Correcting Real Exchange Rate Misalignment

Conceptual and Practical Issues

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Abstract

This paper studies the issue of real exchange rate misalignment and the difficulties in settling international real exchange rate disputes. The authors show theoretically that determining when a country should be sanctioned for real exchange rate “manipulations” is difficult: in some situations a country's real exchange rate targeting can be beneficial to other countries, while in others it is not. Regardless, it is difficult to establish whether a misaligned real exchange rate is intentionally

manipulated rather than unintentionally caused by other policies or by various distortions in the economy. The paper continues by illustrating the difficulty in measuring real exchange rate misalignment, and provides a critical assessment of existing methodologies. It concludes by proposing a new method for measuring real exchange rate misalignment based on differences in marginal products between producers of tradable and non-tradable goods.

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Correcting Real Exchange Rate Misalignment: Conceptual and Practical Issues

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1 Introduction

This paper studies the issue of real exchange rate misalignment, its implication to a country's export competitiveness and the potential role of the international community in settling real exchange rate disputes. Specifically, we discuss three difficulties that an international regulator is likely to face: first, it is difficult to determine when a country should be sanctioned for real exchange rate “manipulations”, as theory predicts that in some situations, real exchange rate targeting is socially efficient, while in others it is not. Second, it is difficult to establish that a misaligned real exchange rate is a consequence of real exchange rate targeting, as the real exchange rate is affected by a variety of distortions in the environment, as well as by policies that are not necessarily intended for real exchange rate targeting. Finally, it is difficult to measure real exchange rate misalignments, as the frictionless benchmark of the real exchange rate is not easily calibrated. We discuss the currently used methodologies that are based on panel regressions, and propose a new approach based on micro data.

The real exchange rate is defined as the relative price of the domestic consumption basket and the foreign consumption basket¹. A real exchange rate misalignment is defined as a deviation of the real exchange rate from its frictionless competitive equilibrium benchmark (which is defined in Appendix A). Of course, other countries are not affected directly by the price of the domestic consumption basket. Rather, a real exchange rate misalignment has the potential to affect other countries through two related prices: the *terms of trade*, that captures the relative price of exports, and the interest rate, that captures the price of saving. This is more than a semantic point: a depreciated real exchange rate need not imply cheaper exports, nor do cheap exports imply a depreciated real exchange rate. Similarly, a depreciated real exchange rate need not imply excessive saving, nor do excessive saving necessarily imply a depreciated real exchange rate. In section 2, we lay out the conditions under which a depreciated real exchange rate coincides with cheaper exports and excessive saving. The subtle mapping between the real exchange rate, the export price and the interest rate poses a first layer of difficulty in evaluating the externalities of real exchange rate targeting.

¹This definition is standard; see, for example, Krugman and Obstfeld [2006], page 389.

In section 3, we continue by illustrating that the welfare implications of real exchange rate targeting may depend on the relevant circumstances. In a neoclassical framework, real exchange rate targeting is typically Pareto-inefficient. However, there may be distributional implications that favor competing exporters, and harm importers. In contrast, Keynesian models and models of export externalities imply that strategic depreciations are sometimes Pareto efficient, and may benefit both the country itself and its importers (though typically not competing exporters).

Next, in section 4, we illustrate that a wide variety of government policies may affect the real exchange rate. The government can affect the real exchange rate by subsidizing the export sector directly, by taxing production inputs at different rates, or by distorting domestic saving decisions. The problem is that many of the policies that affect the real exchange rate are not necessarily targeted at manipulating the real exchange rate. For example, a one-child policy may result in higher domestic savings, and a depreciated real exchange rate; however, the one-child policy was probably not instituted in order to manipulate the exchange rate, but rather in order to stop population growth. The conceptual line between government policies that affect the real exchange rate and real exchange rate *targeting* is blurry.

The issue is complicated further as there are potentially fundamental sources of real exchange rate misalignment. A real-world economy with frictions typically implies a real exchange rate that is different from its frictionless benchmark. For example, financially underdeveloped economies may naturally have depreciated real exchange rates, both because of the precautionary savings motive and because exporting firms may have better access to credit. A misaligned real exchange rate need not be a product of manipulative or even un-manipulative policy, but rather a byproduct of an environment with frictions.

Finally, in section 5, we turn to the issues of measurement, and illustrate the difficulties in measuring real exchange rate misalignments and assessing their causes. We begin by discussing the three methodologies currently used by the IMF to measure real exchange rate misalignments. The key problem with these measurements is that the “misalignment” is measured as a deviation from some country “norm”, that is calibrated based on other similar countries taking into account country specifics such as government policies and financial development. In other words,

the calibrated “frictionless norm” already includes frictions that may distort the real exchange rate. Further, the “norm” is calibrated as a typical value, which is not necessarily normative or frictionless. It is therefore difficult to interpret these measures as misalignment of the real exchange rate.

We propose an alternative methodology for assessing real exchange rate misalignment following the seminal work of Hsieh and Klenow [2009]. We propose to use firm-level or industry-level data to assess whether there are systematic dispersions in the marginal productivities of producers of tradable and non-tradable goods. Such a dispersion would be indicative of a real exchange rate misalignment, as in the frictionless competitive equilibrium, marginal productivities are equated across all firms. We illustrate how this methodology can be useful not only in identifying and quantifying real exchange rate misalignment, but also in assessing its causes.

2 The real exchange rate, the terms of trade and the saving rate

The starting point of the discussion on real exchange rate misalignments is that a devalued real exchange rate is tied to cheap exports and excessive saving. However, it turns out that the conditions under which these equivalences hold are quite subtle. Broadly, reducing domestic demand will result in a lower real exchange rate, and cheaper exports; however, a decline in domestic demand need not coincide with an increase in domestic savings. Supply shifters (such as subsidizing exports) may or may not result in a devalued real exchange rate, depending on the substitutability of inputs from the tradable to the non-tradable sector. When permanent, they will have no effect on savings.

To illustrate these interactions, consider an economy with three goods: an imported good (denoted with superscript $*$), a domestically produced tradable good (denoted with superscript T), and a domestically produced non-tradable good (denoted with superscript NT). Consumers spend a constant fraction of their expenditures on each good; the expenditure shares are denoted α^* , α^T and α^{NT} respectively. The prices of the goods are denoted p^* , p^T and p^{NT} respectively.

The country's CPI is given by:

$$CPI = \alpha^* p^* + \alpha^T p^T + \alpha^{NT} p^{NT} \quad (1)$$

The real exchange rate is defined as the ratio of the domestic CPI and the foreign CPI. For simplicity, we will hold the foreign CPI constant, and think of changes in the CPI as changes in the real exchange rate.

We will begin by assuming that labor is the only input of production, and is used both in the production of tradable goods and in the production of non-tradable goods. Labor is in fixed supply (L). The production technology of good $i = T, NT$ is:

$$Y^i = L^i \quad (2)$$

where L^i is the labor employed in sector i .

Foreign demand for the domestically produced tradable good is given by $D^*(p^T)$, where:

$$D^*(p^T) = \frac{c}{p^T} \quad (3)$$

This demand implies that foreigners spend a constant amount on domestically produced tradable goods.

Demand shifters. Consider the effects of a decline in domestic expenditure, E . The decline in domestic expenditure may reflect an increase in domestic saving; however, it may also reflect lower income. If the lower income is temporary, it may coincide with a decline in saving, as agents try to smooth the income shock. If the change in income is permanent, this will have no effect on savings.

Given E , the equilibrium is characterized by the following equations:

$$w = p^{NT} = p^T \quad (4)$$

$$p^{NT} Y^{NT} = \alpha^{NT} E \quad (5)$$

$$p^T Y^T = \alpha^T E + p^T D^*(p^T) = \alpha^T E + c \quad (6)$$

$$L^T + L^{NT} = L \quad (7)$$

Using the identity $Y^i = L^i$, and the equilibrium condition, we obtain:

$$(\alpha^{NT} + \alpha^T)E + c = p^{NT}Y^{NT} + p^TY^T = p^T(Y^{NT} + Y^T) = p^TL \quad (8)$$

$$\Rightarrow p^T = p^{NT} = \frac{(\alpha^{NT} + \alpha^T)E + c}{L} \quad (9)$$

The domestic CPI is then given by:

$$CPI = \alpha^*p^* + (\alpha^{NT} + \alpha^T)\frac{(\alpha^{NT} + \alpha^T)E + c}{L} \quad (10)$$

Lower domestic expenditure implies both a lower CPI, and a lower export price (p^T). In other words, a shift in domestic demand affects the real exchange rate and the export price in similar ways; a devalued real exchange rate coincides with a depressed export price.

Supply shifters. Consider a policy that subsidizes the production of the tradable good at the rate s (similar results can be obtained for a tax on the production of non-tradables). In other words, the production revenue from tradable production is given by $(1 + s)p^TY^T$. The equilibrium conditions are now:

$$w = p^{NT} = (1 + s)p^T \quad (11)$$

And equations 5-7. Combining, we get that:

$$\alpha^{NT}E = p^{NT}Y^{NT} = (1 + s)p^TL^{NT} \Rightarrow \frac{\alpha^{NT}E}{1 + s} = p^TL^{NT} \quad (12)$$

$$\alpha^TE + c = p^TY^T = p^T(L - L^{NT}) \quad (13)$$

Adding the two equations:

$$\alpha^TE + c + \frac{\alpha^{NT}E}{1 + s} = p^TL \quad (14)$$

$$\Rightarrow \frac{(\alpha^T + \frac{\alpha^{NT}}{1+s})E + c}{L} = p^T \quad (15)$$

A higher subsidy, s , results in a lower p^T . Not surprisingly, the subsidy on the production of tradable goods results in an expansion of the tradable sector, and a decline in the price of the domestically produced tradable good.

However, in this case, the subsidy may imply a real exchange rate appreciation. The CPI is given by:

$$\alpha^* p^* + \alpha^T \frac{(\alpha^T + \frac{\alpha^{NT}}{1+s})E + c}{L} + \alpha^{NT} \frac{((1+s)\alpha^T + \alpha^{NT})E + c}{L} \quad (16)$$

Holding the expenditure (E) constant, the derivative of the above with respect to s is given by:

$$\frac{\partial CPI}{\partial s} = \frac{\alpha^N \alpha^{NT} E}{L} \left(1 - \frac{1}{(1+s)^2}\right) > 0 \quad (17)$$

Of course, domestic expenditure may change in response to the subsidy; if agents believe the price distortion to be temporary, they may respond by saving or dissaving, depending on the relative dominance of income and substitution effects. However, as long as the negative effect on expenditure is not too large, the analysis above illustrates that a subsidy on the production of tradable goods will lead to a real exchange rate *appreciation*.

Non-substitutable inputs. In the previous example, a subsidy on tradable good production led to a reallocation of labor towards the tradable sector, which resulted in a higher non-tradable price. Limiting the extent to which inputs can move from the production of non-tradable goods to the production of tradable goods will mitigate this channel.

To study the case of non-substitutable inputs, rather than assuming a production economy assume that the non-tradable good is in fixed supply (e.g., land), and that labor is employed only in the production of tradable goods. Rather than assuming an inelastic labor supply, assume that labor supply is increasing in the wage ($L(w)$).

The price of the non-tradable good is given by:

$$p^{NT} \bar{Y}^{NT} = \alpha^{NT} E \quad (18)$$

Where $\bar{Y}^{NT}$ is the fixed supply of the non-tradable good. Thus, the price of the non-tradable good moves with domestic expenditure (E), but is otherwise unrelated to the price of the tradable good.

The price of the tradable good is given by:

$$p^T Y^T = \alpha^T E + c \quad (19)$$

In equilibrium, $(1 + s)p^T = w$, and $Y^T = L(w) = L((1 + s)p^T)$:

$$p^T = \frac{\alpha^T E + c}{L((1 + s)p^T)} \quad (20)$$

The price of the tradable good is decreasing in the subsidy, s . Since the subsidy decreases the price of the domestically produced tradable good and leaves the price of the non-tradable good unchanged, it trivially follows that (holding expenditure fixed) an export subsidy leads to a lower CPI and a real depreciation.

Reality lies somewhere in between the two extreme cases: some inputs can be diverted from the production of non-tradable goods to the production of tradable goods, and some cannot. The degree of substitutability will imply whether a “supply shifter” causes a similar move in the real exchange rate and the export price, or changes them in opposite directions.

The analysis in this section illustrates that, contrary to popular assertion, a depreciated real exchange rate is not necessarily equivalent to cheaper exports or to a higher saving rate. This poses a first conceptual difficulty in assessing the implications of real exchange rate misalignment: depending on circumstances, a depressed real exchange rate could imply either that exports are too cheap, or that they are *too expensive*. Further, a devalued real exchange rate need not be reflected in a higher domestic saving rate. In this sense, the real exchange rate is not particularly informative when thinking about welfare externalities for other countries, which necessarily operate either through the export price or through the interest rate.

3 Models of real exchange rate determination

This section reviews the neoclassical model, the Keynesian model and models of export externalities, and discusses the implications of these models regarding both the incentives to maintain a depreciated real exchange rate, and the welfare implications from doing so (keeping in mind that welfare externalities operate through the equilibrium price of exports or the interest rate). We consider the welfare implications for three groups: the home country, the importing country and competing exporters. In addition, we discuss the Pareto efficiency of strategic real exchange rate depreciation in the context of each model. The findings are summarized in table 1.

Table 1: Welfare implications of RER targeting in a large emerging economy

Model	Negative welfare implications	Positive welfare implications
Neoclassical: depressed interest rate	• Developed economies	• Emerging economies (including the home country)
Keynesian: higher saving	• Everyone	
Neoclassical: depressed terms of trade	• The home country • Exporters of substitutable goods	• Importers • Exporters of complementary goods
Keynesian: depressed terms of trade	• Exporters to the home country • Exporters of substitutable goods	• The home country • Exporters of complementary goods
Export externalities: depressed terms of trade	• Exporters of substitutable goods	• The home country • Exporters of complementary goods • Importers (unless the externality changes the pattern of comparative advantage)

The way to read the above table is as a matrix rather than a table. The different rows represent not so much different views of the world, but different relevant

circumstances. For economies experiencing deep recessions, the Keynesian model may be the relevant one. At the same time, for other economies that are closer to their production frontier, the neoclassical model may be more relevant. In some countries, spillovers from exports are important drivers of growth, while in others this channel is less important. A devaluation of the RER in a large emerging economy - regardless of whether it is motivated by neoclassical considerations, Keynesian considerations, learning-by-doing considerations, or entirely exogenous - will have different effects on these different countries.

3.1 Neoclassical model

In the neoclassical model, there may be an incentive for a large emerging economy to increase domestic savings, thereby depreciating the real exchange rate. Importantly, in the neoclassical model a depressed real exchange rate is a consequence of a government trying to strategically decrease the world interest rate, rather than a consequence of a government trying to distort relative prices of foreign and domestic goods. In our analysis, since the emerging economy anticipates having a relatively high endowment in the future, its government desires to reduce the world interest rate to raise the net present value of the country's future endowment. The government has an incentive to increase the price of domestic goods relative to foreign goods, which has the opposite effect on the real exchange rate.

We proceed in two steps. First, we show that the government of a large emerging economy has an incentive to increase domestic savings, thereby lowering the world interest rate and depreciating the real exchange rate. Second, we illustrate that a government never has an incentive to decrease the price of domestic goods relative to foreign goods (this might be an unwanted consequence of exchange rate depreciation targeted at lowering the world interest rate).

3.1.1 The intertemporal incentive for real exchange rate depreciation

Consider the following two period model of international intertemporal trade. The global environment consists of a developed economy and an emerging economy. We will take the perspective of the emerging economy and follow the convention of denoting foreign (developed-market) variables with a superscript *. There is a

single tradable good, and in each economy there is a domestic non-tradable good (denoted with superscript NT).

To simplify, we assume an endowment economy in which the supply of output is fixed. Output in the emerging economy is increasing relatively faster than output in the developed economy, that is, $Y_0 - Y_0^* < Y_1 - Y_1^*$. For simplicity, we assume an extreme case in which $Y_0 = 0$ and $Y_1^* = 0$, that is, the entire output in the first period is produced in the developed economy, whereas the entire output in the second period is produced in the emerging economy.

The frictionless competitive equilibrium. Let p denote the price of non-tradable goods in terms of tradable goods, and let R denote the gross rate of return on savings. The price of one unit of future consumption is therefore $\frac{1}{R}$. Consumers in the home country maximize:

$$\max_{c_0, c_1, c_0^{NT}, c_1^{NT}} u(c_0) + u_{NT}(c_0^{NT}) + \beta(u(c_1) + u_{NT}(c_1^{NT})) \quad (21)$$

s.t.

$$c_0 + p_0 c_0^{NT} + \frac{1}{R}(c_1 + p_0 c_1^{NT}) = p_0 Y_0^{NT} + \frac{1}{R}(Y_1 + p_1 Y_1^{NT}) \quad (22)$$

An equilibrium of this economy is a set of consumption choices c_t^E and c_t^{E*} , that solve the above optimization problem (for the domestic and foreign markets respectively), and a set of prices for the non-tradable goods p_t^E and p_t^{E*} and a gross rate of return R^E that jointly satisfy the market clearing conditions:

$$c_0^E + c_0^{E*} = Y_0^* \quad (23)$$

$$c_1^E + c_1^{E*} = Y_1 \quad (24)$$

The normative properties of the frictionless competitive equilibrium.

The first welfare theorem guarantees that the frictionless competitive equilibrium is Pareto efficient, in the sense that no country can be made better off without making the other country worse off. Moreover, the second welfare theorem guarantees that any Pareto efficient solution can be achieved in a competitive equilibrium setting, provided that we can implement a transfer of endowments between economies.

Optimal government intervention. In contrast, consider the optimization problem of a government that can choose domestic consumption, while internalizing the effect of its choices on equilibrium prices:

$$\max_{c_0, c_1, c_0^{NT}, c_1^{NT}} u(c_0) + u_{NT}(c_0^{NT}) + \beta(u(c_1) + u_{NT}(c_1^{NT})) \quad (25)$$

s.t.

$$c_0 + \frac{1}{R}c_1 = \frac{1}{R}Y_1 \quad (26)$$

$$c_i^{NT} = Y_i^{NT} \quad (27)$$

$$R = R(c_0) \quad (28)$$

In other words, the government takes the consumption of non-tradable goods as given and internalizes the effect of domestic savings on the interest rate (R is increasing in c_0 , as a lower c_0 implies a higher demand for domestic savings and hence a lower R).

Denote with a superscript G the government's choices (assuming that the developed economy continues to behave non-strategically, and chooses its consumption pattern according to the problem described in equations 21-22).

Note that given a non-tradable price p , the real exchange rate is calculated as the ratio of the domestic and foreign CPI:

$$RER = \frac{\alpha + (1 - \alpha)p}{\alpha^* + (1 - \alpha^*)p^*} \quad (29)$$

where α and α^* are the shares of the tradable good in the CPI in the domestic and foreign country.

Proposition 1 *Compared to the frictionless competitive equilibrium, the government chooses a higher saving rate at time 0, a lower interest rate, a higher trade surplus² and a depreciated real exchange rate:*

$$s^E = (Y_0 - c_0^E) < s^G = (Y_0 - c_0^G) \quad (30)$$

²More precisely it is a lower trade deficit in this setup, because for simplicity, we assume $Y_0 = 0$.

$$R^G < R^E \quad (31)$$

$$NX^E = (Y_0 - c_0^E) < NX^G = (Y_0 - c_0^G) \quad (32)$$

$$RER_0^E > RER_0^G \quad (33)$$

The proof of this proposition, as well as other omitted proofs, is in the appendix³. The intuition behind this result is as follows. The government is essentially a monopoly on future goods, and tries to increase the net present value of its endowment by manipulating demand so that the relative price of future goods compared to current goods is higher. This means that the government has a strategic incentive to lower the exchange rate; this can be done by artificially increasing the domestic saving rate. The real exchange rate adjusts as a higher saving rate means that consumers spend less both on tradables and non-tradables; the depressed demand for domestic non-tradable goods results in a lower price, and hence a lower CPI. Similarly, as the developed economy's current expenditures increase, the spending on non-tradable goods in developed economies increases, resulting in a higher CPI; the real exchange rate therefore unambiguously depreciates.

The normative properties of the government's solution. It is fairly straightforward to show that the government's solution is not Pareto optimal, as both foreign and domestic consumers would benefit from a smoother consumption plan; in other words, both countries would benefit from an arrangement in which the developed economy would transfer a lump-sum amount to the emerging economy, in exchange for having the emerging market's government cease its intervention.

Important for our purposes, the emerging economy's market intervention has *positive* externalities on other emerging economies. To see this, consider the welfare of another emerging economy in the global environment described above. The fact that our first emerging economy is manipulating the global interest rate benefits the second emerging economy, as the net present value of its endowment increases as well.

The negative externalities of the emerging economy's market intervention fall entirely on the developed economy, that experiences both a fall in the net present

³Results in similar spirit can be found in contemporaneous work by Korinek [2011] and Costinot et al. [2011], who similarly study the problem of an inter-temporal monopolist.

value of its endowment and a less smooth consumption path.

The strategic equilibrium. Consider next the strategic equilibrium, in which both the emerging and the developed economy may strategically dictate domestic consumption and saving decisions, taking the other country's actions as given. In other words, the emerging economy's problem is given by equations 25-28, and the developed market's economy is similarly given by:

$$\max_{c_0^*, c_1^*, c_0^{NT*}, c_1^{NT*}} u(c_0^*) + u_{NT}(c_0^{NT*}) + \beta(u(c_1^*) + u_{NT}(c_1^{NT*})) \quad (34)$$

s.t.

$$c_0^* + \frac{1}{R}c_1^* = \frac{1}{R}Y_1^* \quad (35)$$

$$c_i^{NT*} = Y_i^{NT*} \quad (36)$$

$$R = R(c_0^*) \quad (37)$$

Interestingly, when we do this exercise from the perspective of the developed country, we will get the opposite result: the developed country has an incentive to subsidize current spending (thereby raising the world interest rate), as its endowment is disproportionately in current goods. We can then characterize the strategic equilibrium, in which each country takes the other country's actions as given and chooses domestic savings.

Proposition 2 *In the strategic equilibrium, the emerging market government increases domestic savings, whereas the developed market government increases domestic consumption.*

The normative properties of the strategic equilibrium. Again, the strategic equilibrium allocation is Pareto inefficient, as both parties could be made better off by a smoother consumption pattern (a formal proof of this claim is in the appendix).

Holding the policy of developed markets fixed, it is still the case that emerging economies benefit from other emerging economies' strategic targeting of the interest rate. However, whether they are made better off by the strategic equilibrium allocation or by the frictionless competitive equilibrium allocation depends on the

net effect on R . Since developed and emerging economies are trying to push R in opposite directions, the net effect on R is inconclusive and depends on the countries relative abilities to manipulate the equilibrium R . If the strategic equilibrium R is lower than the frictionless equilibrium R , emerging markets benefit; if it is higher, they are better off with the competitive equilibrium allocation.

3.1.2 The intratemporal effects of a real exchange rate depreciation

Countries have often been accused of real exchange rate targeting in an attempt to make their domestic goods cheaper relative to foreign goods. While this may be rationalized both in the traditional Keynesian framework as well as in models of positive export externalities (as will be illustrated shortly), this view has no foundation within the standard neoclassical framework. In fact, countries typically have an incentive to make their domestic goods relatively more expensive, thereby improving their terms of trade.

Importantly for our purposes, the neoclassical model naturally implies that a terms of trade depreciation in one country that affects the global prices of goods will carry negative implications for other countries that are exporters of the same (or similar) goods. This is because the depreciation of the terms of trade hurts not only the home country but also other countries with similar exports (of course, countries exporting complementary goods will experience the opposite effect).

To illustrate this point, consider a single period model of international trade. We will begin our discussion assuming only two countries, a home country and a foreign country. Again, we will follow the convention that foreign country variables are denoted with superscript $*$. The countries are endowed with Y and Y^* units of output correspondingly, where the goods produced in the home and foreign country are differentiated. For simplicity we assume log utility, so that consumption utility in the home country is given by:

$$u(c, c^*) = \alpha \ln(c) + (1 - \alpha) \ln(c^*) \quad (38)$$

And consumption utility in the foreign country is given by:

$$u^*(c^*, c) = \alpha \ln(c^*) + (1 - \alpha) \ln(c) \quad (39)$$

Let p denote the price of domestic goods in terms of foreign goods, and normalize the price of the foreign good to 1. The real exchange rate is given by the ratio of the CPIs:

$$RER = \frac{\alpha p + (1 - \alpha)}{\alpha + (1 - \alpha)p} \quad (40)$$

We assume home bias in consumption so $\alpha > 0.5$.

The frictionless competitive equilibrium. Consumers in the home country take p as given and solve:

$$\max_{c, c^*} u(c, c^*) \quad (41)$$

s.t.

$$pc + c^* = pY \quad (42)$$

The government's optimization problem. Next, consider the problem of a government that internalizes its effect on equilibrium prices:

$$\max_{c, c^*} u(c, c^*) \quad (43)$$

s.t.

$$p(c, c^*)c + c^* = p(c, c^*)Y \quad (44)$$

Proposition 3 *Compared to the competitive solution, the government chooses to encourage consumption of the domestic good, in order to benefit from better terms of trade.*

The government therefore has an incentive to encourage domestic consumption of the domestic good. The intuition for this result is again the monopolist problem: this time, the government has an incentive to increase the price of its endowment by manipulating domestic demand. Given the home bias in consumption, this increase in the price of the domestically produced good appreciates the real exchange rate.

From the analysis above, two things become evident: first, in the neoclassical framework, countries have no intratemporal incentive to depreciate their real exchange rate. A strategic real exchange rate depreciation is therefore motivated either by intertemporal considerations, or by Keynesian or learning-by-doing considerations, which will be discussed shortly.

Second, a real exchange rate depreciation in one country carries negative implications for competitor countries that are exporting the same (or similar) goods. To see this, note that a real exchange rate depreciation worsens the country's terms of trade. This means that the terms of trade are worse for all countries with similar exports. It is worth pointing out a nuance: while countries exporting substitute goods will incur negative welfare implications, the opposite is true for countries exporting complementary goods. For example, a depressed price of tea may increase the demand for sugar, and improve the terms of trade of sugar exporters. This nuanced point may be relevant when thinking about the effects of (say) a devalued price of manufacturing goods on exporters of commodities used in manufacturing.

3.2 The Keynesian model

In the Keynesian model, output is determined by aggregate demand, and there is therefore an incentive to increase output through increasing the demand for domestic exports. We will begin by laying out the Mundell Fleming model, that illustrates the incentive to strategically depreciate the real exchange rate. We will then explore the normative implications of this type of exchange rate depreciation and the externalities it imposes on other countries.

The Mundell Fleming model. We follow the specification in Blanchard [2011] (chapter 20). Output is determined by three equations:

1. The “IS” relation, equating aggregate supply of output to aggregate demand:

$$Y = C + I + G + NX = (C - IM) + I + G + EX(\epsilon) \quad (45)$$

The demand for output is given by the demand for domestic consumption of the domestic good ($C - IM$), the demand for domestic investment inputs (I), the demand for government spending (G) and the demand for exports (EX). Net exports NX is a decreasing function of the real exchange rate, ϵ (note that here, the real exchange rate is defined the relative price of domestic exports and foreign exports, in other words, the terms of trade). Importantly, in this model output is a function of **net** exports rather than gross exports.

This means that the real exchange plays a crucial role, both in tilting domestic demand toward the domestic good and in tilting foreign demand towards the domestic good.

2. The “LM” relation, equating money supply with money demand:

$$\frac{M}{P} = YL(i) \quad (46)$$

Where M is the money supply, P is the price level, i is the interest rate and $L(\cdot)$ is a decreasing function.

3. The interest parity condition, requiring indifference between foreign-denominated bonds and local bonds:

$$E = \frac{1+i}{1+i^*} \bar{E} \quad (47)$$

Where E is the nominal exchange rate, and $\bar{E}$ is the expected nominal exchange rate in the next period, and i^* is the foreign interest rate.

Consumption is an increasing function of disposable income, defined as output minus taxes (that are denoted T):

$$C = c_0 + \gamma Y^d = c_0 + \gamma(Y - T) \quad (48)$$

For illustrative purposes, it is useful to begin by abstracting from the interest rate parity condition (equation 47) and focusing on the effect of a real exchange rate depreciation, assuming that the government can influence it without changing the interest rate (i). We will return to this issue in the next section.

The standard logic for a strategic depreciation proceeds as follows. The IS relation (equation 45) implies that a depreciation in the real exchange rate leads to an increase in aggregate demand, thereby leading to an increase in output. Holding tax revenues constant, this increase in output leads to an increase in disposable income and in consumption - translating back into even higher aggregate demand and even higher consumption. Importantly, in contrast to the neoclassical model, increasing net exports has a **positive intratemporal** effect on the economy, as current consumption increases.

The implications of this type of a strategic depreciation on the country's trading partners and its competitors depends on the macroeconomic dynamics relevant to the rest of the world. Specifically, in a pure Keynesian model in which output is determined by aggregate demand in all countries, a strategic depreciation in one country necessarily leads to an appreciation in the other countries, thereby depressing their aggregate demand and deepening their recession.

This type of model may be relevant in Great Depression type environments: the Keynesian model is typically thought of as a good model for describing macroeconomic dynamics in times of deep recessions, in which employment and capacity utilization are abnormally low. This would imply that at times of such global slumps, strategic depreciations of the exchange rate should be sanctioned. Further, a strategic equilibrium of this model will have all countries attempt at depreciating the exchange rate, resulting potentially in a real exchange rate that is unchanged. If there are any costs associated with such attempts, this equilibrium is inefficient, as these costs can be avoided by refraining from strategic behavior.

With that in mind, it is our view that large global slumps such as the Great Depression are quite special (and rare), and that Keynesian dynamics are less relevant for the world as a whole during normal times. Specifically, it is useful to consider a “hybrid” environment, in which there is one country that is in a “Great Depression” mode while other countries are better described by the neoclassical model. In this type of hybrid model, can strategic depreciations be Pareto efficient?

For the “depressed” economy, a strategic depreciation is unambiguously welfare improving: not only does it increase current consumption, but it also increases future consumption through the accumulation of foreign reserves.

The trading partners are also made better off, as they benefit from better terms of trade. If the “depressed” economy's accumulation of reserves is not large enough to affect the global interest rate, this is the only effect and trading partners unambiguously benefit. If the interest rate declines as a result of the reserve accumulation, this may lower the world interest rate, leading to positive valuation effects for emerging economies and negative valuation effects for developed economies, as illustrated in the previous section.

Of course, the terms of trade effects operate in the opposite direction for competitor countries, who are worse off as they face a lower world price for their

exports.

To conclude, in this hybrid model, if the “depressed” country is relatively small (or if the interest rate is relatively inelastic), a real exchange rate depreciation is welfare improving both for the country and its trading partners. The “depressed” economy enjoys both higher current consumption and higher future consumption; the trading partners benefits from better terms of trade. However, this is not a Pareto improvement, as competing exporters are worse off given the altered terms of trade. But (given reasonable price elasticities) it is likely that this adverse distributional implication can be corrected by bilateral transfers (of current or future goods), thereby leading to a Pareto improvement. Alternatively, if there is some ex-ante uncertainty regarding the location of the “slump”, strategic depreciations of the exchange rate may potentially implement international risk sharing with respect to this shock.

The policy implications that emerge from this discussion depend on the nature of the slump: a strategic depreciation of the real exchange rate should be sanctioned during a global slump because it will deteriorate other countries’ economic conditions, but potentially encouraged during country-specific slumps.

Terms of trade depreciation vs. real exchange rate depreciation. When thinking in terms of the Keynesian model, it is useful to revisit the distinction between the terms of trade and the real exchange rate. In this model, the real exchange rate (ϵ) captures the relative price of exports and imports - in other words, it is defined as the terms of trade. The conclusion of the model should therefore be read in terms of the terms of trade: there is an incentive to depreciate the terms of trade, which, as illustrated in section 2, may or may not imply a real exchange rate depreciation. In fact, it is straightforward to see that, while there is an incentive to make exports cheaper, there is also an incentive to increase domestic demand - which will typically translate into a higher price of non-tradable goods, and possibly a real appreciation of the exchange rate.

In a Keynesian model, manipulating the real exchange rate through demand shifters (e.g., forced savings) makes little sense. The first-order effect of a decline in domestic expenditure is a decline in the demand for domestically produced goods, which is contractionary. Supply shifters, that subsidize the production of

tradables, seem more likely - as previously illustrated, this type of policy may lead to an increase in the price of non-tradables, making the effect on the real exchange rate ambiguous.

3.3 Models of export externalities

Recent literature has suggested that there are learning-by-doing externalities in the manufacturing of tradable goods⁴. The presence of positive externalities typically imply that the manufacturing of tradable goods is too low in equilibrium, suggesting a role for government intervention.

In this section, we will consider two stylized models of export externalities, with somewhat different welfare implications. First, we consider a simple model in which there are some positive domestic spillovers from the production of tradable goods, and the pattern of trade specialization is held constant. In this model, it is Pareto efficient to subsidize the manufacturing of tradable goods. Second, we summarize the argument in Samuelson [2004] regarding the welfare implications of a productivity improvement on a country's trading partners. Samuelson [2004] illustrates that, when a productivity improvement changes the pattern of comparative advantage, it may be welfare reducing for the country's trading partners. In light of this, the productivity gains from learning-by-doing in the export sector may have negative externalities for other countries.

3.3.1 A simple model of production externalities and exogenous specialization

The home economy produces two types of goods: a non-tradable good (denoted with superscript NT) and a tradable good. Domestic consumers consume domestically produced tradable goods, non-tradable goods, and foreign-produced goods (denoted with superscript $*$). Production of the tradable good has a positive externality; for simplicity, we will assume that the equilibrium quantity of the tradable good enters directly in the utility function⁵. Specifically, we will assume that

⁴See Krueger [1998] and Korinek and Serven [2011] for examples, and Eichengreen [2008] for an empirical discussion.

⁵The externality can come under different forms, for example, learning by investing, as in Korinek and Serven [2011].

consumption utility takes the following form:

$$U(c, c^{NT}, c^*, Y) = u(c) + u_{NT}(c^{NT}) + u_F(c^*) + u_Y(Y) \quad (49)$$

The tradable and non-tradable production functions are given by $Y = F(L)$ and $Y^{NT} = F_{NT}(L^{NT})$. Labor is supplied inelastically, so:

$$L + L^{NT} = L_0 \quad (50)$$

For simplicity, we assume that the price of the domestically produced tradable good in terms of the foreign produced good is fixed by global markets at p (this would be the case, for example, if the economy is small and accounts for only a small share of the global production of its domestic good).

Frictionless competitive equilibrium. Denote the equilibrium price of the non-tradable good in terms of the foreign good by p^{NT} . Consumer solve the following optimization problem:

$$\max_{c, c^{NT}, c^*} u(c) + u_{NT}(c^{NT}) + u_F(c^*) + u_Y(Y) \quad (51)$$

s.t.

$$pc + p^{NT}c^{NT} + c^* = pY + p^{NT}Y^{NT} \quad (52)$$

Note that in their optimization problem, consumers do not internalize the effect of their decision on Y but rather take Y as given.

Domestic producers maximize profit. Specifically, let w denote the market wage (in terms of the foreign good). Producers of the tradable good solve:

$$\max_L pF(L) - wL \quad (53)$$

Producers of the non-tradable good solve:

$$\max_{L^{NT}} p^{NT}F_{NT}(L^{NT}) - wL^{NT} \quad (54)$$

The equilibrium wage is set so that the labor market clears.

Optimal government intervention. The government faces the following problem:

$$\max_{c, c^{NT}, c^*, L, L^{NT}} u(c) + u_{NT}(c^{NT}) + u_F(c^*) + u_Y(F(L)) \quad (55)$$

s.t.

$$pc + c^* = pF(L) \quad (56)$$

$$c^{NT} = F_{NT}(L^{NT}) \quad (57)$$

$$L + L^{NT} = L_0 \quad (58)$$

Proposition 4 *Compared to the competitive equilibrium, the government chooses higher production of the tradable good.*

Normative implications. It is important to note that (in contrast to the Keynesian models) what matters here is the total production of tradable goods, rather than net exports. If all countries have positive externalities from the production of tradable goods, all countries should subsidize it; the world should simply produce less non-tradable goods and there will not be changes in the real exchange rate.

Of course, the irrelevance of the real exchange rate is highly sensitive to the assumption that the relative prices of tradable goods are fixed. As illustrated in the neoclassical model, countries prefer to sell their exports at a high price. If one country subsidizes the production of its tradable goods in a way that leads to a lower global equilibrium price, its competitors would be hurt by facing worse terms of trade.

However, it turns out that in these models, subsidizing the production of the tradable good to some extent is actually Pareto efficient, in spite of the adverse externalities on competing exporters. The government's solution is actually Pareto optimal. This is because subsidizing exports increases the total size of the pie, due to the externality; Pareto efficiency is achieved when the country subsidizes the domestic tradable good and compensates the competing exporters with a lump-sum transfer⁶.

The following proposition summarizes this result:

⁶Note the assumption that the country is a price taker: the government takes the terms of trade as given.

Proposition 5 *Consider a setup with n countries (indexed $i = 1, \dots, n$). The country i 's consumption of j 's tradable good is denoted c_i^j , and the consumption of its own non-tradable good is denoted $c_{i,NT}$. Each country is endowed with L units of labor; L_i^{NT} is the labor employed in the non-tradable sector in country i , and L_i is the labor employed in the tradable sector. Production functions are given by $Y_i^{NT} = F_{i,NT}(L_i^{NT})$ for non-tradables, and $Y_i = F_i(L_i)$ for tradables. The problem of a social planner maximizing global welfare (with Pareto weights ϕ_i) is given by:*

$$\max_{c_i^j, c_{i,NT}^{NT}, L_i, L_i^{NT}} \sum_{i=1}^n \phi_i \left(\sum_{j=1}^n u_{i,j}(c_i^j) + u_{i,NT}(c_{i,NT}^{NT}) + u_{i,Y}(Y_i) \right) \quad (59)$$

s.t.

$$\sum_{i=1}^n c_i^j = Y_j \quad (60)$$

$$c_i^{NT} = Y_i^{NT} \quad (61)$$

$$Y_i^{NT} = F_{i,NT}(L_i^{NT}) \quad (62)$$

$$Y_i = F_i(L_i) \quad (63)$$

$$L_j + L_j^{NT} = L \quad (64)$$

The solution to the government's problem satisfies the planner's problem.

To conclude, models of production externalities suggest that the government has an incentive to subsidize the production of tradable goods. While competing exporters are made worse off by facing worse terms of trade, the government's solution satisfies Pareto efficiency: it is not possible to make any country better off without hurting the other countries. However, subsidizing the production of tradable goods may have adverse distributional implications, that are to be corrected with appropriate transfers between countries.

3.3.2 Production externalities and the pattern of specialization

A reasonable form of export-manufacturing externalities is productivity improvements. It is therefore useful to understand how productivity improvements in the home country would affect the welfare of its trading partners.

Samuelson [2004] illustrates that this is a complex issue. Specifically, a productivity improvement that maintains the pattern of comparative advantage is unambiguously welfare improving. However, this may not be the case when the productivity improvement changes the pattern of comparative advantage. The argument is simple: assume two countries, North (N) and South (S), and two goods, 1 and 2, both produced with linear production technologies ($A_i^j L_i^j$, for $i = 1, 2$ and $j = N, S$). Assume initially that the North has a comparative advantage in the production of good 1. By the Ricardian theory of comparative advantage, the North specializes in good 1, and there are positive gains from trade. Assume next that there is a productivity improvement in the South, that disproportionately increases the productivity of the production of good 1, so that the relative productivities of producing goods 1 and 2 are the same as in the North. There are no longer any gains from trade. Since the North did not have a productivity improvement, its loss of a comparative advantage essentially brings it back to autarky, and the gains from trade are lost.

This channel may be relevant when thinking about the consequences of subsidizing the production of tradable goods. The “learning by doing” may change the pattern of comparative advantage. For example, managerial skills learned through manufacturing are likely to disproportionately increase the productivity of providing various high-skilled services, thereby changing the pattern of comparative advantage in a way that might reduce welfare in developed economies.

The welfare implications of productivity improvements in one country - whether by learning-by-doing in the production of tradable goods, or otherwise - have ambiguous welfare implications on its trading partners, depending on how the productivity improvement affects the pattern of comparative advantage.

4 Unintentional causes for real exchange rate misalignments

The previous section illustrates that, in some situations, a government may have an incentive to pursue policies that lead to a misaligned real exchange rate. However, a real exchange rate misalignment need not be an outcome of intentional policy. In this section, we discuss other causes of real exchange rate misalignments. We divide the discussion into two parts: first, we discuss policies that, while not necessarily targeted at manipulating the real exchange rate, may have consequences for the real exchange rate. Second, we discuss frictions in the environment that may lead to a misaligned real exchange rate.

4.1 Policies that affect the real exchange rate

The real exchange rate is an equilibrium object. The government does not “choose” the real exchange rate, leaving all else constant; rather, the government institutes various policies, and these policies alter the equilibrium value of the real exchange rate. The problem is that policies that affect the real exchange rate may be targeted at other goals; in the presence of limited policy instruments, the effect on the real exchange rate may not be easily undone. In this section, we review various policies that may affect the real exchange rate, and illustrate that the same policy instruments can be used to pursue other (more “legitimate”) goals.

Monetary policy. It is often assumed that the government can manipulate the real exchange rate by manipulating the nominal exchange rate. This is not obvious: in a world with flexible prices in which money is purely a medium of exchange, nominal exchange rate targeting should have nearly no effect⁷. However, there is evidence suggesting that prices of non-tradable goods move sluggishly relative to the nominal exchange rate (when it is flexible), suggesting that nominal exchange rate targeting may have some temporary effect on the real exchange rate (see Mussa

⁷The only channel is through changes in the distribution of wealth - during a nominal depreciation, people holding the domestic currency will experience a drop in wealth relative to people holding the foreign currency. However, in a model in which cash is merely a medium of exchange, only a small fraction of wealth is held in currency, and the distributional effects are small.

[1996] and Dornbusch [1976]). Of course, this policy instrument cannot sustain a depreciated exchange rate over time. Thus, it is likely that the motivation for using this policy instrument is some temporary need for a depreciated real exchange rate, such as recovery from a slump as in the Keynesian model.

In light of this, the distinction between expansionary monetary policy and short-term exchange rate devaluations is blurry. In our discussion of the Keynesian model in the previous section, we ignored the interest rate parity condition, and assumed that the government can choose the real exchange rate and the interest rate independently. However, in reality the government has limited policy instruments. In the presence of nominal price stickiness, a change in the nominal interest rate will likely affect the real exchange rate through the interest rate parity condition. This poses an additional conceptual difficulty: during a crisis, countries may try to expand output, for example by increasing M . In equilibrium, this will result in lower i , and a depreciated real exchange rate. Of course, all countries can expand their money supplies such that the real exchange rate remains unchanged (both i and i^* decline).

Fiscal policy. Long run depreciations of the real exchange rate are more likely to be sustained if they are implemented through fiscal policy. There are various ways in which the government can use fiscal policy to distort the real exchange rate. Of course, these policy may also be used to achieve other policy goals:

1. **Distorting aggregate savings.** The government can lead to an exchange rate depreciation by encouraging saving. This type of policy can be implemented in various ways, ranging from traditional subsidized saving policies or consumption taxes, to less direct policies that affect demographics and availability of insurance (in the presence of precautionary savings, the inability to insure against risk increases the demand for savings). So, for example, a policy restricting access to global financial markets can lead to an exchange rate depreciation; similarly, a policy restricting or discouraging child birth may result in higher domestic savings, and a lower real exchange rate. The government can also affect aggregate saving by its own spending choices: if a government decides to save more, aggregate savings increase and the real exchange rate depreciates.

It is almost redundant to point out that all of these policies may be used to pursue “legitimate” policy goals, that are unrelated to the real exchange rate. Subsidizing or encouraging savings is common in most countries (including the US), and is typically motivated by behavioral commitment problems that lead to under-saving; a policy restricting childbirth is clearly aimed primarily at controlling the population size; a consumption tax is a relatively undistortive way to raise revenue, and government saving and capital controls can be justified from a macro-prudential standpoint.

2. **Distorting the relative price of exports.** A government can induce a real exchange rate depreciation by taxing non-tradable goods or taxing imports or subsidizing exports. Alternatively, it can increase the value-added tax (which is reimbursed to exporters and levied on importers), as in Farhi et al. [2011]. This type of policy is likely more directly motivated by international trade considerations. However, there may also be redistributive considerations, if non-tradables or imports are disproportionately considered “luxury goods”. So, for a country that primarily exports low-quality goods and primarily imports high-quality goods, taxing imports at a higher rate may be a good way to implement progressive taxation.
3. **Distorting the input supply decision.** A depressed real exchange rate can be sustained if the cost of producing the domestic export is kept low. One way to implement this is through some form of subsidy on input supply, that would lead to a decline in the relative price of both domestically produced tradable goods and domestically produced non-tradable goods. A monetary expansion would implement this temporarily (assuming wages are nominally sticky), and a permanent tax could make this sustainable. Alternatively, inputs may be subsidized disproportionately in the export sector. For example, if the export sector is capital-intensive, a lower tax rate on capital (relative to labor) would lead to a disproportionate decrease in the cost of production in the export sector. Of course, a lower tax on capital could also be justified as a means of encouraging investment in a risky climate.

4.2 Fundamentals that affect the real exchange rate

In addition to policy choices, there are fundamental factors affecting the real exchange rate, that may potentially cause it to deviate from its frictionless competitive equilibrium benchmark. Namely, in reality, there are frictions; the government may need to intervene in order to restore the competitive equilibrium benchmark, and correcting the distortions or countering their effects may not be trivial.

For example, financial underdevelopment would tend to imply a depreciated exchange rate relative to the frictionless competitive equilibrium benchmark (whether the government favors this or not). This is for (at least) two reasons. First, there are grounds to believe that exporting firms have better access to finance. This is because exporting firms tend to be larger and more productive (as in Melitz [2003]) - consequently, they have more collateral and can borrow more easily to finance their operations. Further, there is evidence that firms exporting to reputable importers can borrow against accounts receivable (see Klapper [2000]). In an environment in which access to finance is incomplete, better access to finance results in a lower cost of production and disproportionate expansion. In other words, an exchange rate may be depreciated because the cost of production for exporting firms is indeed lower - for reasons that have nothing to do with government policy.

Second, financial underdevelopment implies that households are unable to properly insure against shocks. In the presence of a precautionary savings motive, this will lead them to save more, thereby leading to a depreciation of the real exchange rate. Similarly, there are discussions about several of China's structural distortions that potentially affects its saving and real exchange rate.⁸

At the same time, other frictions in developing economies might imply an over-valued real exchange rate. For example, traditional gender roles that prevent women from participating in the labor force essentially "lock them in" the production of non-tradables, such as child care or household maintenance. This would imply a disproportionate amount of labor employed in the production of non-tradable goods. Other forms of labor market segmentation may also lead to real exchange rate misalignment: for example, labor immobility problems may keep labor in rural areas, despite higher wages and higher labor productivity in urban

⁸See for example, China's one-child policy (Wei and Zhang [2011]) , or the lack of social safety nets (OECD [2010]) .

areas. Depending on whether urban production has a larger share of non-tradables (such as real estate, restaurants, etc, compared to tradable agricultural goods that are produced in rural areas), this may lead to under-employment in the tradable sector.

These structural distortions illustrate the difficulty in identifying real exchange rate targeting. Are distortions directly a part of a country's effort to "undervalue", or are they a part of other existing frictions in the economy? Is the government trying to restrict domestic access to insurance facilities, or is restricted access to insurance a distortion in the environment that the government cannot correct?

From the perspective of other countries, this of course does not matter: what matters is the end result. However, the distinction between policy-misalignment and fundamental-misalignment is crucial for evaluating the cost-effectiveness of policy in eliminating the misalignment. If the fundamental distortions leading to the misalignment are difficult to eliminate (as is the case when the underlying distortion is an underdeveloped financial system), a "correcting" policy aimed at restoring the frictionless equilibrium real exchange rate may lead to further distortions and increased welfare losses in the home economy.

More generally, the costs of realigning the real exchange rate may be non-trivial, if the underlying cause of the real exchange rate misalignment cannot be easily corrected. For example, a policy restricting childbirth may lead to increased domestic savings and a depreciated real exchange rate. But it is impossible to reverse this outcome with a simple policy reversal. Even if the government ceases to restrict childbirth, this will have implications only for the future real exchange rate. Households beyond a certain age group can no longer alter the number of kids, so their savings decisions will remain unchanged. To restore the frictionless real exchange rate, the government may need to restrict domestic savings in some way, leading to potentially large welfare losses as the ability of households to use savings to buffer adverse shocks is diminished.

To conclude, there are cases in which realigning the real exchange rate is not simply reverting back to the frictionless competitive equilibrium; rather, it must involve some distortive policy measures that counter the real exchange rate effects of the underlying source of the misalignment. But such policies may lead to other internal distortions, the costs of which must be taken into account.

5 Assessing real exchange rate misalignment

In this section we offer a critical review of the existing approaches currently used to assess real exchange rate misalignment, and propose a new approach to do so. The new approach is based on comparing the marginal products and the revenue-expenditure ratios across sectors of interest (which we will elaborate on later). We argue that the new approach complements the existing approaches, by providing additional measures that are relevant for discussing international real exchange rate disputes.

5.1 A critical review of existing approaches

In this section we review three existing methods currently being used by the IMF for assessing real exchange rate misalignment. The three methods are referred to as the macroeconomic balance approach (MB), the equilibrium real exchange rate approach (ERER) and the external sustainability approach (ES). Below is a summary of the three methods. For more details, please see Lee et al. [2006].

The macroeconomic balance approach (MB): This method consists of three steps. First, an equilibrium relationship between current account balances and a set of “fundamentals” is estimated with panel econometric techniques⁹. Second, for each country, equilibrium current accounts (“current account norms”) are computed from this relationship as a function of the levels of fundamentals. Finally, the frictionless real exchange rate is calibrated as the real exchange rate that would bring the current account back to its norm.

The reduced-form equilibrium real exchange rate (ERER): Similarly, this method consists of three steps. First, panel regression techniques are used to estimate an equilibrium relationship between real exchange rates and a set of fundamentals¹⁰. Second, equilibrium real exchange rates are computed as a func-

⁹The “fundamentals” used in this method are fiscal balance, old-age dependencies, population growth, lagged current account, oil balance, output growth, relative income, whether the country experienced a banking crisis, whether the country experienced the Asian crisis, and whether the country is a financial center.

¹⁰The fundamentals are net foreign assets, productivity differential to trading partners, commodity terms of trade, government consumption, trade restriction and price control index

tion of the medium-term level of the fundamentals. Third, the magnitude of the exchange rate adjustment that would restore equilibrium is calculated directly as the difference between each country’s actual real exchange rate and the equilibrium value identified in the second step.

The external sustainability (ES): This method also consists of three steps. The first involves determining the ratio of trade or current account balance to GDP that would stabilize the net foreign asset position at given chosen “benchmark” values. The second step compares the NFA stabilizing trade or current account balance with the actual level of a country’s trade or current account balance. The third step consists of assessing the adjustment in the real effective exchange rate that is needed to close the gap between the actual trade and current account balances and the NFA-stabilizing trade and current account balances.

Using cross-country regressions, the above methods identify the typical exchange rate, calibrated based on comparisons with similar countries (i.e. countries with the same “fundamentals”). The practice of equating this calibrated real exchange rate with the frictionless competitive equilibrium benchmark is a problematic one, as it is likely that the real exchange rate of similar countries are systematically distorted.

Specifically, the first two methods answer the following questions: what is the typical current account (for the MB method) or exchange rate (for the ERER method) of a country as a function of its fundamentals? It does not address the question of what a country’s real exchange rate should be, or what is its frictionless benchmark. In other words, the methods calibrate “typical” rather than “normative” or “frictionless” current accounts and exchange rates. There are two problems with this. First, the residual may include neglected fundamentals affecting the left hand side variable (the current account or the real exchange rate). It is impossible to come up with an exhaustive list of factors affecting productivity and consumption and saving decisions. The identification of the real exchange rate misalignment essentially as a regression residual is likely to be very noisy, as the residual includes other things as well.

Second, many variables that are considered “fundamentals” for the “right” (i.e., market-determined) real exchange rate might contain elements that distort it. For

example, in the ERER method, government consumption is considered a “fundamental”. However, there are several reasons why government consumption could be directly affected by an incentive to lower the real exchange rate, as discussed in the preceding sections. Government consumption may be incorrectly counted as a “fundamental” thereby concealing a real exchange rate misalignment.

The ES approach, while less subject to the above critiques, is equally problematic. Conceptually, identifying the correct benchmark for the NFA is perhaps more difficult than identifying the correct benchmark for the real exchange rate. This is because it is unclear how an “unsustainable” NFA could be observed at all, as presumably intertemporal budget constraints must always be satisfied.

Further, the key identifying assumption behind the ES approach (as well as the MB approach) is that there is a one-to-one mapping between real exchange rate misalignments and current account misalignments. For example, if the current account surplus is too large, it is concluded that an appreciation of the terms of trade may help close the gap. This type of reasoning is perhaps reasonable when thinking about sustainability issues from the perspective of the home country, or (for large countries) when thinking about the effect on the world interest rate. However, it does not seem to be relevant when thinking about the terms of trade from the perspective of the country’s trading partners (or competing exports). As illustrated in sections 2 and 3, a devalued real exchange rate (or, more importantly, depressed terms of trade) need not translate into an inflated current account surplus. For example, a permanent subsidy on the manufacturing of tradable goods will have a permanent effect on the terms of trade, and no effect on the current account; the current account may be balanced while the price of exports in terms of imports is too low. As cross-country externalities operate both through the world interest rate and through the terms of trade, focusing solely on intertemporal distortions potentially leaves out important aspects of the problem.

5.2 An alternative approach to assessing real exchange rate misalignment

We will lay out a new approach for identifying and quantifying real exchange rate misalignment, to be potentially implemented in future work. Our view is that

this method has the potential to address many of the shortcomings of the IMF methodologies, and may prove useful in contributing to the real exchange rate misalignment debate and possibly settling international disputes.

Our approach relies on explicitly contrasting the characteristics of subsidized sectors with other sectors. We will focus on two types of measures: one is the marginal products and the other is the revenue-expenditure ratio. The idea is that the marginal products and the revenue-expenditure ratio will be lower for sectors that are explicitly or implicitly subsidized. The “subsidies” we identify need not be strictly related to policy; for example, easier access to finance is equivalent to a subsidy in our context.

As previously discussed in section 2, there are two types of distortions that can lead to real exchange rate undervaluation: “supply shifters” and “demand shifters”. The first is a wedge between the return to producing tradable goods and the return to producing non-tradable goods. Examples include taxes and subsidies that favor tradable good production, and distortions in the environment that make the production of tradable goods easier. In the case of “supply shifters”, the tradable sectors’ marginal products and revenue-expenditure ratios will be systematically lower.

“Demand shifters” are distortions that lower domestic demand for current consumption goods. In principle, any distortion that leads to lower current consumption - either through increased saving, or simply through lower income - is a “demand shifter”. The lower demand for consumption will typically translate into a lower CPI, and a lower real exchange rate. An example of such a demand shift policy is a subsidy to investment. A subsidy to investment discourages consumption demand. Since a decline in demand hurts non-tradable sectors more, the real exchange rate will depreciate and resources will move from non-tradable sectors to tradable sectors. In this situation, since the investment good sector is subsidized, its marginal products and the revenue-expenditure are systematically lower than those of other sectors.

Advantages over currently used methodologies. The main advantage of this approach is that it directly tests a property of the frictionless competitive equilibrium that is likely to be violated in the presence of distortions that affect

the real exchange rate. As we have illustrated in the preceding section, there are many reasons to be cautious about equating “expected” or “average” real exchange rates with the frictionless competitive equilibrium benchmark. It is indeed possible that real exchange rates are systematically distorted, making the “expected” value a distorted one. Our approach utilizes a robust property of the frictionless competitive equilibrium, that is necessary for efficiency.

Our methodology has the potential to identify countries with distorted terms-of-trade, which may not be reflected in their current account or even in their real exchange rate. This fills an important gap, as the IMF methodologies have the scope to identify terms-of-trade distortions only when they are reflected in a distortion of saving rates or non-tradable consumption. As illustrated in section 2, supply shifters that lead to depressed export prices may lead to higher non-tradable prices, and an *overvalued* real exchange rate. Further, these distortions need not alter the domestic saving rate; it is therefore likely that the IMF approaches fail to identify these distortions, and may infact lead to opposite conclusions regarding the externalities of the distortions.

Disadvantages of this approach. The implementation of this approach is likely to be primarily constrained by data availability, as currently high quality firm-level or industry-level data are available only for a limited number of countries. However, the development of such data sets is rapidly expanding, and the collection of such data will likely yield benefits far beyond the assessment of real exchange rate misalignment. Conditional on data availability, standard tests and procedures could be developed to maintain routine assessments, adding to the current routine calculations done by the IMF.

Similar to the IMF methodologies, our approach has its limitations in terms of the types of distortions it can hope to identify. Specifically, we hope to identify distortions that lead to a wedge between tradable and non-tradable production, and the production of consumption goods and investment goods. This leaves out many important and relevant cases. For example, there is no hope in using this methodology to identify “demand shifters” that operate through lower income. As an extreme example, a country that loses a constant fraction of its income in every period will have lower demand for consumption and for saving; this will depress

the real exchange rate, but will not show up as a wedge between tradables and non-tradables, or as a wedge between consumption and investment. It will also not show up as a distortion to the current account, as the permanent nature of the distortion will leave the saving rate unchanged.

Our ability to identify “demand shifters” that operate by changing the saving rate is limited to the extent that these changes are reflected through changes in investment. For example, in a perfectly integrated small open economy, changes in the saving rate will not change investment, as foreign investors (or foreign investment opportunities) will fill in the gap so that the expected marginal product of capital (including any capital adjustment costs) will be equal to its global equilibrium level. Our approach can therefore hope to identify intertemporal “demand shifters” only when there is some home bias in investment, or when there are some barriers to capital mobility. Similarly, an economy that adjusts its saving primarily through bonds or other non-investment forms of savings is unlikely to show up as “distorted” in our analysis. In this sense, the IMF methodologies can be seen as complementary to our approach, as the MB approach and the ES approach may help identify deviations in the saving rate.

5.3 Identifying real exchange rate misalignment based on marginal products

In their seminal paper, Hsieh and Klenow [2009] estimate a non-structural model of distortions, based on the following idea. Regardless of whether distortions are caused by incomplete access to credit, corruption, or other frictions, the distortions lead to the misallocation of inputs, causing some relatively productive firms to employ too few inputs while less productive firms employ too many or too much inputs. They thus are able to quantify the extent of misallocation by measuring the dispersion in marginal products. Using the Hsieh and Klenow [2009] methodology, we will measure whether there is a *systematic* dispersion in marginal products between producers of tradable goods and non-tradable goods, and between producers of investment goods and consumption goods.

To illustrate the methodology, consider a simplified environment with two firms, producing two distinct goods, a tradable and a non tradable ($i \in \{T, NT\}$). As-

sume that firm i is taxed at a rate τ_i , and assume that labor and capital are taxed at rates $\tau_{L,i}$ and $\tau_{K,i}$ respectively. Both firms have Cobb-Douglas production functions, where the labor share is θ_i . Let W and R be the wage rate and the capital rent respectively.

Importantly, the tax rates τ_i , $\tau_{i,L}$ and $\tau_{i,K}$ are to be interpreted more broadly as distortions that prevent the competitive equilibrium allocation. For example, finding that $\tau_{i,K}$ is higher for some firms does not necessarily imply that these firms are (literally) taxed at a higher rate; rather, we learn that these firms face an effective higher price of capital, which may be a result of incomplete access to credit or other distortions.

Firm i maximizes:

$$\max_{L_i, K_i} p_i(1 - \tau_i)A_i L_i^{\theta_i} K_i^{1-\theta_i} - (1 + \tau_{L,i})W L_i - (1 + \tau_{K,i})R K_i \quad (65)$$

Denote the (“pre-tax”) revenue of firm i by:

$$I_i = p_i A_i L_i^{\theta_i} K_i^{1-\theta_i} \quad (66)$$

The FOC with respect to labor is:

$$\theta_i p_i (1 - \tau_i) \frac{A_i L_i^{\theta_i} K_i^{1-\theta_i}}{L_i} = (1 + \tau_{L,i})W \Rightarrow \theta_i I_i = \frac{1 + \tau_{L,i}}{1 - \tau_i} W L_i \quad (67)$$

Similarly, the FOC with respect to capital yields:

$$(1 - \theta_i) I_i = \frac{1 + \tau_{K,i}}{1 - \tau_i} R K_i \quad (68)$$

These simple equations allow us to approach two questions: first, are there differences in the effective rates of taxation in the tradable and non-tradable sectors? Second, is capital taxed differently than labor, thereby giving an edge to capital-intensive industries (which may be disproportionately tradable)?

To answer the questions above, we need firm-level or industry-level data that includes the following variables:

1. Labor costs, $W L_i$.

2. Capital costs, RK_i .
3. Revenues, I_i .
4. Labor shares, θ_i .

As in Hsieh and Klenow [2009], labor shares can be inferred from US input-output tables. As for firm-level or industry-level data, there are a variety of datasets that include these variables for different countries. For example, Hsieh and Klenow [2009] use India’s Annual Survey of Industries (conducted by the Indian government’s Central Statistical Organization) for India, and the Chinese Annual Surveys of Industrial Production (conducted by the Chinese government’s National Bureau of Statistics) for China. Other private and more standardized datasets may also suffice for our purposes. For example, the AMADEUS dataset includes firm-level data for all European (and some Eastern-European) firms.

Note that we do not take a stand about the sources of the frictions. In other words, we just calculate the marginal products of labor and capital in tradable and non-tradable sectors as they are. To test for “supply shifts” such as subsidies on the tradable consumption sectors, we will calculate if the marginal products of the tradable consumption sectors are systematically lower than those of the non-tradable sectors. To test for “demand shift” such as subsidies on the investment good sectors, we will calculate if the marginal products of the investment good sectors are systematically lower than those of the consumption good sectors.

5.4 Identifying real exchange rate misalignment based on the revenue-cost ratio

A potential problem with the Hsieh and Klenow [2009] approach outlined above is that it relies on knowledge of the production functions, and in particular, the capital and labor shares. For our purposes, this is problematic as, in reality, inputs are not homogeneous; the “labor” used in the production of tradable goods need not be the same as the “labor” employed in the non-tradable sectors. Further, production technologies may differ across countries, and taking this heterogeneity into account is likely to be a complicated task.

It turns out that, under certain assumptions, simply looking at revenue-cost ratios is sufficient to identify distortions. Our idea is based on a simple insight: in equilibrium, an entrepreneur should be indifferent between entering into either sector. Under the assumption of constant return to scale technologies, this implies that the “after-tax” revenue-expenditure ratios for the two sectors should be the same. If we observe that the “pre-tax” revenue-expenditure ratio for sector A is lower than that of the sector B, subsidies of one form or another are taking place for sector A.

This method is more general than the one using marginal products. The latter relies on a perfect market integration of input factors, which does not always hold. For example, different skills and education of workers in different sectors can create market segmentation and consequently, differential marginal products. The approach of revenue-expenditure ratio does not depend on this assumption.

To illustrate, using the analysis in the previous section, note that the expenditure of firm i is given by:

$$E_i = WL_i + RK_i = \frac{1 - \tau_i}{1 + \tau_{L,i}} \theta_i I_i + \frac{1 - \tau_i}{1 + \tau_{K,i}} (1 - \theta_i) I_i \quad (69)$$

The ratio of revenue to expenditure is equal to:

$$\frac{I_i}{E_i} = \frac{1}{(1 - \tau_i) \left(\frac{\theta_i}{1 + \tau_{L,i}} + \frac{1 - \theta_i}{1 + \tau_{K,i}} \right)} \quad (70)$$

Notice that when the taxes are higher (τ_i , $\tau_{L,i}$ and $\tau_{K,i}$), the ratio of “pre-tax” revenue to expenditure is higher. Conversely, when the subsidies are higher, the ratio of “pre-tax” revenue to expenditure is lower. Notice that, in the absence of any taxes or subsidies, the ratio of the marginal revenue and the marginal expenditure is equal to 1.

To test for “supply shifts” such as subsidies on the tradable consumption sectors, we will calculate if the (pre-tax) revenue-expenditure ratio of the tradable consumption sectors is systematically lower than that of the non-tradable sectors. To test for “demand shift” such as subsidies on the investment good sectors, we will calculate if the (pre-tax) revenue-expenditure ratio of the investment good sectors is systematically lower than that of the consumption good sectors.

5.5 Further analysis

This approach can be extended to pin point more precisely the source of distortion. For example, if the source of distortion is that exporting firms have better access to credit, we would expect that the dispersions in marginal products and revenue-expenditure ratio between exporting and non-exporting firms are largely explained by the differences in the loan amount given to exporting v.s. non-exporting firms.

Similarly, if nominal depreciations are at play, we would expect to see that firms that rely more heavily on nominally-sticky inputs like labor will be more affected than firms that rely primarily on internationally traded inputs (such as oil). We would therefore expect that, within the tradable sector, the implicit “subsidy” will be higher for labor-intensive producers.

By such further analysis, one can hope to identify the source of the distortion. This understanding will be helpful both when thinking about measures to correct the misalignment, and potentially for settling real exchange rate disputes (if it can be established that the real exchange rate misalignment is a result of some policy).

6 Conclusion

In this paper, we highlighted three potential difficulties in the settlement of international disputes regarding real exchange rate misalignment. First, we illustrated the conceptual difficulty in assessing the normative properties of real exchange rate misalignment. Depending on the model and on the relevant circumstances, real exchange rate misalignment may be efficient or inefficient (in a Pareto sense); it may be either beneficial or harmful to importing countries, as well as to competing exporters. Thus, even if the international community is able to identify real exchange rate misalignment in a convincing way, there is still a fair amount of judgment as to when this misalignment should be sanctioned, and which countries should be compensated.

The second difficulty is in identifying real exchange rate *targeting*. As we have illustrated, a depreciated real exchange rate is not necessarily an outcome of “manipulative” policy; in fact, in the prominent neoclassical model, it is typically difficult to rationalize such a policy choice (unless the country is large enough to

affect the world interest rate). A depreciated real exchange rate may be a result of fundamental distortions, such as incomplete access to credit or savings. In the presence of such distortions, it is not clear whether it is efficient to take measures aimed at correcting the real exchange rate misalignment without addressing the underlying sources of distortions. Further, it is not clear whether a country with a “fundamental” real exchange rate misalignment should be sanctioned, as the government did not necessarily deviate from any cooperative optimal solution.

Finally, we illustrated the difficulty in measuring real exchange rate misalignment. We argued that the current methodologies are problematic, as they identify real exchange rate misalignment as a deviation from some country-specific “norm” that corresponds to an average or expected level, rather than to the competitive frictionless benchmark. We proposed an alternative methodology, that quantifies distortions by the dispersion in marginal products and revenue-expenditure ratios between producers of tradable and non-tradable goods, and producers of consumption and investment goods.

Despite the difficulties, there are potentially gains from overcoming these difficulties and establishing a mechanism for enforcing international cooperation on real exchange rate issues. Theory suggests that in certain circumstances, real exchange rate misalignment may be highly inefficient and harmful both for competing exporters and for importers, and that greater global welfare can be achieved if countries are able to enforce an efficient cooperative solution.

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A The frictionless competitive equilibrium benchmark

In this section, we lay out the frictionless competitive equilibrium model. A real exchange rate misalignment will be defined as a deviation from the real exchange rate predicted by this benchmark. The frictionless equilibrium economy consists of n countries. Each country produces a tradable good and a non-tradable good. In each country there is a continuum of identical agents. They are price-takers. They work, invest in capital, buy shares in the domestic countries as well as in foreign countries. The only source of uncertainty is productivity shocks. The detailed description of the frictionless economy is as follows:

Consider an infinite horizon representative agent framework with n countries, indexed $j = 1, \dots, n$. Goods produced in country j will be denoted with superscript j . Each country produces two types of goods: a tradable good (denoted with superscript T) and a non-traded good (denoted with superscript NT). Agents also incur a disutility of labor (L). Consumption values of the representative agent in country i are denoted with subscript i . The utility of the representative agent in country i is given by:

$$U_i(\{\{c_{i,t}^{j,T}\}_{t=0}^{\infty}\}_{j=1}^n, \{c_{i,t}^{i,NT}\}_{t=0}^{\infty}, \{L_{i,t}\}_{t=0}^{\infty}) = E(\sum \beta^t u_i(\{c_{i,t}^{j,T}\}_{j=1}^n, c_{i,t}^{i,NT}, L_{i,t})) \quad (71)$$

Where u_i is increasing in $c^{j,T}$, $c^{i,NT}$, but decreasing in L_i .

There are two inputs of production - capital (K) and labor (L)- and two neo-classical production functions, one for tradable goods and one for non-tradable goods: $F^T(K, L)$ and $F^{NT}(K, L)$. The production functions are increasing and concave in both capital and labor, and exhibit constant returns to scale. Denote by K^T and L^T the amounts of capital and labor employed in the tradable sector, and let K^{NT} and L^{NT} be the amounts of capital and labor employed in the non tradable sector.

The only source of uncertainty is shocks to productivity. In the most general specification, there are 4 productivity shocks per country: $A_t^{T,K}$, $A_t^{T,L}$, $A_t^{NT,K}$ and $A_t^{NT,L}$. $A_t^{s,i}$ is the productivity of input i in sector s at time t . For example, in the

tradable sector, the production function is given by:

$$Y^T = F(A^{T,K} K^T, A^{T,L} L^T) \quad (72)$$

The output of the non-tradables is given by:

$$Y^{NT} = F(A^{NT,K} K^{NT}, A^{NT,L} L^{NT}) \quad (73)$$

The share of sector s in country j owned by country i is denoted $\phi_{i,t}^{j,s}(S_t)$ (for example, $\phi_{i,t}^{j,NT}(S_t)$ is the share of the non-tradable sector in country j owned by country i). The stock price of $\phi_{i,t}^{j,s}(S_t)$ is denoted $q_t^{j,s}(S_t)$. Stock holders distribute profits according to their stock shares. The profits of sector s in country j are denoted $D_t^{j,s}(S_t)$.

The price of the tradable good of country 1 at time 0 is normalized to 1, which will serve as the numeraire. Other prices depend on the aggregate state, which will be denoted by S_t (the state includes all current and passed productivity shocks). The price of the tradable good in country j at time t (in terms of the tradable good of country 1 at time 0) is denoted $p_t^{j,T}(S)$, and the price of the non-tradable good of country j at time t is denoted $p_t^{j,NT}(S)$.

The wage rate is also state contingent, and is denoted $w_t^j(S_t)$. The rental rate of capital is denoted $R_t^j(S_t)$. Capital depreciates at a rate δ . The non-traded good can be converted into domestic capital, and there are no barriers to foreign ownership of domestic capital. The investment of country i in capital in country j is given by $I_{i,t}^j(S_t)$. The capital in country j owned by country i is $K_{i,t}^j(S_t)$.

Agents trade in a spot market in time 0. They can buy and sell state contingent claims on goods, labor and capital, as well as state-contingent stock shares.

Definition of equilibrium. An equilibrium is defined as a set of state contingent price sequences $p_t^{j,T}(S_t)$, $p_t^{j,NT}(S_t)$, $q_t^{j,s}(S_t)$, a set of state contingent investment decisions $I_t^j(S_t)$, a set of state contingent labor supplies $L_t^j(S_t)$, a set of state contingent capital and labor employments in the tradable and the non-tradable sector $L_t^{j,T}(S_t)$, $L_t^{j,NT}(S_t)$, $K_t^{j,T}(S_t)$, $K_t^{j,NT}(S_t)$, consumption of tradables $c_{i,t}^{j,T}(S_t)$, consumption of non-tradables $c_{i,t}^{j,NT}(S_t)$, dividends $D_t^{j,T}(S_t)$ and $D_t^{j,NT}(S_t)$, stock shares $\phi_{i,t}^{j,T}(S_t)$ and $\phi_{i,t}^{j,NT}(S_t)$ and output of tradables and non-tradables $Y_t^{j,T}(S_t)$,

$Y_t^{j,NT}(S_t)$ that jointly satisfy:

1. The representative agent takes prices as given and maximizes utility:

$$\max_{c_{i,t}^{j,T}(S_t), c_{i,t}^{i,NT}(S_t), L_{i,t}(S_t)} U_i(\{\{c_{i,t}^{j,T}(S_t)\}_{t=0}^\infty\}_{j=1}^n, \{c_{i,t}^{i,NT}(S_t)\}_{t=0}^\infty, \{L_{i,t}(S_t)\}_{t=0}^\infty)$$

s.t.

$$\begin{aligned} \sum_{t,S} (p_t^{i,NT}(S_t) c_{i,t}^{i,NT}(S_t) + \sum_{j=1}^n (p_t^{j,T}(S_t) c_{i,t}^{j,T}(S_t) + p_t^{j,NT}(S_t) I_{i,t}^j(S_t) + \\ \sum_{s=T,NT} q_t^{j,s} \phi_{i,t}^{j,s}(S_t))) = \\ \sum_{t,S} (w_t^i(S_t) L_t^i(S_t) + \sum_{j=1}^n (R_t^j(S) K_{i,t}^j(S_t) + \sum_{s=T,NT} \phi_{i,t}^{j,s}(S_t) D_t^{j,s}(S_t))) \end{aligned} \quad (74)$$

$$K_{i,t+1}^j(S_{t+1}) = (1 - \delta) K_{i,t}^j(S_t) + I_{i,t}^j(S_t) \quad (75)$$

$K_{i,0}^j$ and $\phi_{i,0}^{j,s}$ are given.

2. Both tradable and non-tradable producers take wages and capital rental rates as given and maximize profit:

$$D_t^{i,T}(S_t) = \max_{L_t^{i,T}(S_t), K_t^{i,T}(S_t)} p_t^{i,T} F(A_t^{T,L} L_t^{i,T}(S_t), A_t^{T,K} K_t^{i,T}(S_t)) \quad (76)$$

$$-w_t^i(S_t) L_t^{i,T}(S_t) - R_t^i(S_t) K_t^{i,T}(S_t)$$

$$D_t^{i,NT}(S_t) = \max_{L_t^{i,NT}(S_t), K_t^{i,NT}(S_t)} p_t^{i,NT} F(A_t^{NT,L} L_t^{i,NT}(S_t), A_t^{NT,K} K_t^{i,NT}(S_t)) \quad (77)$$

$$-w_t^i(S_t) L_t^{i,NT}(S_t) - R_t^i(S_t) K_t^{i,NT}(S_t)$$

3. Market clearing of capital and labor:

$$K_t^{i,NT}(S_t) + K_t^{i,T}(S_t) = \sum_{j=1}^n K_{i,t}^j(S_t) \quad (78)$$

$$L_t^{i,NT}(S_t) + L_t^{i,T}(S_t) = L_{i,t}(S_t) \quad (79)$$

4. Goods market clearing:

$$Y^{i,T}(S_t) = \sum_{j=1}^n c_{j,t}^{i,T}(S_t) \quad (80)$$

$$Y^{i,NT}(S_t) = c_{i,t}^{i,NT}(S_t) + \sum_{j=1}^n I_{j,t}^i(S_t) \quad (81)$$

Definition of the frictionless real exchange rate. To define the real exchange rate, we first need to define the CPI. We will choose the benchmark basket of consumption to correspond to the consumption baskets at time 0. The CPI is given by:

$$CPI_{i,t}(S_t) = p_t^{i,NT}(S_t) c_{i,0}^{i,NT}(S_0) + \sum_{j=1}^n p_t^{j,T}(S_t) c_{i,0}^{j,T}(S_0) \quad (82)$$

In other words, the CPI is the current (state contingent) price of the consumption basket at time 0, when prices are given by their equilibrium value. The frictionless real exchange rate between countries i and i' is then defined as:

$$RER_{i,i',t}(S_t) = \frac{CPI_{i,t}(S_t)}{CPI_{i',t}(S_t)} \quad (83)$$

real exchange rate misalignment are defined as deviations from this frictionless competitive equilibrium benchmark. Distortions in the real exchange rate may be an outcome of anything that distorts equilibrium prices; in principal, any deviation from the frictionless competitive equilibrium may result is the misalignment of the real exchange rate.

Normative properties. By the first welfare theorem, this solution is Pareto efficient, in the sense that no country can be made better off without making another country worse off. The second welfare theorem guarantees further than *any* Pareto efficient solution can be achieved with a competitive equilibrium, with an appropriate redistribution of initial endowments (here, initial endowments are capital endowments, $K_{i,0}^j$, and stock shares, $\phi_{i,0}^{j,s}$ for $s = T, NT$).

Implications for government spending. In the frictionless competitive equilibrium, there is typically no role for government spending. However, government spending is not necessarily *inconsistent* with the frictionless competitive equilibrium, as long as the government behaves as if it were a competitive price taker. In other words, the efficiency properties of the frictionless competitive equilibrium suggest certain prescriptions for *efficient* government spending. There is a role for government spending only to the extent that it is the most efficient provider of certain non-tradable goods (for example, national security or law enforcement services). As a producer of non-tradable goods, the government should behave *as if* it is a price taker in a competitive environment.

Non-distortionary government spending is consistent with solving the following procedure. First, the government should construct a fictitious production function for non-tradable goods, which is composed of government services and private non-tradable goods:

$$F^{NT}(K^{NT}, L^{NT}) = \max_{K^G, L^G, K^P, L^P} (F^G(K^G, L^G) + F^P(K^P, L^P)) \quad (84)$$

s.t.

$$K^{NT} = K^G + K^P \quad (85)$$

$$L^{NT} = L^G + L^P \quad (86)$$

Where F^G is government production of non-traded goods, F^P is private production of non-traded goods, and K^G, L^G, K^P, L^P are capital and labor employed in the government sector and the non-tradable private sector respectively. This specification delivers L^G and K^G as a function of K^{NT} and L^{NT} .

Second, the government should calculate the frictionless competitive equilibrium values of K^{NT} and L^{NT} , based on the fictitious production function F^{NT} . It should set taxes such that the price of the private non-tradable good is at the equilibrium value, and employ capital and labor that are consistent with the optimization problem above (equation 84).

While this procedure may seem unnaturally complicated, it is the only procedure that guarantees the efficiency of equilibrium. There is no role, for example, for counter-cyclical government policy, as international risk sharing arrangements

should provide optimal cross-country insurance; instead, if there is a negative local productivity shock, the government should follow other producers and contract.

These prescriptions for government spending and taxation present a conceptual difficulty in assessing real exchange rate misalignment. In the presence of a government, the frictionless competitive equilibrium is unlikely to be an equilibrium: governments are likely to realize their “market power” and internalize the effect of their spending decisions on equilibrium prices and output.

B Proof of Proposition 1

To characterize the frictionless competitive equilibrium, let λ denote the Lagrange multiplier on the constraint in equation 22. The first order conditions of the Lagrangian are given by:

$$u'(c_0) = \lambda \quad (87)$$

$$u'_{NT}(c_0^{NT}) = \lambda p_0 \quad (88)$$

$$\beta R u'(c_1) = \lambda \quad (89)$$

$$\beta R u'_{NT}(c_1^{NT}) = \lambda p_1 \quad (90)$$

This implies the following two equilibrium relations:

$$u'(c_0) = \beta R u'(c_1) \quad (91)$$

$$p_0 = \frac{u'_{NT}(c_0^{NT})}{u'(c_0)} \quad (92)$$

The government’s problem can therefore be written as:

$$\max_{c_0} u(c_0) + \beta u(Y_1 - R(c_0)c_0) \quad (93)$$

The first order condition of this problem is:

$$u'(c_0) = \beta R u'(c_1) + \beta c_0 \frac{\partial R}{\partial c_0} u'(c_1) \quad (94)$$

Denote with superscript E the equilibrium solution. By equation 91, the market

solution satisfies:

$$u'(c_0^E) = \beta R u'(c_1^E) \quad (95)$$

This cannot be the planners solution because:

$$\begin{aligned} u'(c_0^E) &= \beta R u'(c_1^E) < \beta R u'(c_1^E) + \beta c_0^E \frac{\partial R}{\partial c_0} u'(c_1^E) \\ &= \beta R u'(Y_1 - R(c_0^E)c_0^E) + \beta c_0^E \frac{\partial R}{\partial c_0} u'(Y_1 - R(c_0^E)c_0^E) \end{aligned} \quad (96)$$

From the analysis above, it is apparent that the government chooses $u'(c_0) > u'(c_0^E)$, that is, $c_0 < c_0^E$ and higher domestic savings.

The government's policy results in the depreciation of the exchange rate. Note that the real exchange rate is given by the ratio of the domestic and foreign CPIs:

$$RER_t = \frac{CPI_t}{CPI_t^*} \quad (97)$$

Let α_t and α_t^* denote the benchmark fractions of the tradable goods used in calculating the CPI at the emerging home country and the foreign developed country correspondingly. Note that the CPI is given by:

$$CPI_t = \alpha + (1 - \alpha)p_t \quad (98)$$

The equilibrium real exchange rate is therefore given by:

$$RER = \frac{\alpha + (1 - \alpha)p}{\alpha^* + (1 - \alpha^*)p^*} \quad (99)$$

Note that the price of the non tradable good is given by equation 92. Thus, we have that $p_0^E > p_0$:

$$p_0^E = \frac{u'_{NT}(c_0^{NT,E})}{u'(c_0^E)} = \frac{u'_{NT}(Y_0^{NT})}{u'(c_0^E)} > \frac{u'_{NT}(Y_0^{NT})}{u'(c_0)} = \frac{u'_{NT}(c_0^{NT})}{u'(c_0)} = p_0 \quad (100)$$

Similarly, note that $c_0^{E*} > c_0^*$, as market clearing implies that foreigners consume more of the tradable good in period 0. Hence, following similar algebra we get that

$p_0^{E*} < p_0^*$. Thus, we have that:

$$RER_0 < RER_0^E \quad (101)$$

C Proof of Proposition 2

The optimization problem of the developed market government can be rewritten as:

$$\max_{c_0^*} u(c_0^*) + \beta u(R(c_0^*)(Y_0^* - c_0^*)) \quad (102)$$

The first order condition with respect to c_0^* is given by:

$$u'(c_0^*) = \beta R u'(c_1^*) - \beta(Y_0^* - c_0^*) \frac{\partial R}{\partial c_0^*} u'(c_1^*) \quad (103)$$

Thus, the developed economy encourages spending in equilibrium, causing a negative wedge between $u'(c_0^*)$ and $\beta R u'(c_1^*)$. Similarly, from the emerging market's problem, it is evident that the government encourages saving in equilibrium, causing a positive wedge between $u'(c_0)$ and $\beta R u'(c_1)$.

To show that this strategic equilibrium is Pareto inefficient, we will characterize the set of efficient allocations as the set of solutions to the following problem (indexed by the Pareto weight ϕ):

$$\max_{c_t, c_t^*} u(c_0) + \phi u(c_0^*) + \beta(u(c_1) + \phi u(c_1^*)) \quad (104)$$

s.t.

$$\lambda_1 : c_0 + c_0^* = Y_0^* \quad (105)$$

$$\lambda_2 : c_1 + c_1^* = Y_1 \quad (106)$$

Note that the consumption of non-tradables drops out as constants. λ_1 and λ_2 denote the Lagrange multipliers on the constraint. The first order conditions of this problem are:

$$u'(c_0) = \phi u'(c_0^*) \quad (107)$$

$$u'(c_1) = \phi u'(c_1^*) \quad (108)$$

Hence, all of the planners solution satisfy:

$$\frac{u'(c_0)}{u'(c_1)} = \frac{u'(c_0^*)}{u'(c_1^*)} \quad (109)$$

These first order conditions are violated in the strategic competitive equilibrium, as well as in the equilibrium in which only one party intervenes in its market. To see this, note that the strategic equilibrium implies:

$$u'(c_0) = u'(c_1)\beta(R + c_0 \frac{\partial R}{\partial c_0}) \quad (110)$$

$$u'(c_0^*) = u'(c_1^*)\beta(R - (Y_0^* - c_0^*) \frac{\partial R}{\partial c_0^*}) \quad (111)$$

Thus,

$$\frac{u'(c_0)}{u'(c_1)} = \beta(R + c_0 \frac{\partial R}{\partial c_0}) > \beta(R - (Y_0^* - c_0^*) \frac{\partial R}{\partial c_0^*}) = \frac{u'(c_0^*)}{u'(c_1^*)} \quad (112)$$

The proof of the inefficiency of the equilibrium in which only one government intervenes in its domestic market proceeds along similar lines.

D Proof of Proposition 3

The competitive equilibrium of this model satisfies:

$$\frac{u_c(c, c^*)}{u_{c^*}(c, c^*)} = p \quad (113)$$

The first order conditions of the government's problem yield:

$$u_c(c, c^*) = \lambda(p(c, c^*) - (Y - c) \frac{\partial p}{\partial c}) = \lambda p(1 - (Y - c) \frac{\partial p}{\partial c}) \quad (114)$$

$$u_{c^*}(c, c^*) = \lambda(1 + (Y - c) \frac{\partial p}{\partial c^*}) \quad (115)$$

Combining the two first order conditions, we get that:

$$\frac{u_c(c, c^*)}{u_{c^*}(c, c^*)} = p \frac{1 - (Y - c) \frac{\partial p}{\partial c}}{1 + (Y - c) \frac{\partial p}{\partial c^*}} \quad (116)$$

As $\frac{\partial p}{\partial c} > 0$, and $\frac{\partial p}{\partial c^*} < 0$, we get that:

$$\frac{u_c(c, c^*)}{u_{c^*}(c, c^*)} > p \quad (117)$$

E Proof of Proposition 4

In the competitive equilibrium, the first order conditions of the consumer's problem yield the following relations:

$$u'_F(c^*) = \frac{u'(c)}{p} = \frac{u'_{NT}(c^{NT})}{p^{NT}} \quad (118)$$

The first order conditions of the producers yield:

$$pF'(L) = p^{NT}F'_{NT}(L^{NT}) = w \Rightarrow \frac{F'_{NT}(L^{NT})}{F'(L)} = \frac{p}{p^{NT}} \quad (119)$$

The government's problem can be rewritten as:

$$\max_{c, c^{NT}, c^*, L} u(c) + u_{NT}(c^{NT}) + u_F(c^*) + u_Y(F(L)) \quad (120)$$

s.t.

$$\lambda_1 : pc + c^* = pF(L) \quad (121)$$

$$\lambda_2 : c^{NT} = F_{NT}(L_0 - L) \quad (122)$$

The first order conditions with respect to c and c^* yield:

$$\frac{u'(c)}{p} = u'_F(c^*) \quad (123)$$

The first order condition with respect to c^{NT} yields:

$$u'_{NT}(c^{NT}) = \lambda_2 \quad (124)$$

Using the above first order conditions, the first order condition with respect to L yields:

$$u'_Y(Y)F'(L) + u'(c)F'(L) = u'_{NT}(c^{NT})F'_{NT}(L^{NT}) \quad (125)$$

Rewriting:

$$u'_Y(Y) + u'(c) = u'_{NT}(c^{NT}) \frac{F'_{NT}(L^{NT})}{F'(L)} \quad (126)$$

Comparing this to the equilibrium solution, it is apparent that the government restricts consumption of non-tradable goods. As we've seen, in the competitive equilibrium, the ratio of marginal products is equal to the inverse of the ratio of prices. Thus, in the competitive equilibrium we have:

$$u'(c) = u'_{NT}(c^{NT}) \frac{F'_{NT}(L^{NT})}{F'(L)} \quad (127)$$

In the government's solution, there is an extra positive term on the left hand side, suggesting that both $u'_{NT}(c^{NT})$ and $F'_{NT}(L^{NT})$ are lower. Hence, L^{NT} and c^{NT} are smaller relative to the non-intervention equilibrium.

F Proof of Proposition 5

Writing down the Lagrangian and taking first order conditions yields the following FOC with respect to c_i^i :

$$\phi_i u'_{i,i}(c_i^i) = \lambda_1 \quad (128)$$

The FOC with respect to Y_i is:

$$\phi_i u'_{i,Y}(Y_i) = -\lambda_1 + \lambda_4 \quad (129)$$

Combining the two, we arrive at the following equation:

$$\phi_i u'_{i,Y}(Y_i) + \phi_i u'_{i,i}(c_i^i) = \lambda_4 \quad (130)$$

Where λ_4 is the multiplier on equation 63. Going back to the planner's problem, and taking FOC with respect to c_i^{NT} :

$$\phi_i u'_{i,NT}(c_i^{NT}) = \lambda_3 \quad (131)$$

Where λ_3 is the multiplier on equation 62.

Finally, taking first order condition on L_i (and replacing $L_i^{NT} = L - L_i$) yields:

$$-\lambda_3 F'_{i,NT}(L_i^{NT}) + \lambda_4 F'_i(L_i) = 0 \quad (132)$$

Manipulating the above equations, we get that:

$$\lambda_4 = \frac{\lambda_3 F'_{i,NT}(L_i^{NT})}{F'_i(L_i)} = \phi_i u'_{i,NT}(c_i^{NT}) \frac{F'_{i,NT}(L_i^{NT})}{F'_i(L_i)} \quad (133)$$

Substituting the above into equation 130, we get that:

$$u'_{i,Y}(Y_i) + u'_{i,i}(c_i^i) = u'_{i,NT}(c_i^{NT}) \frac{F'_{i,NT}(L_i^{NT})}{F'_i(L_i)} \quad (134)$$

This is precisely the condition characterizing the government's solution (see equation 126).