002; Lane and Milesi-Ferretti, 2005, 2006; Gourinchas and Rey, 2006). Cavallo and Tille (2006) have shown that valuation gains also help to make the adjustment more smoothly over time. Estimates suggest that a 10% decline in the dollar would imply a wealth transfer of close to $700 billion from the rest of the world to the US.[4] It would also imply potentially large changes for domestic prices in the economies concerned even though recent evidence points to a decline in pass-through globally (Campa and Goldberg, 2005; Marazzi et al, 2005; Gust and Sheets, 2006; Goldberg and Tille, 2006). And finally, large exchange rate changes could significantly impact bond yields, which could be another element impacting adversely the global economic environment (Mehl and Capiello, 2007). All these papers illustrate that exchange rate adjustment has many important implications for the economies involved.

Our angle of analysis provides for a refinement to the well-know policy paradigm relating to global imbalances: the US current account deficit is unlikely to close up without a substantial change in its own and its trading partners' industrial structure. Measures that go beyond demand policy management – i.e. through fiscal or monetary policy – but that also include areas of structural change, education, training, productive capacity in export sectors, infrastructure, as well as a different macroeconomic policy stance, would facilitate an orderly adjustment of the US current account deficit and hence of global imbalances.[5]

The paper is organised as follows. Section 2 extends the Obstfeld and Rogoff framework to allow for endogenous production; Section 3 reviews the model parameterisation and presents the simulation results; some empirical findings are summarised in Section 4; finally Section 5 concludes.

2 The Model

The model we employ is a variant of the set-up used by Obstfeld and Rogoff (2006). There, two large countries, the US and the rest of the world, are connected through trade and holdings of foreign assets. Both the US and the rest of the world produce a tradable and a non-tradable good. Domestic and foreign demand for non-tradable and domestic and foreign tradable goods is a function of relative prices in the four different sectors. The main innovation in the model presented here, is that – in contrast to Obstfeld and Rogoff (2006) – supply in all sectors is not fixed but – like demand – a function of relative prices in the four different sectors. This is implemented by introducing Cobb-Douglas type production functions with labour as the only input in each sector and profit maximising firms that allocate labour among the different sectors.

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[4] This assumes that about 65% of US external assets (about $ 11 trillion) and 5% of US external liabilities (about $ 14 trillion) are denominated in foreign currency.
[5] See Reeve (2006) for an analysis on the relation between factor endowments and industrial change.

Thus, for any given level of the current account balance, relative prices between the different goods, relative quantities in production and consumption in each of the two countries, the terms of trade, and the real exchange rate are simultaneously determined. We can then simulate changes in these variables that are consistent with changes – or a closing up – of the current account balance.

The demand side

We introduce the demand side through relative demand functions for tradable and non-tradable goods in the US and the rest of the world. These are derived from CES-aggregators of consumption goods, with asterisks denoting rest of the world variables:

$$C = \left[\gamma^{\frac{1}{\theta}} C_T^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_N^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{1}$$

$$C^* = \left[\gamma^{\frac{1}{\theta}} C_T^{*\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_N^{*\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{2}$$

C_N represents consumption of non-tradable goods produced in the respective country, and γ is a weight parameter of tradable goods. C_T represents aggregate consumption of tradable goods, consisting of goods produced in the US ("at home") and abroad, denoted C_H and C_F respectively:

$$C_T = \left[\alpha^{\frac{1}{\eta}} C_H^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} C_F^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{3}$$

$$C_T^* = \left[\alpha^{*\frac{1}{\eta}} C_F^{*\frac{\eta-1}{\eta}} + (1-\alpha^*)^{\frac{1}{\eta}} C_H^{*\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{4}$$

The shares α and α^* are assumed to be greater than 0.5 implying a home bias in tradable goods consumption. Crucial parameters in the analysis are the elasticities of substitution between non-tradables and tradables, θ, and between home and foreign tradables, η, for simplicity assumed to be equal in the US and the rest of the world.

For these consumption indices the standard price indices can be derived by optimizing the consumption index subject to some expenditure constraint:

$$P = \left[\gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{5}$$

$$P^* = \left[\gamma P_T^{*1-\theta} + (1-\gamma) P_N^{*1-\theta}\right]^{\frac{1}{1-\theta}} \tag{6}$$

$$P_T = \left[\alpha P_H^{1-\eta} + (1-\alpha) P_F^{1-\eta}\right]^{\frac{1}{1-\eta}} \quad (7)$$

$$P_T^* = \left[\alpha^* P_F^{*1-\eta} + (1-\alpha^*) P_H^{*1-\eta}\right]^{\frac{1}{1-\eta}} \quad (8)$$

P denotes the consumer price index and is defined as the minimum price for the purchase of a unit of the consumption bundle *C*.[6] P_T is, accordingly, a price index for tradable goods consumption in the US. By assumption the law of one price holds for tradables, i.e. $P_F = \varepsilon P^*_F$ and $P_H = \varepsilon P^*_H$ where ε is the nominal exchange rate expressed in US dollars per foreign currency unit. However, because of the home bias in tradable consumption the consumption indices and respective price indices in the US and rest of the world differ and purchasing power parity does not hold, i.e. generally $P \neq \varepsilon P^*$.[7]

The terms of trade τ are defined as the relative price of rest of the world and US tradable goods, and the real exchange rate q is given by the relative aggregate price levels, expressed in a common currency:

$$\tau = \frac{P_F}{P_H} = \frac{P_F^*}{P_H^*} \quad (9)$$

$$q = \frac{\varepsilon P^*}{P} \quad (10)$$

We denote the relative prices of the domestic and foreign non-tradable goods as ι and ι^*:

$$\iota = \frac{P_N}{P_H} \text{ and } \iota^* = \frac{P_N^*}{P_F^*} \quad (11)$$

From these definitions the precise relationship between the real exchange rate q and the three relative prices can be derived:

$$q = \left(\frac{\alpha^*\tau^{1-\eta} + (1-\alpha^*)}{\alpha + (1-\alpha)\tau^{1-\eta}}\right)^{\frac{1}{1-\eta}} \left(\frac{\gamma + (1-\gamma)\left(\alpha^* + (1-\alpha^*)\tau^{\eta-1}\right)^{\frac{\theta-1}{1-\eta}} \iota^{*1-\theta}}{\gamma + (1-\gamma)\left(\alpha + (1-\alpha)\tau^{1-\eta}\right)^{\frac{\theta-1}{1-\eta}} \iota^{1-\theta}}\right)^{\frac{1}{1-\theta}} \quad (12)$$

where q, τ and ι^* are positively related while q and ι move in opposite directions, i.e.

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[6] See Obstfeld and Rogoff (1996), Chapter 4.3-4.4.
[7] See Obstfeld and Rogoff (2006).

$$\frac{dq}{d\tau}, \frac{dq}{d\iota^*} > 0 \quad \text{and} \quad \frac{dq}{d\iota} < 0 \tag{13}$$

Through maximization of C subject to an expenditure constraint one obtains the demand functions for domestic non-tradable and tradable goods, Y_N^D and Y_H^D

$$Y_N^D = C_N = (1-\gamma)\left(\frac{P_N}{P}\right)^{-\theta} C \tag{14}$$

$$Y_H^D = C_H + C_H^* = \alpha\gamma\left(\frac{P_H}{P_T}\right)^{-\eta}\left(\frac{P_T}{P}\right)^{-\theta} C + (1-\alpha^*)\gamma\left(\frac{P_H/\varepsilon}{P_T^*}\right)^{-\eta}\left(\frac{P_T^*}{P^*}\right)^{-\theta} C^* \tag{15}$$

The above equations show that the demand for domestic non-tradables as well as the demand for domestic tradables decrease in their respective relative price. For the rest of the world corresponding equations apply. As we are not concerned with the determination of total period consumption and savings, which are usually determined in an intertemporal setting, but with relative demand for tradable and non-tradable goods, we write the demand for US tradables and non-tradables as a function of the tradables consumption index:

$$Y_H^D = \alpha\left(\frac{P_H}{P_T}\right)^{-\eta} C_T + (1-\alpha^*)\left(\frac{P_H/\varepsilon}{P_T^*}\right)^{-\eta} C_T^* \tag{16}$$

$$Y_N^D = \frac{1-\gamma}{\gamma}\left(\frac{P_N}{P_T}\right)^{-\theta} C_T \tag{17}$$

Expressing this in nominal terms and normalising by domestic tradables output yields:

$$1 = \alpha\left(\frac{P_H}{P_T}\right)^{1-\eta}\frac{P_T C_T}{P_H Y_H^D} + (1-\alpha^*)\left(\frac{P_H/\varepsilon}{P_T^*}\right)^{1-\eta}\frac{\varepsilon P_T^* C_T^*}{P_H Y_H^D} \tag{18}$$

$$\frac{P_N Y_N^D}{P_H Y_H^D} = \frac{1-\gamma}{\gamma}\left(\frac{P_N}{P_T}\right)^{1-\theta}\frac{P_T C_T}{P_H Y_H^D} \tag{19}$$

For the rest of the world these equations read as follows:

$$\frac{P_F Y_F^D}{P_H Y_H^D} = (1-\alpha)\left(\frac{P_F}{P_T}\right)^{1-\eta}\frac{P_T C_T}{P_H Y_H^D} + \alpha^*\left(\frac{P_F}{\varepsilon P_T^*}\right)^{1-\eta}\frac{\varepsilon P_T^* C_T^*}{P_H Y_H^D} \tag{20}$$

$$\frac{\varepsilon P_N^* Y_N^{*D}}{P_H Y_H^D} = \frac{1-\gamma}{\gamma}\left(\frac{P_N^*}{P_T^*}\right)^{1-\theta} \frac{\varepsilon P_T^* C_T^*}{P_H Y_H^D} \tag{21}$$

Hence relative demand is described by equations (18)-(21) above.

The supply side

Production of the four goods is described by Cobb-Douglas functions with labour as the only input:

$$Y_i^S = A_i L_i^\beta \text{ for } i = N,\ H,\ N^*,\ F \tag{22}$$

L_i is labour input in sector *i*, β the coefficient for the labour share in total output, assumed to be equal across sectors and countries, and A_i the total factor productivity in sector *i*. Assuming perfect integration of domestic sectoral labour markets and no international migration, there will be a single nominal wage rate ω in the US and a single wage rate ω^* in the rest of the world. Hence profit maximization requires equalisation of marginal value products to the same nominal wage in both sectors in the same country:

$$\beta P_N A_N L_N^{\beta-1} = \varpi = \beta P_H A_H L_H^{\beta-1} \tag{23}$$

Solving the production function for the relative quantities of non-tradable and tradable goods and the wage equation above for the relative labour input in the two sectors and substituting for labour yields the relative supply function:

$$\frac{Y_N^S}{Y_H^S} = \left(\frac{A_N}{A_H}\right)^{\frac{1}{1-\beta}} \left(\frac{P_N}{P_H}\right)^{\frac{\beta}{1-\beta}} \tag{24}$$

From this equation one can see that for plausible $\beta < 1$ the relative supply of non-tradable goods increases in their relative price. Furthermore, rearranging the equation shows that also the share in output increases in the relative price, ι.

$$\frac{P_N Y_N^S}{P_H Y_H^S} = \left(\frac{A_N}{A_H}\iota\right)^{\frac{1}{1-\beta}} \tag{25}$$

This equation describes a simple production possibility frontier. For the rest of the world this relationship is:

$$\frac{P_N^* Y_N^{*S}}{P_F^* Y_F^S} = \left(\frac{A_N^*}{A_F}\iota^*\right)^{\frac{1}{1-\beta}} \tag{26}$$

A similar equation for relative supply of US and rest of the world tradable output is a function of the terms of trade, the relative nominal wage and relative total factor productivities, where the production of domestic tradable relative to foreign tradable goods increases in the productivity differential and the terms of trade and decreases in the wage differential:

$$\frac{P_F Y_F}{P_H Y_H} = \left(\frac{A_F}{A_H}\left(\frac{\varepsilon\varpi^*}{\varpi}\right)^{-\beta}\tau\right)^{\frac{1}{1-\beta}} \tag{27}$$

From the three preceding equations relating to the production frontier one can see that the Obstfeld and Rogoff model is a special case of the one proposed here, with β set zero and relative quantities therefore only determined by – exogenous – factor productivities.

Relative wages in turn are determined through the firms' first order conditions which can be re-written as:

$$L_H = \left(\frac{\varpi}{\beta P_H A_H}\right)^{\frac{1}{\beta-1}} \tag{28}$$

$$L_N = \left(\frac{\varpi}{\beta P_N A_N}\right)^{\frac{1}{\beta-1}} \tag{29}$$

Using the definition for economy-wide labour input as $L=L_H+L_N$ yields:

$$\frac{\varpi}{P_H A_H} = \beta\left[\frac{1+\left(\iota\frac{A_N}{A_H}\right)^{\frac{1}{1-\beta}}}{L}\right]^{1-\beta} \tag{30}$$

For the rest of the world, with $L^*=L^*_N+L^*_H$, an equivalent equation applies:

$$\frac{\varepsilon\varpi^*}{P_F A_F} = \beta \left[\frac{1 + \left(\iota^* \frac{A_N^*}{A_F} \right)^{\frac{1}{1-\beta}}}{L^*} \right]^{1-\beta} \tag{31}$$

Combining these two equations and re-arranging them yields an expression in terms of relative prices and total factor productivities that completes the supply side of the economy:

$$\frac{\varepsilon\varpi^*}{\varpi} = \left(\frac{L}{L^*} \right)^{1-\beta} \left[\frac{1 + \left(\iota^* \frac{A_N^*}{A_F} \right)^{\frac{1}{1-\beta}}}{1 + \left(\iota \frac{A_N}{A_H} \right)^{\frac{1}{1-\beta}}} \right]^{1-\beta} \frac{A_F}{A_H} \tau \tag{32}$$

General equilibrium

A general equilibrium is defined as a vector of relative prices (τ, ι, ι^*, ω^*/ω, q) for which

(a) goods markets clear, i.e.

$$Y_i^D = Y_i^S \quad \text{for } i = N,\ H \quad \text{and} \quad Y_i^{*D} = Y_i^{*S} \quad \text{for } i = N^*,\ F \tag{33}$$

and (b) the current account identity, which is the sum of net absorption of tradables and the income balance, holds:

$$CA = P_H Y_H + iF - P_T C_T \tag{34}$$

$$\varepsilon CA^* = \varepsilon P_F^* Y_F - iF - \varepsilon P_T^* C_T^* = -CA \tag{35}$$

Here F is the stock of net foreign assets and i the interest rate. Combining the above results yields a system of five simultaneous equations in the five endogenous variables τ, ι, ι^*, ω^*/ω and q, where *ca* and *if* denote the current account and income balance as a share of tradable output:

$$1 = \frac{\alpha}{\alpha + (1-\alpha)\tau^{1-\eta}}(1 + if - ca) + \frac{1-\alpha^*}{\alpha^*\tau^{1-\eta} + 1 - \alpha^*} \left[\tau^{\frac{1}{1-\beta}} \left(\frac{\varepsilon\varpi^*}{\varpi} \right)^{\frac{\beta}{\beta-1}} \left(\frac{A_F}{A_H} \right)^{\frac{1}{1-\beta}} - if + ca \right] \tag{36}$$

$$\iota = \left[\frac{1-\gamma}{\gamma} \left(\alpha + (1-\alpha)\tau^{1-\eta} \right)^{\frac{\theta-1}{1-\eta}} (1 + if - ca) \left(\frac{A_N}{A_H} \right)^{\frac{1}{\beta-1}} \right]^{\frac{1-\beta}{\beta + (1-\beta)\theta}} \tag{37}$$

$$\iota^* = \left[\frac{1-\gamma}{\gamma}\left(\alpha^* + (1-\alpha^*)\tau^{\eta-1}\right)^{\frac{\theta-1}{1-\eta}}\left(1+\left(\frac{\varepsilon\varpi^*}{\varpi}\right)^{\frac{\beta}{1-\beta}}\left(\frac{A_F}{A_H}\right)^{\frac{1}{\beta-1}}\tau^{\frac{1}{\beta-1}}(-if+ca)\right)\left(\frac{A_N^*}{A_F}\right)^{\frac{1}{\beta-1}}\right]^{\frac{1-\beta}{\beta+(1-\beta)\theta}} \tag{38}$$

$$\frac{\varepsilon\varpi^*}{\varpi} = \left(\frac{L}{L^*}\right)^{1-\beta}\left[\frac{1+\left(\iota^*\frac{A_N^*}{A_F}\right)^{\frac{1}{1-\beta}}}{1+\left(\iota\frac{A_N}{A_H}\right)^{\frac{1}{1-\beta}}}\right]^{1-\beta}\tau\frac{A_F}{A_H} \tag{39}$$

$$q = \left(\frac{\alpha^*\tau^{1-\eta}+(1-\alpha^*)}{\alpha+(1-\alpha)\tau^{1-\eta}}\right)^{\frac{1}{1-\eta}}\left(\frac{\gamma+(1-\gamma)\left(\alpha^*+(1-\alpha^*)\tau^{\eta-1}\right)^{\frac{\theta-1}{1-\eta}}\iota^{*1-\theta}}{\gamma+(1-\gamma)\left(\alpha+(1-\alpha)\tau^{1-\eta}\right)^{\frac{\theta-1}{1-\eta}}\iota^{1-\theta}}\right)^{\frac{1}{1-\theta}} \tag{40}$$

The first four equations completely describe the equilibrium of the model while the last one is the resulting real exchange rate.[8]

3 Rebalancing the current account

In the following we compute two sets of relative equilibrium prices, one with the US current account being in a deficit range broadly corresponding to the level observed in recent years and another set of relative prices with the current account being balanced. These two sets of equilibrium prices allow us to compute the real depreciation implied by the closing of the current account deficit as the logarithmic difference of the real exchange rate. Furthermore, the movements in the terms of trade, the relative prices of non-tradable goods and the relative outputs can be derived. Hence we can differentiate between the contribution of quantities and prices to the hypothetical rebalancing of the US current account. In order to allow for a direct comparison, we choose the same parameters and initial relative quantities as Obstfeld and Rogoff (2006).

Parameter choice and calibration approach

The baseline parameter choice follows Obstfeld and Rogoff (2006) with α=0.7, α^*=0.925, and γ=0.25. Furthermore, we also report results for different combinations of θ and η, i.e. the elasticities of substitution between tradable and non-tradable goods as well as between domestic and foreign produced tradables.[9] The labour share β is set to 0.7 in our benchmark paramterisation although results are not sensitive to this choice as is shown in the Appendix.[10]

[8] Because of Walras' Law one of the four goods market equations is redundant, allowing us to eliminate one of them.

[9] For a discussion of the other parameters see Obstfeld and Rogoff (2006).

[10] Data on labour compensation taken from the Industry Growth Accounting Database of the Groningen Growth and Development Centre indicate a labour share of between 0.7 and 0.74 between 1980 and 2001.

We make the same assumption as Obstfeld and Rogoff (2006) with respect to the original relative quantities in order to allow comparisons to be as transparent as possible:

$$\frac{Y_N}{Y_H} = \frac{Y_N^*}{Y_F} = 1 \tag{41}$$

and

$$\frac{Y_F}{Y_H} = 4.55 \tag{42}$$

In principle it would be desirable if relative prices multiplied with relative quantities resulted in observable relative sector sizes. However, results do not change significantly when choosing initial quantities such that this feature is fulfilled.

The assumptions on (initial) relative quantities imply values for relative total factor productivities, assumed to be constant, once relative prices and relative nominal wages are determined. We calculate them by solving the relative output relations for the relative total factor productivities:

$$\frac{A_N}{A_H} = \left(\frac{Y_N}{Y_H}\right)^{1-\beta} \iota^{-\beta} \tag{43}$$

$$\frac{A_N^*}{A_F} = \left(\frac{Y_N^*}{Y_F}\right)^{1-\beta} \iota^{*-\beta} \tag{44}$$

$$\frac{A_F}{A_H} = \left(\frac{Y_F}{Y_H}\right)^{1-\beta} \left(\frac{\varepsilon\varpi^*}{\varpi}\right)^{\beta} \tau^{-\beta} \tag{45}$$

For the initial *ca*, which is the current account expressed as a share of the value of domestic tradable production, we follow Obstfeld and Rogoff (2006) and assume a value of -0.2. Obstfeld and Rogoff take this value as consistent with a current account deficit of 5% of GDP and the assumption of around a quarter of total output being tradable. *f* and *i* are set to -0.8 and 0.05 and assumed to be constant, i.e. the net foreign asset position and the income balance are kept at around -20% and -1% of GDP.[11]

As a last assumption we need to assign a value to $(L/L^*)^{1-\beta}$. At first sight, it is hard to see why one should not treat this term as an endogenous expression because changes in hours are

[11] See Cavallo and Tille (2006) for an analysis in which the income balance is allowed to change due to valuation effects.

likely to occur in an adjustment process. However, two reasons speak in favour of treating this as a constant. First, since we abstract from consumers' and workers' intertemporal optimization decisions, we assume a constant consumption index *C*, which in more elaborate frameworks is determined by respective Euler equations. If the determination of *C* is assumed as exogenous, the same should apply for the total labour supply *L*. Second, according to data from the Groningen Growth and Development Center, $(L/L^*)^{1-\beta}$ fluctuated almost not at all for the available time series between 1980 and 2002 and all changes over the last twenty years are reflected in lower digit variations. For β=0.7 it is 0.8.

Simulation results

The results of the simulation exercise are presented in Tables 1 and 2, jointly with the benchmark results of Obstfeld and Rogoff, denoted "w/o supply". Three main results are noteworthy.

First of all, the most striking feature is the reduced real depreciation in all specifications with the greatest reductions occurring at low elasticities of substitution between tradable and non-tradable goods. For Obstfeld and Rogoff's most "alarmist" scenario the implied depreciation is halved, from 64% to 33%, and in their baseline case the depreciation is reduced by a quarter, from 32% to 24%. Also, as shown in Tables 8 and 9 of the Appendix, results are robust to the parametrisation of the labour share in output. As the Obstfeld and Rogoff framework is equivalent to assuming β=0 or fixed sectoral supply in the very short run, the case of β=1 can be interpreted as the opposite extreme or very long run scenario.[12] However, the reduction of the implied depreciation is already substantial for realistically low labour shares.

Table 1: Changes of real exchange rate and terms of trade

Parameters		**Real depreciation**		**TOT depreciation**		**ROW/US quantity**
θ	η	**w/o supply**	**with supply**	**w/o supply**	**with supply**	**with supply**
0,5	2	64	33	16	24	-22
1	2	32	24	16	21	-13
1	3	26	17	9	13	-13
2	2	19	18	16	18	-6
2	3	14	12	9	11	-7
1	1000	18	5	0	0	-66

Notes: Changes in percent. θ refers to the elasticity of substitution between tradables and non-tradablen, η refers to the elasticity of substitution between domestic and foreign tradables.

Secondly, the exchange rate hardly moves as long as foreign and domestic tradable goods are close substitutes, as illustrated by a very high elasticity of substitution between foreign and

[12] For all parameterizations the depreciation falls when β increases (Table 8 in the Appendix).

domestic tradable goods of η=1000, and θ=1. In fact, the exchange rate depreciation already falls below 10% when using an elasticity of substitution between foreign and domestic tradables of η=6 while in the same parameterisation it would still be as high as 21% when not allowing for an endogenous supply side change (not reported in Table 1).

A third result refers to the terms of trade. At first sight possibly surprisingly, these move more in the case of endogenous production. This is explained by the fact that the relative output of foreign to domestic tradables, for which the terms of trade are the relative price, falls due to the domestic tradables output expansion. In order for the bigger domestic quantity to be absorbed by the market, its relative price has to fall by more relative to its foreign (imperfect) substitute. Hence the depreciation of the terms of trade is larger than in the Obstfeld and Rogoff setup.

The relative price of domestic tradable and domestic non-tradable goods as well as the relative price of foreign tradable and foreign non-tradable goods move less for all specifications, contributing to the reduction of the depreciation of the real exchange rate (Table 2). In the case of very low demand elasticity the fall in the relative price of domestic non-tradables and domestic tradables is huge, from 43% to 8%. Hence the main impact of the introduction of the supply changes is on the relative price of non-tradables when demand is relatively inelastic. The "bottleneck" of sluggish demand response which is responsible for the big price adjustment is thus circumvented by the supply response. The impact is much lower for higher demand elasticities.[13]

Table 2: Changes in US and ROW relative price and quantity of non-tradables

Parameters		US non-tradables vs tradables			ROW non-tradables vs tradables		
		Price		Quantity	Price		Quantity
θ	η	w/o supply	with supply	with supply	w/o supply	with supply	with supply
0,5	2	-43	-8	-19	11	2	5
1	2	-19	-6	-13	5	2	4
1	3	-19	-6	-13	5	1	3
2	2	-7	-3	-7	2	1	2
2	3	-8	-4	-8	2	1	2
1	1000	-19	-6	-13	4	2	4

Notes: Changes in percent. θ refers to the elasticity of substitution between tradables and non-tradablen, η refers to the elasticity of substitution between domestic and foreign tradables.

A final note refers to the magnitude of the quantity adjustment. At first sight, the implied increase in the relative volume of tradable production of between 7% and 19% might seem rather big. However, the overall effect on the share of tradable output in total GDP is comparable and

[13] Here a closer look at the role played by the size of the labour share parameter is insightful (Table 9 in the Appendix). With increasing values of β the price change falls, finally approaching zero for the constant returns to scale case where the entire adjustment rests on quantity changes.

even somewhat smaller than as implied by the original Obstfeld and Rogoff framework. Assuming an initial share of tradable output of around 25% of nominal GDP (which is implicitly underlying the parametrisation of both the original Obstfeld and Rogoff model and the extension proposed in this paper) the share of tradable output increases by less than five percentage points of GDP in nearly all specifications. Only in the case of θ=0.5 the share of tradable output in nominal GDP increases to slightly above 30%. In the original Obstfeld and Rogoff framework, however, the increase is much bigger and the share of tradable output approaches 40% of GDP.

A final remark relates to two contributions to the literature incorporating adjustments on the supply side. The first one is Obstfeld and Rogoff (2006) who analyse an alternative scenario where the adjustment is accompanied by a change in relative output driven by a boost to productivity in the tradable goods sector. However, the authors claim that an increase of 20% of tradables output underlying this exercise is unrealistic and hence this analysis supposedly of little use. In our analysis the relative output change is between 7% and 13% (in the cases which Obstfeld and Rogoff present for this exercise) while the real depreciation is comparable to that reported by Obstfeld and Rogoff. Hence the relative output change required is significantly less than what Obstfeld and Rogoff had in mind and it does not need to rely on unrealistic assumptions for productivity changes.

The second contribution is Engel and Rogers (2006) who explicitly allow the share of tradable output to vary over time in response to changes in relative productivity between the domestic and foreign tradables and non-tradables sector and do find a significant effect of relative productivity and hence supply changes in the tradable sector on the real exchange rate. However in their approach, it is the change in relative productivity that is exogenous. Therefore our analysis is not comparable to the exercises undertaken by Obstfeld and Rogoff and Engel and Rogers, as we stress the endogenous nature of both demand and supply and the structural change that is inevitably involved in the closing of the US current account. Furthermore, we highlight the role for sectoral adjustments in the current account reversal which is of particular interest for economic policy which may have to support the sectoral migration pattern in order to prevent widespread unemployment.

4 Stylised facts

This section provides some stylised facts and empirical evidence that support our theoretical findings of Section 3. While the aim of this section is not to provide an econometric "test" of the model in a strict sense, it presents some evidence in favour of a long-run relation between the supply side structure, the real exchange rate, and the current account. First, we find that the share of tradable goods in total output – when measured in the "traditional" way as an aggregate of agriculture, mining and manufacturing products – appears to be on a declining trend. Second, this is not due to "shrinking" production, but rather reflects productivity increases and declining relative prices whereas the volume of tradables production has not declined (relative to that of non-tradable production) over the last thirty years. Third, we find that a broader measure of tradable output that accounts for an increased tradability of high-skilled technical and professional services does not display a downward trend. Fourth, the relative volume of tradable goods in total production displays considerable volatility, allowing for sectoral adjustment as modelled in Section 3. Finally, we find some empirical support for our claim that the relative volume of tradable production co-moves (positively) with the relative price and that both significantly (and positively) correlate with the current account balance.

For a sample of up to 28 OECD countries including the United States, we find that a depreciation of the currency by 10 percent is on average accompanied by an increase in the *volume* of tradable goods relative to non-tradable goods of between 5½ and 7 percent. A 10 percent increase of relative tradable output improves the current account by around 2 to 3 percentage points.

Value, volume and price of tradable goods

How much of US GDP is tradable? The theoretical literature neatly divides production into tradable and non-tradable goods, but in practice this distinction is less straightforward. Traditionally, the empirical literature has used a rather narrow definition of the tradable sector consisting of agriculture, mining and quarrying, and manufacturing.[14] In principle however, a very large part of goods and services can be traded – though at varying costs – and therefore the tradable share of output is likely to be understated. In an attempt to find a more formal definition of "tradability" of goods the empirical literature has resorted to the concept of "tradedness" as a proxy of tradability. According to this definition, tradable goods are identified through a relatively high share of international trade relative to the production of these goods. Alternatively, tradable goods have been defined as such goods that are either substantially exported or imported relative to their total domestic production.[15] The tradable sectors as identified by this more formal approach broadly concur with those traditionally said to be tradable.[16] However, also measures based on the actual "tradedness" are by construction likely to understate the true degree of "tradability", especially in a large economy like the US. More recently, Mann (2003, 2004) and Jensen and Kletzer (2005) have emphasised the increased "tradability" of professional, scientific and technical services, as well as financial services. However, lack of reliable disaggregated data

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[14] See, for example, Kravis and Lipsey (1988).
[15] See, for example, Goldstein and Officer (1979) and Goldstein, Khan and Officer (1980).
[16] See, for example De Gregorio, Giovanni and Wolf (1994).

on trade flows in the service sectors makes it difficult to give an estimate of the share of tradable services.

Table 3: Tradable output in % of GDP

Country	Narrow definition			Broad definition		
	1980	**2003**	**Average pp change**	**1980**	**2003**	**Average pp change**
Australia	32	21	-0.5	50	50	0.0
Austria	30	22	-0.3	43	45	0.1
Belgium	27	19	-0.3	45	47	0.1
Canada	31	26	-0.2	48	52	0.2
Denmark	24	20	-0.2	44	44	0.0
Finland	37	26	-0.4	50	48	-0.1
France	30	19	-0.5	53	50	-0.1
Greece	32	19	-0.5	48	39	-0.4
Iceland	33	22	-0.5	50	43	-0.3
Italy	36	22	-0.6	52	49	-0.1
Japan	31	21	-0.4	50	49	0.0
Korea	43	31	-0.5	54	52	-0.1
Netherlands	28	19	-0.3	43	46	0.1
New Zealand	33	27	-0.3	47	53	0.3
Norway	35	31	-0.2	50	50	0.0
Portugal	35	20	-0.6	49	39	-0.4
Spain	35	20	-0.6	50	40	-0.4
Sweden	27	22	-0.2	43	47	0.2
United Kingdom	35	17	-0.7	51	48	-0.1
United States	26	16	-0.4	48	48	0.0
Average	**32**	**22**	**-0.4**	**48**	**47**	**-0.1**

Notes: Narrow defintion of tradables includes agriculture, hunting, forestry and fishing, mining and quarrying, total manufacturing. Broad definition adds finance, insurance, real estate and business services. For Austria, Norway data start in 1981; for Australia, Canada, New Zealand data end in 2001; for Iceland data end in 2002.

Table 3 reports two different measures of the share of tradable output in total GDP for 20 OECD economies.[17, 18] The narrow definition refers to the combined shares of (i) *agriculture, hunting, forestry and fishing,* (ii) *mining and quarrying,* and (iii) *total manufacturing* in GDP. The second measure adds *finance, insurance, real estate and business services*. Data are taken from the OECD Structural Analysis Statistics which provide information on value added in constant and current prices in 57 sectors.[19] While the narrow measure of tradable output certainly fails to capture some activities that are either traded or at least in principle tradable, the broader measure serves as an upper bound in identifying the size of the tradable goods sector. Using the

[17] For Ireland there are no disaggregated volume indices. For Mexico sufficiently disaggregated volume indices only start in 1988. For Luxembourg, Switzerland, Germany, Hungary, Czech Republic, Poland, Slovak Republic data 1985, 1990, 1991, 1991, 1990, 1992, 1993, respectively.
[18] Time series are plotted in Figure 1.
[19] The OECD Structural Analysis Statistics are based on the United Nations' *International Standard Industrial Classification of all Economic Activities, Revision 3* (ISIC Rev. 3).

narrow definition, we indeed find that in all countries included in the sample the share of the tradable goods sector has substantially declined over the last two and a half decades. While at the beginning of the 1980s tradable goods accounted for on average around 32% of GDP, by 2003 their share in total valued added had shrunk by roughly one third to 22% of GDP, an average reduction of around 0.4% of GDP per year. This is also the case for the US, which in 2003 displayed the lowest share of tradable goods of 16% of GDP.

Interestingly, the broader definition of tradable goods including financial, scientific, and technical services provides a very different picture. First, there has been no clear downward trend in the broader measure, reflecting the increase of the services sector across all countries. Secondly, possibly owing to the particular importance of the services and especially financial sector in the US, the broader measure for the US concurs with the average observed across countries.

The observed differences are in line with the literature's explanation for the decline of the tradables sector as commonly defined. The literature provides two complementary explanations for this downward trend in the share of tradables. First, differential productivity increases may have lowered the relative price of tradables possibly contributing to a lower share of the value of tradable goods in total value added. A second explanation is that economic growth tends to contribute to a shift of relative demand towards the non-tradable sector.[20] While a supply induced reduction of relative prices should naturally correlate with an increase in the relative *volume* of tradable goods production, the demand based explanation implies a reduction in both the price and volume of tradable goods.

We construct value-weighted volume indices for both tradable and non-tradable goods from the disaggregated data.[21] Price indices are constructed as deflators of value added in both sectors. Finally *relative* volume and price indices are calculated. Table 4 summarises the results, and the corresponding time series are presented in Figures 2–4 of the Appendix.

The relative price of tradable goods as traditionally defined has declined over our sample by on average around 30% implying an inflation differential between the non-tradable and tradable goods sectors of around 1.3% per year. When using the broader measure, however, the inflation differential decreases to around 0.4% per year which is roughly equivalent to a 10% decrease in the relative price of tradables over the sample period. Interestingly, the US have witnessed a relatively sharp decline in the relative price of tradables according to the narrow definition (1.9%) while when using the broad definition including financial and other business services the decrease has been in line with the average over all countries.

[20] See, for example De Gregorio, Giovanni and Wolf (1994).
[21] Goldstein and Officer (1979) show that this is in fact superior to simply using export and import price indices.

Table 4: Average annual percentage change of relative price and volume of tradables 1980–2003

Country	Percent change in relative price		Percent change in relative volume	
	Narrow defintion	Broad definition	Narrow defintion	Broad definition
Australia	-1.5	-0.5	-0.7	0.4
Austria	-1.4	-0.1	-0.1	0.5
Belgium	-1.0	0.0	-0.7	0.4
Canada	-0.8	-0.2	-0.2	0.9
Denmark	-1.0	-0.3	0.1	0.3
Finland	-1.9	-1.2	0.6	1.1
France	-1.0	0.6	-1.1	-0.9
Greece	-0.3	0.0	-2.0	-1.3
Iceland	-0.5	-0.7	-1.6	-0.4
Italy	-1.5	-0.5	-1.0	0.1
Japan	-1.5	-0.8	-0.2	0.8
Korea	-2.1	-1.4	0.9	1.6
Netherlands	-1.0	-0.2	-0.7	0.7
New Zealand	-0.8	1.5	-0.5	-0.2
Norway	-1.3	-0.6	0.7	0.7
Portugal	-1.6	-1.9	-1.1	0.9
Spain	-1.7	-1.0	-0.8	-0.5
Sweden	-1.8	-0.6	1.6	1.6
United Kingdom	-1.5	0.4	-1.6	-0.8
United States	-1.9	-0.3	0.1	0.3
Average	**-1.3**	**-0.4**	**-0.4**	**0.3**

Notes: Narrow defintion of tradables includes agriculture, hunting, forestry and fishing, mining and quarrying, total manufacturing. Broad definition adds finance, insurance, real estate and business services. For Austria, Norway data start in 1981; for Australia, Canada, New Zealand data end in 2001; for Iceland data end in 2002.

Results for the relative volume of tradables are less homogeneous. In fact, although 14 out of the 20 countries summarised in Table 4 have witnessed a decrease also in the relative volume of tradables when measured using the narrow aggregate – suggesting that there has indeed been a demand shift away from tradables – in a few countries the share of tradables has increased, including the US for which however the increase has been rather modest. Broadening the definition of the tradable goods sector even turns the picture. According to the broad measure, the relative volume of tradable goods in total production has actually increased by on average 0.3% per year, including for the US. Finally, while there is no clear trend in the relative volume of tradable production, the series displays considerable volatility. As summarised in Table 5, the average annual *absolute* percentage change of the relative volume of tradables lies between 2.6% (for the broader measure) and 2.9% (for the narrow measure). These findings are an indication that substantial sectoral factor reallocation is taking place over time and suggest that significant sectoral change is possible over a medium term horizon.

Table 5: Average annual absolute percentage changes 1980–2003

Country	Absolute percent change in relative price		Absolute percent change in relative volume	
	Narrow defintion	Broad definition	Narrow defintion	Broad definition
Australia	3.1	2.1	2.2	1.5
Austria	1.8	1.1	1.7	1.5
Belgium	3.0	3.8	2.5	3.8
Canada	3.4	1.9	3.0	1.5
Denmark	2.7	1.6	2.6	2.2
Finland	3.4	2.4	3.3	2.7
France	2.5	4.1	3.2	3.7
Greece	3.4	3.6	4.9	5.2
Iceland	5.4	5.5	5.1	5.2
Italy	2.0	1.2	1.9	1.1
Japan	2.2	1.1	2.7	1.6
Korea	3.7	2.7	4.0	3.3
Netherlands	2.7	1.5	1.9	1.6
New Zealand	4.3	2.9	2.6	2.4
Norway	8.4	5.3	2.8	1.8
Portugal	4.0	5.9	4.2	6.2
Spain	2.7	1.5	1.7	1.1
Sweden	3.0	2.2	3.5	2.2
United Kingdom	3.2	2.3	2.3	1.6
United States	2.8	1.0	2.4	1.6
Average	**3.4**	**2.7**	**2.9**	**2.6**

Notes: Narrow defintion of tradables includes agriculture, hunting, forestry and fishing, mining and quarrying, total manufacturing. Broad definition adds finance, insurance, real estate and business services. For Austria, Norway data start in 1981; for Australia, Canada, New Zealand data end in 2001; for Iceland data end in 2002.

Tradable output, the exchange rate and the current account

In what follows, we briefly examine co-movements between the current account and the relative volume and relative price of tradables as well as the real exchange rate. In doing so, we focus on two questions. First, we want to assess whether changes in the relative price of tradables have an impact on the (relative) supply of tradables. In particular, we want to explore whether an increase in the relative price of tradables can trigger a reallocation of production factors to the tradable goods sector and eventually result in an increase in the relative supply of tradables. Second, we want to assess whether there is a link between the production of tradable goods and the current account, i.e. whether an increase in the relative quantity of tradable goods produced results in an improvement of the current account.

Concerning the first hypothesis, our analysis is subject to two caveats. First – as noted above – the analysis suffers from an identification problem. While (supply side) shocks to productivity imply a negative correlation between the price and the volume of tradable goods, demand shocks would tend to yield a positive correlation between the price and the volume of tradables. Second, our hypotheses focus on long-term developments which are extremely difficult to isolate from other factors that impact the volume and price of tradable goods production and the current account.

In order to capture the long run dimension of the relation between the real exchange rate and the relative volume of tradable goods in total production we run an error correction type regression that tests for a long run relation between the real exchange rate and the relative volume of tradable goods and short run adjustments of the volume of tradables to deviation from the long run equilibrium. As error-correction implies co-integration between the two variables we test for a unit-root in the levels of the real exchange rate and the relative volume of tradable output. As we fail to reject the hypothesis of a unit-root in the level, while we can reject the hypothesis of a unit-root in the first difference we proceed under the assumption of first order integration (results are reported in Table 10 of the Appendix). The error-correction equation takes the following form:

$$\Delta YNYH_{i,t} = \alpha_i + \beta(YNYH_{i,t-1} - \gamma REER_{i,t-1}) \quad (46)$$

YNYH is the natural logarithm of the relative volume of non-tradable and tradable output, $\Delta YNYH$ denotes the percent change in the relative volume, and *REER* is the natural logarithm of the real exchange rate (where an increase represents an appreciation). A positive value for γ indicates a positive long-run relationship between the relative volume of non-tradables and the real exchange rate. Temporary deviations from this long-run equilibrium are adjusted each period by a fraction β of the disequilibrium.

Table 6: Error correction model of real exchange rate and tradable output

Tradable aggegate	Adjustment coefficient	Long run coefficient	R-squared	Number of observations
Narrow defintion				
full sample	-0.12 (-5.62)	0.71 (3.52)	0.16	515
excluding EMEs	-0.11 (-5.18)	0.70 (3.01)	0.15	448
Broad defintition				
full sample	-0.11 (-6.40)	0.54 (2.57)	0.17	515
excluding EMEs	-0.11 (-5.87)	0.55 (2.09)	0.17	448

Results are summarised in Table 6. First, we find that the long run coefficient γ is statistically significant both when using the narrow and – although to a lesser extent – when using the broad definition of tradable goods. Second, the coefficient is also economically significant, as it implies that a 10 percent depreciation on average results in a long run increase of the relative volume of tradable to non-tradable output by between around 7% when using the narrow measure or around 5.5% when using the broad measure. This estimated long run coefficient is in fact consistent with the elasticities as implied by the model simulation in Section 3. The adjustment coefficient β is significant and has the expected sign, indicating that the share of tradables in output indeed adjusts to the long-run equilibrium. Finally, the residuals from the error correction regression are well behaved and serially uncorrelated. Unit-root tests on the residuals (as reported in Table 11 of the Appendix) fail to reject the hypothesis of a unit-root in the residuals thus lending support to our hypothesis of cointegration between the real exchange rate and the relative volume of tradable output.

A final note refers to the relation between the volume and price of tradables and the nominal current account. As we are interested in the long-run correlation of the production of non-tradable goods (and their relative price) and the current account, we divide our sample into four five-year windows and regress five-year changes in the current account (*CAGDP*) on five-year percentage changes in the relative volume (*YNYH*) and price (*PNPH*) of non-tradable goods over the same period:

$$\Delta CAGDP_{i,t} = \alpha + \beta \Delta YNYH_{i,t} + \gamma \Delta PNPH_{i,t} \tag{47}$$

Results are summarised in Table 7. While we do not aim at postulating a causal relation-ship, our results clearly show that indeed there is significant co-movement between the current account and both the quantities and prices of tradable production. In all specifications, the coefficients on both the percentage change of the relative volume of non-tradable goods and the percentage change of the relative price of non-tradable goods are highly significant and have the expected sign. The point estimates for the relationship between the relative volume and the current account suggests that a 10 percent decrease in the relative volume of non-tradable goods is on average accompanied by an improvement in the current account between 1.8 and 2.7 percentage points. Furthermore, a 10 percent decrease in the relative price of non-tradables comes with an improvement of the current account by between 1 to 2 percentage points.

In summary, the stylised facts and empirical evidence presented in this section render support to the theoretical findings developed in Section 2 and 3. In particular, the supply of tradable goods displays considerable volatility and tends to adjust to price changes. For a sample of up to 28 OECD countries including the United States, we find that a depreciation of the currency by 10 percent on average increases the *volume* of tradable goods relative to non-tradable goods by between 5% and 7.5%. and that a 10 percent increase of relative tradable output comes on average with an improvement of the current account by around 2 percentage points. These findings are broadly in line with our simulation results in Section 3.

Table 7: Regression of current account on relative volume and price

Tradable aggegate	Change in relative volume	Change in relative price	R-squared	Number of observations
Narrow defintion				
full sample	-0.18 (3.62)	-0.11 (2.72)	0.14	87
excluding EMEs	-0.21 (3.73)	-0.11 (2.36)	0.16	77
Broad defintition				
full sample	-0.26 (4.96)	-0.20 (3.73)	0.23	87
excluding EMEs	-0.27 (4.68)	-0.20 (3.49)	0.23	77

5 Conclusions

This paper contributes to the literature on the adjustment of global imbalances in several ways. First, it adds to the recent policy-oriented literature that provides a number of extensions of the Obstfeld and Rogoff model that emphasise the considerable sensitivity of stylised models of the current account not only to calibration but also to assumptions on the structure of the economy.

Second, the paper shows how changes in the industrial structure of an economy are linked to the current account and hence – within the Obstfeld and Rogoff framework – to the exchange rate. In particular, allowing for an endogenous supply – or some flexibility in the industrial structure of the economy responding to price signals – significantly attenuates the exchange rate change implied in the Obstfeld and Rogoff framework. Moreover, supply side changes will almost "mechanically" share part of the burden in a current account adjustment.

Our findings suggest that supply-side policies, including those to increase productivity in the US export sectors, would facilitate the external adjustment by alleviating an exclusive reliance on demand and exchange rate changes. Therefore, our angle of analysis provides for a refinement to the well-know paradigm relating to global imbalances: the US current account deficit is unlikely to close up without a substantial change in its own and its trading partners' industrial structure. Measures that go beyond demand policy management – i.e. through fiscal or monetary policy – but that also include areas of structural change, education, training, productive capacity in export sectors, infrastructure, as well as a different macroeconomic policy stance, would facilitate an orderly adjustment of the US current account deficit and hence of global imbalances.

Appendix

Table 8: Alternative labour share: Changes of real exchange rate and terms of trade

Parameters		Real depreciation			TOT depreciation			ROW/US quantity		
θ	η	β=0.65	β=0.75	β=1	β=0.65	β=0.75	β=1	β=0.65	β=0.75	β=1
0,5	2	34	31	26	24	25	26	-21	-23	-27
1	2	25	24	21	20	21	23	-12	-14	-18
1	3	17	16	13	12	13	14	-12	-14	-18
2	2	18	18	17	18	18	20	-5	-6	-10
2	3	12	12	11	11	11	12	-6	-7	-12
1	1000	6	5	0	0	0	0	-61	-70	-93

Notes: Changes in percent. θ refers to the elasticity of substitution between tradables and non-tradablen, η refers to the elasticity of substitution between domestic and foreign tradables.

Table 9: Alternative labour share: Changes in US and ROW relative price and quantity of non-tradables

Parameters		US non-tradables vs tradables						ROW non-tradables vs tradables					
		Price			Quantity			Price			Quantity		
θ	η	β=0.65	β=0.75	β=1	β=0.65	β=0.75		β=0.65	β=0.75	β=1	β=0.65	β=0.75	β=1
0,5	2	-10	-7	0	-18	-20	-23	3	2	0	5	5	6
1	2	-7	-5	0	-12	-14	-19	2	1	0	3	4	5
1	3	-7	-5	0	-12	-14	-19	2	1	0	3	4	5
2	2	-3	-3	0	-6	-8	-12	1	1	0	2	2	4
2	3	-4	-3	0	-7	-9	-15	1	1	0	2	2	4
1	1000	-7	-5	0	-12	-14	-19	2	1	0	3	4	6

Notes: Changes in percent. θ refers to the elasticity of substitution between tradables and non-tradablen, η refers to the elasticity of substitution between domestic and foreign tradables.

Table 10: Unit-root tests of real exchange rate and relative volume of tradable output

	Constant				Constant and trend			
	ADF		*PP*		*ADF*		*PP*	
REER	-1.69	[0.05]	-0.88	[0.19]	-3.62	[0.00]	-0.55	[0.29]
YNYH narrow	-0.17	[0.43]	-0.40	[0.35]	-0.16	[0.43]	-0.48	[0.32]
YNYH broad	0.27	[0.60]	0.06	[0.53]	-0.72	[0.23]	0.20	[0.58]
ΔREER	-12.95	[0.00]	-12.15	[0.00]	-10.22	[0.00]	-9.42	[0.00]
ΔYNYH narrow	-11.60	[0.00]	-13.36	[0.00]	-8.60	[0.00]	-11.51	[0.00]
ΔYNYH broad	-10.60	[0.00]	-11.64	[0.00]	-8.68	[0.00]	-9.89	[0.00]

Notes: *ADF* and *PP* are the Choi Augmented-Dickey-Fuller and Phillips-Perron statistics on the null of a unit root in at least one cross-section. Corresponding p-values are presented in brackets.

Table 11: Unit-root tests of residuals form error-correction model of real exchange rate and relative volume of tradable output

	ADF		*PP*	
Narrow defintion				
full sample	-14.54	[0.00]	-16.42	[0.00]
excluding EMEs	-14.36	[0.00]	-15.94	[0.00]
Broad defintition				
full sample	-15.95	[0.00]	-16.21	[0.00]
excluding EMEs	-15.21	[0.00]	-15.06	[0.00]

Notes: ADF and *PP* are the Choi Augmented-Dickey-Fuller and Phillips-Perron statistics on the null of a unit root in at least one cross-section. Corresponding p-values are presented in brackets.

Figure 1: Narrow and broad aggregate of tradables in % of GDP

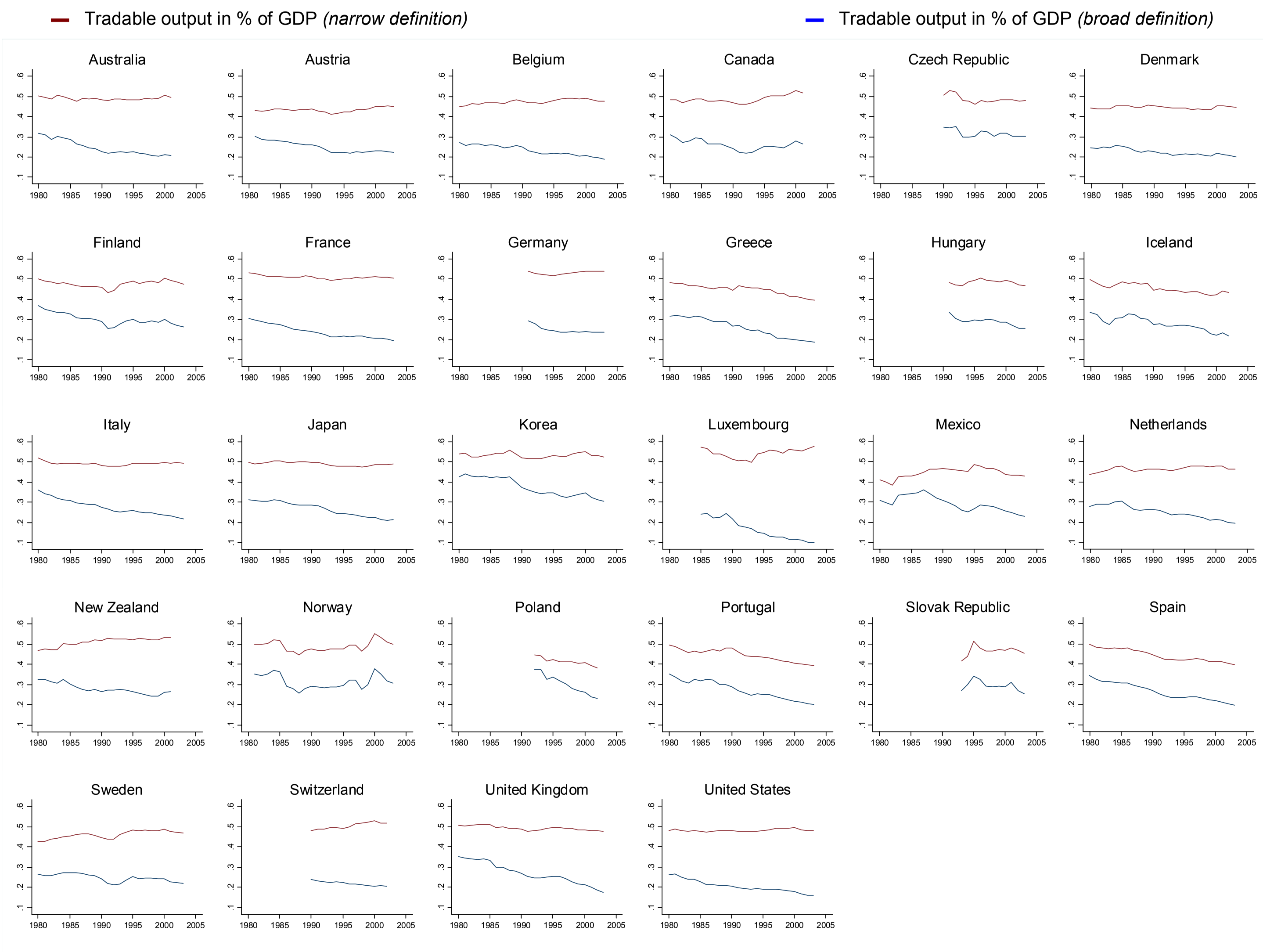


Figure 2: Real effective exchange rate and relative volume of tradables and non-tradables

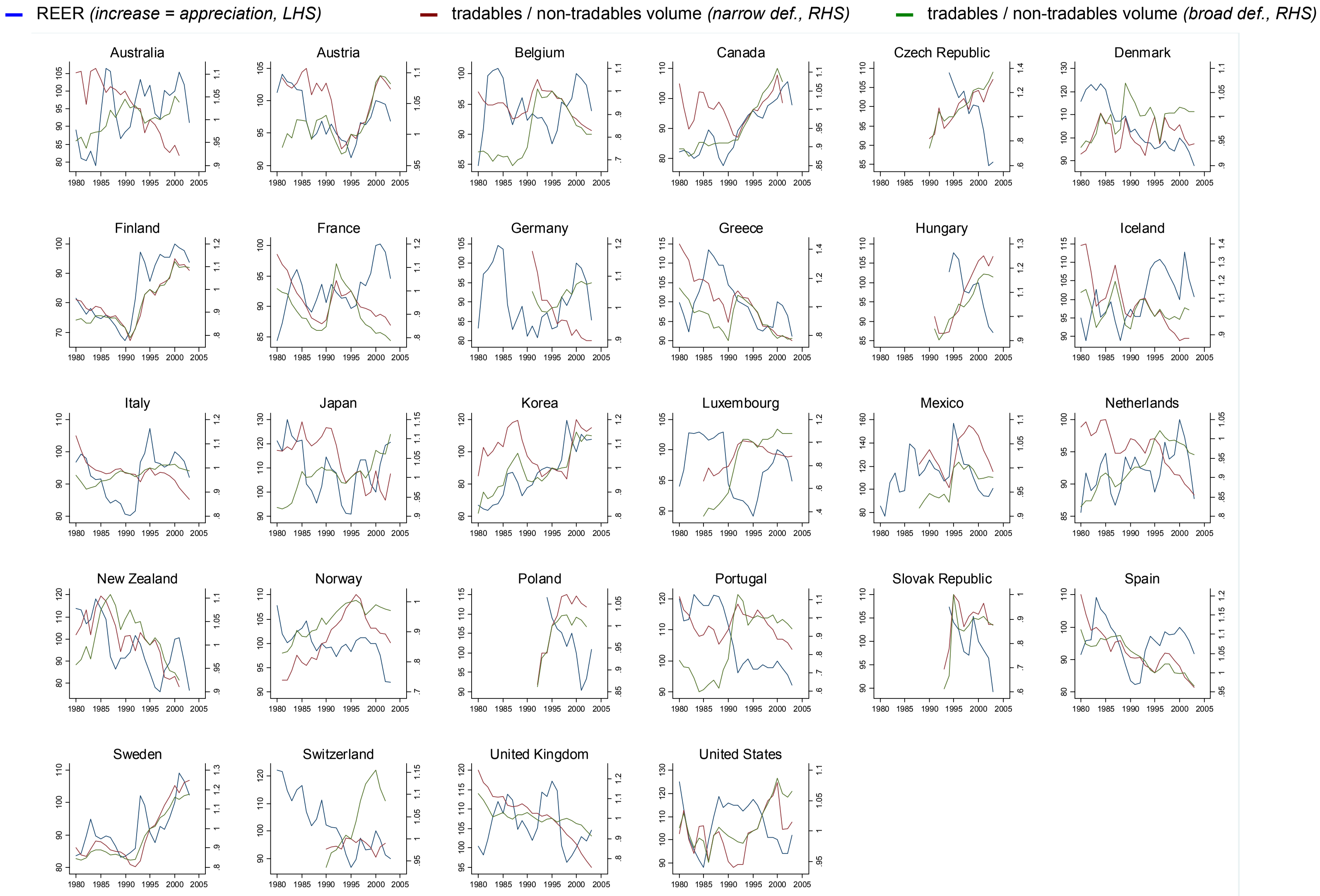


Figure 3: Current account and relative volume of tradables and non-tradables

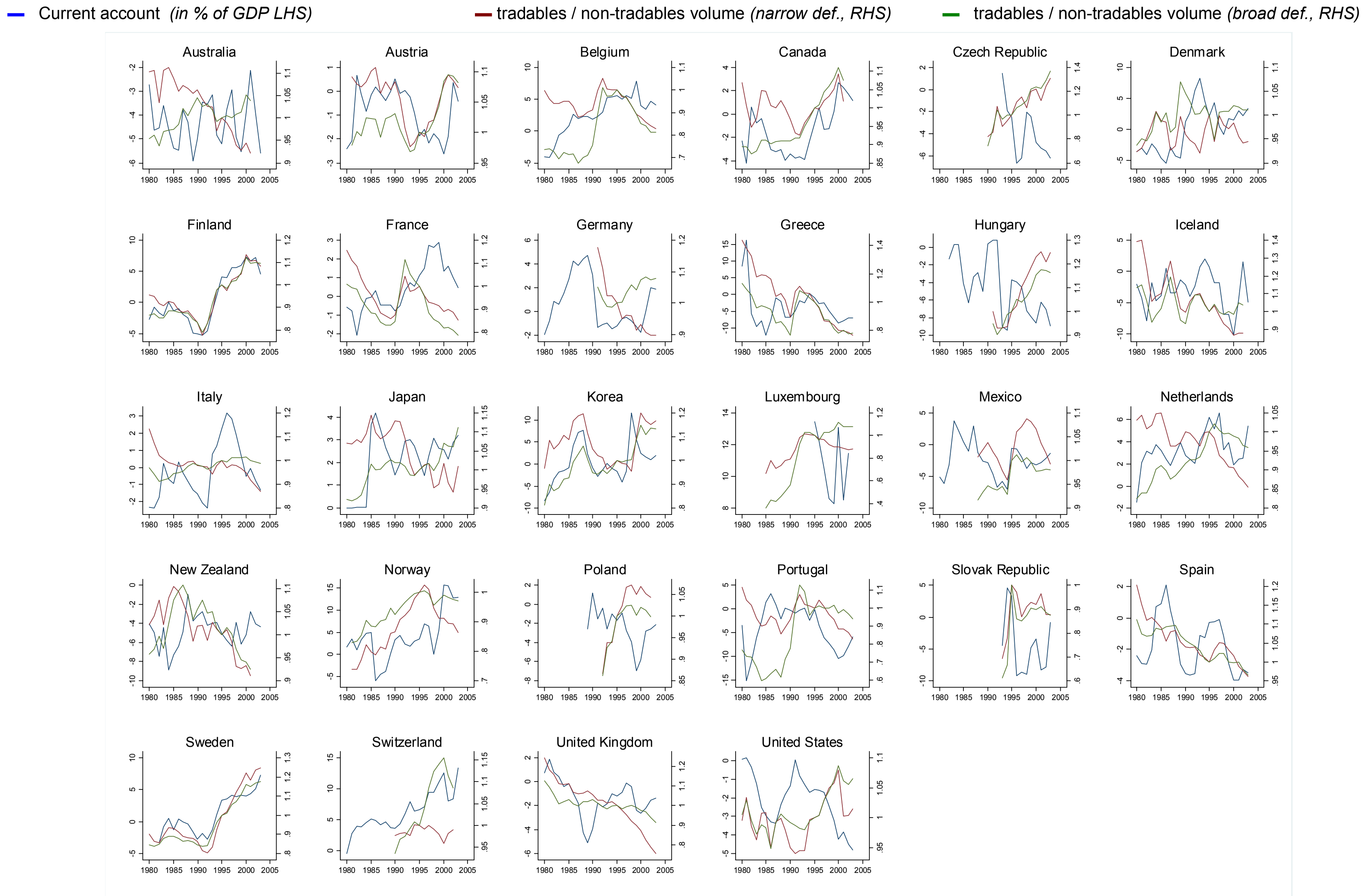
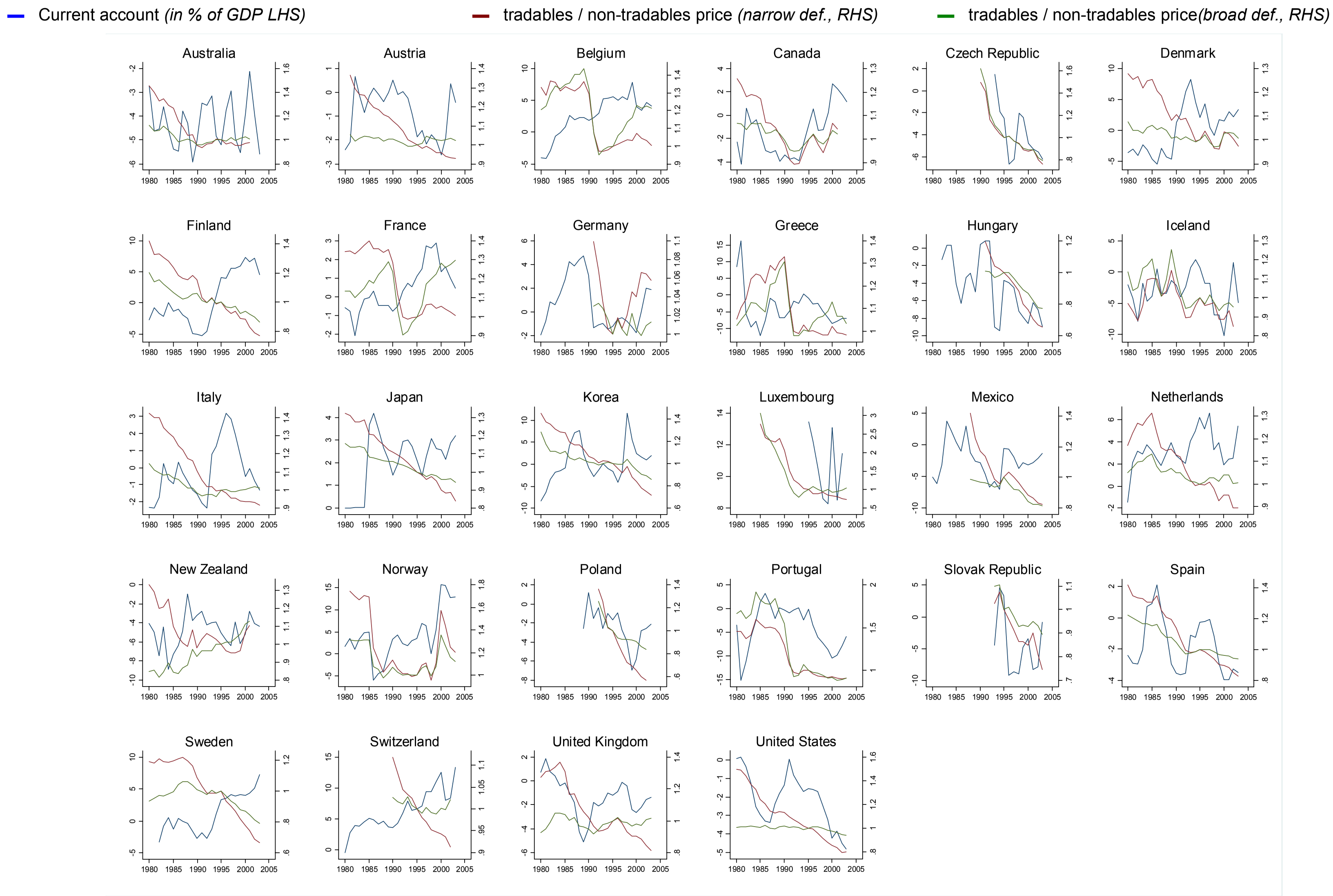


Figure 4: Current account and relative price of tradables and non-tradables



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