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A WELFARE-BASED APPROACH

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ABSTRACT

This paper studies the mechanism of international transmission of exchange rate shocks within a 3-country Center-Periphery model, providing a choice-theoretic framework for the policy analysis and empirical assessment of competitive devaluations. If relative prices and terms of trade exhibit some flexibility conforming to the law of one price, a devaluation by one country is *beggar-thy-neighbor* relative to another country through its effects on cost-competitiveness in a third market. Yet, due to direct bilateral trade among the two countries, there is a large range of parameter values for which a country is better off by maintaining a peg in response to its partner's devaluation. If instead deviations from the law of one price are to be considered the dominant empirical paradigm, then the *beggar-thy-neighbor* effect based on competition in a third market may disappear. However, a country's devaluation has a negative welfare impact on the economies of its trading partners based on the deterioration of their export revenues and profits and the increase in disutility from higher labor effort for any level of consumption.

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"The concern over competitive devaluations reflected in the Fund's charter, and the system-wide implications of changes in exchange rates, still motivate Fund policy recommendations. A major Fund concern in the Asian crisis has been the fear that Asian currencies would become so undervalued and current account surpluses so large as to damage the economies of other countries, developing countries included. This is one reason the Fund has stressed the need first to stabilize and then to strengthen exchange rates in the Asian countries now in crisis — and for this purpose, not to cut interest rates until the currency stabilizes and begins to appreciate." Stanley Fischer, "The IMF and the Asian Crisis", Los Angeles, March 20, 1998.

1 Introduction

The use of exchange rate policy to gain competitive advantage over a country's trading partners has long been recognized as a major threat to the stability of the international monetary system. Since Bretton Woods, concerns over 'competitive devaluations' have motivated the design of institutions and rules to prevent countries from adopting *beggar-thy-neighbor* exchange rate policies and starting devaluation spirals. Such concerns — as the epigraph highlights — have remained strong during the most recent events in Asia, playing a key role in shaping crisis management strategies and policy prescriptions in the region.

Despite the objective relevance of the notion of competitive devaluation in policy analysis and design, the analytical literature has devoted relatively little attention to the logical structure of the argument. It is actually difficult to find in the literature anything more than an intuitive exposition of the basic idea, and a comparative study of existing contributions raises a number of issues. For instance, some analyses focus exclusively on the effects of a devaluation on the export performance of the devaluing country *vis-à-vis* its competitors in a third market; other analyses only look at its effects on the bilateral trade flows between the devaluing country and its partners.

In addition, the literature typically qualifies a devaluation as *beggar-thy-neighbor* only insofar as a weaker currency spurs output growth and employment domestically at the expense of output growth and employment abroad.[1]

[1] The standard reference is Ragnar Nurkse's analysis of the devaluations that took

But clearly these are not the only elements that are relevant in assessing the welfare impact of exchange rate policies. Unfortunately, the analytics of a competitive devaluation[2] is generally derived from some version of the classic Mundell-Fleming-Dornbusch model, which lacks explicit micro-foundations and does not provide a consistent welfare criterion for policy assessment. In fact, 'welfare' analysis in the traditional scheme is typically based on ad-hoc objective functions representing some arbitrarily weighted averages of current account, price and employment effects.

Drawing on recent developments in open-economy macroeconomics,[3] this paper studies the logic of competitive devaluations using a theoretical apparatus that is apt at carrying out welfare analysis. In analogy with the traditional models of international transmission of exchange rate shocks, our construction allows for short-run nominal rigidities and highlights the role of losses in cost-competitiveness experienced by trading partners when a country devalues. In contrast to the traditional analyses, however, we assess *beggar-thy-neighbor* effects (or the absence thereof) within a choice-theoretic framework.

The need for thoroughly revisiting the logic of competitive devaluations is particularly evident in light of the recent proliferation of studies on currency and financial 'contagion'. Based on the experience of Western Europe in 1992-93, Latin America in 1994-95, and Southeast Asia in 1997-98, system-wide surges in interest rate and exchange rate volatility have represented a recurring pattern in the crises of the 1990s.[4] Some theoretical contributions have suggested that a currency crisis in one country may worsen market participants' perception of the economic outlook in countries with

place in the interwar period: "in contemporary discussions much stress was laid on the competitive aspects of currency devaluation. In many quarters devaluation was regarded primarily as a means of improving a country's foreign trade balance and hence its volume of domestic employment — an effective means but one that operated necessarily at the expense of other countries and invited retaliation" (Nurkse (1944), p.129).

[2]For a comprehensive survey see Kenen (1985).

[3]See among others Obstfeld and Rogoff (1995, 1996 ch.10, 1998), Corsetti and Pesenti (1997), Tille (1998), Devereux and Engel (1998).

[4]Among recent studies focusing on the large-scale speculative episodes in the 1990s, see *e.g.* Eichengreen and Wyplosz (1993) and Buiter, Corsetti and Pesenti (1998a, b) on the European Monetary System crisis of 1992-93, Sachs, Tornell and Velasco (1996) on the Mexican peso crisis of 1994, and IMF (1997, 1998a,b) and Corsetti, Pesenti and Roubini (1998) on the Asian crisis since 1997. For recent analyses of cross-border financial contagion see *e.g.* Baig and Goldfajn (1998) and Forbes and Rigobon (1998).

similar characteristics, triggering a domino effect.[5] Other contributions have argued that, when multiple instantaneous equilibria can occur as rational phenomena, what drives contagion are parallel shifts in financial markets' expectations affecting more than one currency simultaneously.[6]

Currency instability also spreads, however, via structural links across countries: a devaluation by one country affects the state of economic fundamentals and may therefore induce currency instability elsewhere in the world economy. While the mechanism of transmission can involve financial or macroeconomic links, trade links have received by far the largest share of attention in the literature.[7] Because of trade links, a country-specific currency crisis increases the incentive to devalue for a larger set of countries, and with it the likelihood and scope of speculative attacks in foreign exchange markets. In other words, 'competitive' devaluations have been recently been re-interpreted as 'contagious' devaluations.[8]

Our methodology takes the initial devaluation in one country as an exogenous shock (without modeling what causes such devaluation in the first place), and focuses on the welfare repercussions of this shock on the economies of the trading partners or competitors. To the extent that the latter are better off by retaliating and devaluing their exchange rates in response to the initial devaluation, international domino effects can be understood as rational phenomena based on the assessment of social welfare costs and benefits. From this vantage point, a systematic study of the nature of competitive

[5] See *e.g.* Calvo and Mendoza (1997) and Drazen (1998).

[6] See *e.g.* Masson (1998).

[7] In support to this approach to currency contagion are the findings of recent econometric research, which emphasize that explanations of the international transmission of currency crises based on trade links across countries perform empirically better than explanations based on similarities in the macroeconomic characteristics of the economies concerned. See *e.g.* Eichengreen, Rose and Wyplosz (1996) and Glick and Rose (1998). Kaminsky and Reinhart (1998) compare alternative approaches to contagion.

[8] This interpretation seems to provide the theoretical underpinnings of the recent IMF prescriptions in Asia. Quoting once again from the speech by Stanley Fischer mentioned in the epigraph, "from the viewpoint of the international system, the devaluations in Asia will lead to large current account surpluses in those countries, damaging the competitive positions of other countries and requiring them to run current account deficits. Although not by the intention of the authorities in the crisis countries, these are excessive competitive devaluations, not good for the system, not good for other countries, indeed *a way of spreading the crisis* — precisely the type of devaluation the IMF has the obligation to seek to prevent" (our italics). On the issue of competitive devaluations in Asia see also Liu, Noland, Robinson and Wang (1998) and Fernald, Edison and Loungani (1998).

devaluations can contribute to identifying the fundamental impulses at the root of the contagious deterioration of market sentiment regarding exchange rate stability.[9]

The paper is organized as follows. Section 2 revisits the logic and mechanism of a competitive devaluation within the framework of a simple model where two countries (the Periphery) compete in a third country market (the Center). If the law of one price holds internationally, the simple model corroborates the traditional view: a devaluation by one country (A) causes consumption and output to fall in the other Periphery country (B), as this country loses cost-competitiveness in the market of country C. Country B is better off by matching country A's devaluation. However, the *beggar-thy-neighbor* effect via cost-competitiveness in a third-market may disappear if the law of one price fails to hold.

The analysis of competitive devaluations is completed and refined in the full-fledged intertemporal model presented in Section 3. Under the law of one price, there is now a large range of parameters' values for which country B is better off by *not* matching country A's devaluation. This is especially true when country B is large and the Periphery as a whole is small relative to the Center. If the law of one price does not hold, the model sheds light on a different mechanism through which A's devaluation may be *beggar-thy-neighbor*, via a deterioration of country B's terms of trade between consumption and leisure: the welfare impact in country B may be dominated by the disutility of higher labor efforts required to sustain any given level of consumption. Section 4 concludes.

2 The logic of competitive devaluations

Throughout the paper, our theoretical framework consists of a *3-country, Center-Periphery* model. Countries A and B represent the 'Periphery' of the system, while country C is the 'Center'. Each country is specialized in the production of a traded good. Domestic producers only use domestic labor inputs, and goods markets are imperfectly competitive. The Periphery

[9] To this kind of impulses refer the official IMF publications in statements like "the floating of the baht engendered among market participants the perception of a need for competitive devaluations among currencies in the region, and caused investors to take a closer look at the similar financial sector problems, albeit to different degrees, in the region." See IMF (1998b, p.48).

countries are direct competitors in the market of the Center country, in the sense that the goods exported by countries A and B are highly substitutable from the vantage point of country C's consumers.[10]

Before delving into a complete dynamic specification of the model, it is useful to gain insights using a simplified static setup. We momentarily abstract from inter-temporal trade as well as from intra-Periphery trade, *i.e.* we assume that countries A and B trade their goods exclusively with the Center and bilateral trade balances are zero. These highly restrictive assumptions will be relaxed in the next section, in which we only maintain that the elasticity of substitution *among* Periphery goods is larger than the elasticity of substitution *between* Periphery goods and the Center good. We refer to the setup in this section as an 'extreme' Center-Periphery model, as the equilibrium allocation entails corner solutions.

2.1 An 'extreme' Center-Periphery model

The specification of the economy is as follows. The utility functions of the representative agents in the three countries are:[11]

$$U^i = \ln C^i - \frac{\kappa}{2}\left(Y^i\right)^2, \quad i = A, B, C \tag{1}$$

where the consumption index for each country is defined as

$$\begin{aligned} C^A &\equiv \left(C_A^A\right)^{\frac{1}{2}}\left(C_C^A\right)^{\frac{1}{2}} \\ C^B &\equiv \left(C_B^B\right)^{\frac{1}{2}}\left(C_C^B\right)^{\frac{1}{2}} \\ C^C &\equiv \left(C_A^C + C_B^C\right)^{\frac{1}{2}}\left(C_C^C\right)^{\frac{1}{2}} \end{aligned} \tag{2}$$

Throughout the model, the superscripts of the consumption indexes denote the country of the consumer and the subscripts denote the country of the producer. For instance, C_A^C denotes consumption of good A by the residents of country C.

[10] A detailed game-theoretical Center-Periphery model with similar characteristics — although without micro-foundations — is adopted by Buiter, Corsetti and Pesenti (1998 a,b) in their analysis of the European Monetary System crisis.

[11] To facilitate the comparison with the literature, where possible we adopt the same notation and parameterization of the Obstfeld and Rogoff (1996) textbook.

According to the expressions (2) above, each Periphery country consumes its own good and the Center good, with unit elasticity of substitution. Similarly, the Center consumes both its own goods and imported goods and the elasticity of substitution between Center and Periphery goods is 1. However, the elasticity of substitution between the two Periphery goods, C_A^C and C_B^C, is infinite: country C's consumers consider imports from A and B as perfect substitutes.

In all countries, Y denotes output, and the quadratic expressions on the right hand sides of (1) reflect the higher labor effort (thus, the disutility) associated with higher levels of economic activity. The resource constraints are

$$\begin{aligned} Y^A &= C_A^A + C_A^C \\ Y^B &= C_B^B + C_B^C \\ Y^C &= C_C^A + C_C^B + C_C^C \end{aligned}$$

Denoting with M the stock of money supply, and assuming that all consumption exchanges within a country are financed with national money balances, the equilibrium conditions in the three national money markets are

$$\begin{aligned} M^A &= P_A^A C_A^A + P_C^A C_C^A \\ M^B &= P_B^B C_B^B + P_C^B C_C^B \\ M^C &= P_A^C C_A^C + P_B^C C_B^C + P_C^C C_C^C \end{aligned} \tag{3}$$

where goods prices are denoted by P. The model is closed by the equilibrium trade balance relations:

$$\begin{aligned} P_C^A C_C^A &= E^A P_A^C C_A^C \\ P_C^B C_C^B &= E^B P_B^C C_B^C \end{aligned}$$

where E^A and E^B denote the nominal exchange rates of the Periphery countries *vis-à-vis* the Center.

2.2 Optimization and equilibrium

In country A, optimizing agents choose their consumption levels by maximizing U^A subject to the constraint (3). This yields

$$M^A = 2P_A^A C_A^A = 2P_C^A C_C^A.$$

By defining the (utility-based) consumption price index[12] P^A as

$$P^A \equiv 2 \left(P_A^A\right)^{\frac{1}{2}} \left(P_C^A\right)^{\frac{1}{2}},$$

we can rewrite the above equilibrium condition as $M^A = P^A C^A$. Similar relations hold in country B.[13]

To characterize the consumption pattern of country C's residents, we first define the Center's consumption of Periphery goods as

$$C_P^C \equiv C_A^C + C_B^C$$

where the P subscript stands for 'Periphery'. Given our extreme assumption of infinite elasticity of substitution between the two Periphery goods, note that if $P_A^C < P_B^C$, the Center consumes only country A's goods, so that $C_P^C = C_A^C$. Conversely, if $P_A^C > P_B^C$, the Center consumes only country B's goods, so that $C_P^C = C_B^C$.

If $P_A^C = P_B^C$, the Center is indifferent between importing from A or B. In this case, we will assume that C will import an equal amount from each country. It follows that the price of the goods imported from the Periphery as a whole, denoted with P_P^C, will be equal to

$$P_P^C = \min\left\{P_A^C,\ P_B^C\right\}.$$

Using this index, we can write the equilibrium conditions of the Center country in analogy with the Periphery conditions:

$$M^C = P_P^C C_P^C + P_C^C C_C^C = 2 P_P^C C_P^C = 2 P_C^C C_C^C = P^C C^C$$

where $P^C = 2 \left(P_P^C\right)^{\frac{1}{2}} \left(P_C^C\right)^{\frac{1}{2}}$.

The three economies are characterized by *nominal rigidities*: over the time horizon relevant for the analysis prices are predetermined and producers

[12] The consumption-based price index P^A is defined as the minimum expenditure that is necessary to buy one unit of the composite good C^A, given the prices of the two goods P_A^A and P_C^A. For details on the construction of consumption-based price indexes and the optimization process, the reader is referred to Obstfeld and Rogoff (1996).

[13] Defining the consumption price index P^B as $P^B \equiv 2 \left(P_B^B\right)^{\frac{1}{2}} \left(P_C^B\right)^{\frac{1}{2}}$, we obtain $M^B = 2P_B^B C_B^B = 2P_C^B C_C^B = P^B C^B$.

are willing to accommodate any increase in demand at given prices.[14] We first consider the case in which prices are predetermined in terms of the *sellers' currency*, then the case in which prices are predetermined in the *buyers' currency*. In the first case, domestic firms do not modify the nominal prices of their products in the national markets (P_A^A, P_B^B and P_C^C are fixed) and the law of one price holds: international *arbitrageurs* buy cheap and sell dear across markets, until prices expressed in terms of a common currency are equalized worldwide (so that, for instance, $P_C^A = E^A P_C^C$). In the second case, markets are segmented and the law of one price does not hold: P_j^i are constant for all $i, j = A, B, C$.

The economy starts at an initial equilibrium in which the price of each of these goods is equalized across countries ($P_A^A/E^A = P_B^B/E^B$), and the monetary authorities of the Periphery countries peg their currencies against the Center.

2.3 How are devaluation shocks transmitted across countries?

The main goal of our analysis is to study the effects of an unanticipated devaluation by country A on the equilibrium allocation and welfare in the other two countries. Throughout the analysis, the Center is assumed to maintain its monetary stance unchanged, regardless of external developments. Country B (the 'neighbor' of country A), instead, may decide to devalue in response to country A's devaluation.

2.3.1 Baseline scenario: the law of one price holds

In the baseline case, prices are fixed in the seller's currency, and the law of one price holds. In this case, when country A devalues its currency against the Center (E^A increases), the price of its exports to the Center falls below its competitor's ($P_A^C < P_B^C$). If country B attempts to maintain its unilateral peg, the demand for the Periphery goods by the Center falls exclusively on

[14] A word of caution is warranted here. Consistently with the current macro literature, the analysis above takes price rigidities as a *datum*, *i.e.* does not attempt to develop microeconomic foundations for either price stickiness or pricing to market. This means that, by construction, the analysis excludes a price response by firms to policy and fundamental shocks. Also, with imperfectly competitive goods markets and nominal rigidities output is demand determined only insofar as prices remain above marginal costs.

exports from country A, so that C_B^C drops to zero. Since under the law of one price the trade balance is

$$E^B P_C^C C_C^B = P_B^B C_B^C$$

for given E^B, P_C^C and P_B^B, the fall in exports C_B^C translates into a fall in imports C_C^B.

Now, the optimal consumption allocation for the consumers in country B

$$M^B = 2P_C^B C_C^B = 2E^B P_C^C C_C^B,$$

shows that, for given domestic prices, money demand moves one-to-one with import. Thus, to avoid a devaluation, monetary authorities in country B must contract M^B as much as C_C^B falls.[15] Since $C_B^B = M^B/P_B^B$, the monetary contraction implies a dramatic fall in domestic consumption and output. To sum up, an attempt by country B to maintain the peg entails a very large welfare cost: the country loses its export market and collapses under a process of rapid demonetization of the economy.[16]

Conversely, the demand of imports from the Periphery goods by the Center country *increases* after a devaluation by A. Namely, since

$$C_P^C = \frac{M^C}{2P_P^C} = \frac{M^C E^A}{2P_A^A}$$

the Center's optimal consumption of Periphery goods rises at the same rate as E^A. With producers in B being driven out of the market, country A therefore experiences a record increase of its exports to the Center, equal to $\Delta C_A^C = C_B^C + \Delta C_P^C$. In percentage terms, this corresponds to a growth rate of exports exceeding 100% by twice the size of the devaluation ($\Delta C_A^C / C_A^C = 1 + 2\Delta E^A / E^A$).

Despite the adverse movements of the terms of trade, such an export boom allows the residents in A to increase their consumption of the Center

[15] In our extreme scenario, this translates into the complete demonetization of the economy!

[16] Once again, it is worth emphasizing that these corner solutions for the real and monetary equilibrium of country B are the consequence of the original assumption that goods of country A and B are perfectly substitutable from the vantage point of country C consumers. Relaxing such assumption of perfect substitutability leads to less extreme consequences without modifying the key message of the model: see section 3.

good, C_C^A. To show this, we rewrite the trade balance condition as

$$C_C^A = \frac{P_A^A}{P_C^C} \frac{C_P^C}{E^A} \frac{C_A^C}{C_P^C}$$

and compare the equilibrium outcomes before and after country A's devaluation. Recalling that prices are sticky in the seller's currency and that the increase in the Center's import from the Periphery is proportional to the changes in E^A, the increase of country A's consumption of the Center's good is equal to

$$\Delta C_C^A = \left(\frac{\Delta C_A^C}{C_A^C} - \frac{\Delta C_P^C}{C_P^C} \right) C_C^A = \left(1 + \frac{\Delta E^A}{E^A} \right) C_C^A$$

Consumption of the Center goods in country A more than doubles. Using this result together with the equilibrium conditions for country A's agents we see that, in equilibrium, the growth rate of money supply M^A exceeds the devaluation rate. Given P_A^A, this implies that consumption of local goods C_A^A must increase as well.

Since the Center country is assumed to keep its money supply fixed, the consumption of domestically produced goods C_C^C does not change *vis-à-vis* the increasing import from the Periphery. Nonetheless, production of the domestic good Y_C must now rise to match the higher external demand.[17]

The consequences of the devaluation in country A are summarized in Table 1. The subscript **PEG** means that all the effects are contingent on country B attempting to maintain the peg. The defense of the fixed exchange rate forces the monetary authorities of country B to lean against a vital adjustment in relative prices, and imposes a sharp contraction in domestic economic activity, consumption and welfare. Country B suffers a loss in cost-competitiveness and, as a consequence of the domestic liquidity crunch, the demand for country B's products collapses. Country A's devaluation is unambiguously *beggar-thy-neighbor*.

The scenario changes radically if country B decides to follow country A in devaluing its currency. By doing so, country B is able to restore its 'lost competitiveness' and prevent the plunge in the level of economic activity and consumption. The resulting pattern of macroeconomic effects in the world economy is summarized in Table 2, where **DEV** indexes the levels of the variables contingent on country B's devaluation.

[17] Note that the increase in C_C^A more than offsets the fall in C_C^B and C_C^C remains unchanged, so that Y_C rises.

Table 1: The ‘extreme’ model under the **PEG** regime

$C^{A}_{A,\mathbf{PEG}} \uparrow$	$C^{A}_{C,\mathbf{PEG}} \uparrow$	$Y^{A}_{\mathbf{PEG}} \uparrow$
$C^{B}_{B,\mathbf{PEG}} \downarrow$	$C^{B}_{C,\mathbf{PEG}} \downarrow$	$Y^{B}_{\mathbf{PEG}} \downarrow$
$\underbrace{C^{C}_{A,\mathbf{PEG}} \uparrow \quad C^{C}_{B,\mathbf{PEG}} \downarrow}_{\uparrow}$	$C^{C}_{C,\mathbf{PEG}} =$	$Y^{C}_{\mathbf{PEG}} \uparrow$

Table 2: The ‘extreme’ model under the **DEV** regime

$C^{A}_{A,\mathbf{DEV}} \uparrow$	$C^{A}_{C,\mathbf{DEV}} =$	$Y^{A}_{\mathbf{DEV}} \uparrow$
$C^{B}_{B,\mathbf{DEV}} \uparrow$	$C^{B}_{C,\mathbf{DEV}} =$	$Y^{B}_{\mathbf{DEV}} \uparrow$
$\underbrace{C^{C}_{A,\mathbf{DEV}} \uparrow \quad C^{C}_{B,\mathbf{DEV}} \uparrow}_{\uparrow}$	$C^{C}_{C,\mathbf{DEV}} =$	$Y^{C}_{\mathbf{DEV}} =$

Note that there is an obvious link between our analysis and 'second-generation' models of currency crises, in which the decision whether to fix or float a currency is related to a rational assessment of the social costs and benefits from each policy alternative. Given a devaluation by A, the costs for country B to maintain the peg are too high: country B cannot but devalue its currency by the same percentage as A.

2.3.2 The role of deviations from the law of one price

Pricing behavior by firms has crucial implications for our results. We will now re-visit our analysis for the case in which prices are predetermined in terms of the buyer's currency, and the law of one price does not hold across national markets.[18] Under such an assumption, the model simplifies significantly relative to the baseline scenario. From the money market equilibrium conditions, we can see that aggregate consumption moves in parallel to the money supply:

$$C^i \propto M^i \ \ i = A, B, C,$$

where $\propto$ denotes 'proportional to'. In addition, any change in the level of consumption is evenly spread across all goods, as there are no changes in the relative prices faced by consumers:

$$C^i_j \propto C^i, \qquad j = A, B, C$$

In the Center country, because of a fixed money supply M^C, the consumption of domestically produced and imported goods is not affected by devaluations in the Periphery. Thus, the balanced trade conditions imply:

$$C^A_C \propto E^A, \, C^B_C \propto E^B$$

In other words, for a Periphery country, a devaluation raises the revenue from exports in domestic currency. After a devaluation, domestic consumers can afford to consume more of all goods. Both exchange rates and consumption move together with the stock of money supply with unit elasticity.

So, when A devalues, country C is worse off as its residents do not consume more but supply more labor to meet the increased demand from country A. Conversely, there are neither welfare gains nor losses for the residents in

[18] As a reminder, P^j_i are predetermined for all $i, j = A, B, C$.

country B. This is because country B can maintain its currency peg without implementing any monetary contraction. As consumption in B and C is unaffected by a devaluation of currency A, world demand for the goods produced by country B is also constant.

Of course, it is possible that the law of one price holds for some goods, while fails to hold for others. A particularly realistic assumption is that the law of one price holds for the goods produced in the Center, but not for the goods produced in the Periphery and sold in the Center. The prices of the latter goods are assumed to be set in the Center's currency.

If this is the relevant scenario, the Center is completely insulated from a devaluation of the Periphery. The reason is that domestic relative prices in C are independent of exchange rate movements, while consumption and output only respond to country C's own money supply (that we hold fixed by assumption). It follows that imports from the Periphery, C_C^A and C_C^B also remain constant.[19]

Turning to the Periphery, we can write:

$$C_C^A = \frac{M^A}{2E^A P_C^C}, \qquad C_C^B = \frac{M^B}{2E^B P_C^C}$$

Using our previous results, it is easy to see that the exchange rates E^A and E^B move one-to-one with the money supplies M^A and M^B. This implies that a monetary expansion in country A raises the consumption of the domestic goods and the price of the imported good, but leaves imports at their initial level. In other words, the exchange rate shock in country A does not affect country B equilibrium at all: there is no welfare-incentive for country B to abandon its peg against the Center and match country A's devaluation.

3 Macroeconomic and welfare effects of a devaluation

Our 'extreme' model in section 2 yields strong conclusions in the analysis of competitive devaluations. If the law of one price holds, a devaluation by one country (A) is *beggar-thy-neighbor* relative to another country (B) mainly through its effects on cost-competitiveness in a third market (C). If the law

[19] From the balanced trade conditions we obtain $P_C^A C_C^A = E^A P_A^C C_A^C$, which implies $P_C^C C_C^A = P_A^C C_A^C$, and $P_C^B C_C^B = E^B P_B^C C_B^C$, which implies $P_C^C C_C^B = P_B^C C_B^C$.

of one price does not hold, such *beggar-thy-neighbor* effect disappears, and there is no rationale for competitive devaluations.

These results hinge upon the assumption of perfect substitutability among Periphery goods and — more crucially — the fact that Periphery countries compete against each other in the Center market only. To understand intuitively the implications of the latter assumption, consider the effects of opening up trade within the Periphery. In our baseline scenario (in which the law of one price holds), if countries A and B were to trade directly with each other, the devaluation of country A would improve country B's terms of trade and purchasing power. With imperfect substitutability across Periphery goods, the presence of intra-Periphery trade would then raise the possibility that a devaluation by country A increases welfare in country B.

Were B to trade with A in the alternative scenario *without* the law of one price, however, its output would have to raise to meet A's increasing demand. This additional effect would clearly reduce welfare in country B: its residents would need to work and produce more at an unchanged consumption level. Interestingly, in this case the negative spillover on country B's welfare would stem from higher disutility of labor per unit of consumption, as opposed to the collapse of consumption that occurs under the law of one price.

In other words, when the law of one price holds the cost-competitiveness effect of a devaluation by A (hitting producers in B) coexists with a terms of trade effect (favoring consumers in B). Since the former effect decreases, while the latter increases welfare in country B, direct intra-Periphery trade makes the overall impact of a devaluation by country A potentially ambiguous. When the law of one price does not hold, instead, direct intra-Periphery trade between A and B becomes the only channel through which country A's devaluation can hurt the rest of the Periphery.

To inspect these issues more thoroughly, we now introduce a full-fledged intertemporal model which allows for intra-Periphery trade, asymmetries in country size and finite elasticity of substitution among Periphery goods in the Center market. Such a framework will allow us to analyze in detail the different roles played by bilateral trade *vs.* trade with a third country in transmitting *beggar-thy-neighbor* policy shocks. It will also allow us to analyze the impact of a devaluation on the current account balances of the trading partners, under alternative hypotheses on their policy reactions to the devaluation.

3.1 The setup

The objective function of country i's representative consumer, with $i = A, B, C$, is now given by:

$$\sum_{s=0}^{\infty} \beta^s \left\{ \ln C^i_{t+s} - \frac{\kappa}{2} \left(Y^i_{t+s}\right)^2 + \chi \ln \left(\frac{M^i_{t+s}}{P^i_{t+s}} \right) \right\}$$

where the consumption indexes are defined below, β is the discount rate, and χ is a positive constant. The available assets are domestic real balances, M/P, and a nominal bond denominated in the Center's currency and denoted by B. Real balances provide liquidity services which enter the utility function. The bond is in zero-net supply worldwide; its nominal yield is denoted i_t. The budget constraints of the representative agents in the three economies are:

$$\frac{E^i_t B^i_{t+1}}{P^i_t} + \frac{M^i_t}{P^i_t} + C^i_t = (1 + i_t) \frac{E^i_t B^i_t}{P^i_t} + \frac{M^i_{t-1}}{P^i_t} + \frac{P^i_{i,t}}{P^i_t} Y^i_t - T^i_t$$

where $E^C = 1$ and T denotes net taxes, denominated in units of the local consumption index.

The consumption basket in country i is now given by a CES index:

$$C^i = \left[\gamma_P^{\frac{1}{\rho}} \left(C^i_P\right)^{\frac{\rho-1}{\rho}} + (1 - \gamma_P)^{\frac{1}{\rho}} \left(C^i_C\right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

where γ_P and $1 - \gamma_P$ are the weights of the Periphery and the Center respectively, and ρ is the elasticity of substitution between Center and Periphery.

In turn, the consumption index for the Periphery is defined as:

$$C^i_P = \left[\gamma_A^{\frac{1}{\psi}} \left(C^i_A\right)^{\frac{\psi-1}{\psi}} + (1 - \gamma_A)^{\frac{1}{\psi}} \left(C^i_B\right)^{\frac{\psi-1}{\psi}} \right]^{\frac{\psi}{\psi-1}}$$

where γ_A and $1 - \gamma_A$ are the weights of each Periphery country in the basket of goods produced in the Periphery, and ψ is the elasticity of substitution between the two Periphery consumption indexes.[20] Consistently with the

[20] The model can be understood as a combination of two-country models on two levels: the Center-Periphery setup, and the within-Periphery setup. In our analysis we only focus on the aspects of the model directly related to the issue of competive devaluations. For further details on the structure and the solution of the model the reader is referred to the two-country models analyzed in Corsetti and Pesenti (1997) and Tille (1998).

'extreme' model, the maintained assumption is that the elasticity of substitution among Periphery goods is higher than that between Periphery and Center goods, namely $\rho < \psi$.[21]

The consumption indexes for each country, C_j^i, are summarized in Table 3, together with the respective utility-based price indexes. Each country produces a continuum of goods indexed by z. Each unit of a good z is produced with one unit of labor provided by a country resident. To minimize algebraic complexities we adopt the normalization suggested by Obstfeld and Rogoff (1998), setting the world size to unity and the numbers of consumer-producers in country A, B and C to $\gamma_A \gamma_P$, $(1-\gamma_A)\gamma_P$ and $1-\gamma_P$ respectively.[22] Country A thus produces goods $z \in [0, \gamma_A \gamma_P)$, country B produces goods $z \in [\gamma_A \gamma_P, \gamma_P)$, and the Center produces goods $z \in [\gamma_P, 1]$. Within each country, the goods are not perfectly homogeneous; the elasticity of substitution across goods in any country is denoted $\theta > 1$, so that there is monopolistic competition among domestic producers.

The law of one price is assumed to hold (we modify this assumption in a section below), while prices which are set in the seller's currency can exhibit nominal rigidities. The equilibrium conditions are then summarized by the following Euler and money demand equations:[23]

$$\frac{C_{t+1}^i}{C_t^i} = \beta \left(1 + i_{t+1}\right) \frac{P_t^C}{P_{t+1}^C}$$

$$\frac{M_t^i}{P_t^i} = \chi C_t^i \frac{\left(1 + i_{t+1}\right) E_{t+1}^i}{\left(1 + i_{t+1}\right) E_{t+1}^i - E_t^i}$$

If prices are flexible, the equilibrium markups are given by

$$\frac{P_{i,t}^i}{P_t^i} = \frac{\theta \kappa}{\theta - 1} C_t^i Y_t^i \tag{4}$$

[21] In the simple model of the previous section, the parameters are $\gamma_C = \gamma_P = 1/2$, $\rho = 1$, $\psi = \infty$. Note however that the two models are not nested: in the simple model we have ruled out intra-Periphery trade, so that $\gamma_A = 1$ in the consumption index of country A, $\gamma_A = 0$ in the consumption index of country B, and $\gamma_A = 1/2$ in the consumption index of country C. In the extended model of this section, γ_A is symmetric across countries. Similar considerations hold for γ_B.

[22] Our qualitative results go through even if population size and preference parameters are kept separated.

[23] As revenues from seigniorage are rebated to the public through a lump-sum transfer T, under the law of one price and PPP the current account identities are given by: $E_t^i B_{t+1}^i + P_t^i C_t^i = (1 + i_t) E_t^i B_t^i + P_{it}^i Y_t^i$ and $B_t^A + B_t^B + B_t^C = B_t^P + B_t^C = 0$.

Table 3: Consumption and price indexes

Consumption indexes

$$C_A^i = \left[(\gamma_A \gamma_P)^{-\frac{1}{\theta}} \int_0^{\gamma_A \gamma_P} \left(C_A^i(z)\right)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}$$
$$C_B^i = \left[((1-\gamma_A)\gamma_P)^{-\frac{1}{\theta}} \int_{\gamma_A \gamma_P}^{\gamma_P} \left(C_B^i(z)\right)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}$$
$$C_C^i = \left[(1-\gamma_P)^{-\frac{1}{\theta}} \int_{\gamma_P}^{1} \left(C_C^i(z)\right)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}$$

Consumption allocation

$$C_A^i(z) = \left[\frac{P_A^i(z)}{P_A^i}\right]^{-\theta} \left[\frac{P_A^i}{P_P^i}\right]^{-\psi} \left[\frac{P_P^i}{P^i}\right]^{-\rho} C^i$$
$$C_B^i(z) = \left[\frac{P_B^i(z)}{P_B^i}\right]^{-\theta} \left[\frac{P_B^i}{P_P^i}\right]^{-\psi} \left[\frac{P_P^i}{P^i}\right]^{-\rho} C^i$$
$$C_C^i(z) = \left[\frac{P_C^i(z)}{P_C^i}\right]^{-\theta} \left[\frac{P_C^i}{P^i}\right]^{-\rho} C^i$$

Utility-based price indexes

$$P_A^i = \left[\frac{1}{\gamma_A \gamma_P} \int_0^{\gamma_A \gamma_P} \left(P_A^i(z)\right)^{1-\theta} dz \right]^{\frac{1}{1-\theta}}$$
$$P_B^i = \left[\frac{1}{(1-\gamma_A)\gamma_P} \int_{\gamma_A \gamma_P}^{\gamma_P} \left(P_B^i(z)\right)^{1-\theta} dz \right]^{\frac{1}{1-\theta}}$$
$$P_C^i = \left[\frac{1}{1-\gamma_P} \int_{\gamma_P}^{1} \left(P_C^i(z)\right)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \quad \frac{1}{1-\psi}$$
$$P_P^i = \left[\gamma_A \left(P_A^i\right)^{1-\psi} + (1-\gamma_A)\left(P_B^i\right)^{1-\psi} \right]^{\frac{1}{1-\rho}}$$
$$P^i = \left[\gamma_P \left(P_P^i\right)^{1-\rho} + (1-\gamma_P)\left(P_C^i\right)^{1-\rho} \right]$$

while, when prices are sticky, goods supply adjusts to meet changes in demand.[24]

We can now delve into the analysis of the effects of unanticipated, permanent monetary shocks and devaluations, assuming that in the short-run prices are predetermined — and set at their pre-shock equilibrium levels — while they fully adjust to their new equilibrium levels in the long run. As in Obstfeld and Rogoff (1995) the adjustment is assumed to take one period only. We denote long-run (steady-state, flex-price) variables with upperbars, to distinguish them from short-run variables.

The algebraic complexity of our setup makes it impossible to analyze the impact of discrete shocks without resorting to numerical simulations. In what follows, we choose instead to focus on the impact of 'small' monetary shocks and reformulate the model in terms of log-deviations from an initial symmetric equilibrium. As a general rule, denoting by X_0 the level of a variable in the initial equilibrium and by X the new level of the variable, lowercase letters denote log-linear approximations:

$$x \approx \frac{X - X_0}{X_0}$$

Details of the solution are found in the Appendix.

3.2 Policy reactions to a devaluation: a comparison of macroeconomic outlooks

The economy is initially in a symmetric equilibrium, where all prices in a given country are identical[25] and the net-asset positions across countries are all equal to zero.[26] As in the 'extreme' model, we study the consequences of a permanent monetary expansion in country A associated with a devaluation

[24] Note that the markups are independent of both elasticities of substitution across countries (*i.e.*, ρ and ψ); only the intra-country elasticity of substitution θ enters equation (4). In fact, the disutility of effort in terms of consumption depends on θ, whereas ρ and ψ determine the rate at which exports, to the Center and the other Periphery country respectively, are transformed into consumption.

[25] Prices are set ex ante, when no shocks are expected. Following the usual steps, each producers charges a positive markup over marginal cost, reflecting the elasticity of the demand she faces.

[26] We leave to future contributions the formal analysis of competitive devaluations under scenarios in which country B is a net debtor in the initial equilibrium and its debt is denominated in foreign currency. Intuitively, such circumstances would increase the welfare

of its currency against the Center ($\bar{m}^A > 0$, implying $\bar{e}^A > 0$) while the Center keeps its money supply unchanged ($\bar{m}^C = 0$).

Our focus is on the implications of three possible policy reactions in country B: a policy of monetary stabilization ($\bar{m}^B = 0$), hereinafter referred to as **MST**; the defense of the exchange rate peg *vis-à-vis* the Center ($\bar{e}^B = 0$), referred to as **PEG**; and a devaluation of the exchange rate in order to maintain unaltered country B's market share in the Center ($\bar{e}^B = \bar{e}^A$), referred to as **DEV**.

In Table 4 we outline the key implications of the three policy regimes. Under the **MST** regime, the exchange rate of country B depreciates against the Center, making imports more expensive, but appreciates against country A. Under the **PEG** regime country B must contract its money supply in response to country A's monetary expansion and exchange rate devaluation; note however that the fall in $\bar{m}^B$ does not offset the increase in $\bar{m}^A$, so that the net effect is a Periphery-wide monetary expansion. Given $\bar{m}^A$, therefore, the equilibrium devaluation of A is lower under **PEG** than under the **MST** scenario, in which monetary authorities of country B do not contract $\bar{m}^B$ and let the currency depreciate. Finally, under the **DEV** regime the depreciation of $\bar{e}^A_{\mathbf{DEV}}$ — for a given $\bar{m}^A$ — is larger than under the **MST** regime. Under all these policy scenarios, the Periphery-wide monetary stance is never contractionary ($\bar{m}^P \equiv \gamma_A \bar{m}_A + (1-\gamma_A)\,\bar{m}_B > 0$).

The above results shed light on an important feature of exchange rate contagion across countries, namely, the *feedback* effects of a devaluation in country B on the equilibrium depreciation of the exchange rate of country A, the country from which the shock itself originates. In fact, for a given monetary expansion in country A, the size of the implied exchange rate depreciation in country A is a function of the policy response in country B. In general, *for a given monetary shock in country A, the larger the depreciation of country B, the larger the depreciation of country A in equilibrium.*

Consider now the response of the current account balances to the devaluation shock. For the Periphery as a whole we have:

$$\frac{\bar{b}^P}{1-\gamma_P} \equiv \bar{b}^P - \bar{b}^C = \frac{2\beta\,(\rho-1)}{1+\beta+\rho\,(1-\beta)}\bar{m}^P$$

The sign of the above expression depends on the size of ρ. As long as $\rho > 1$ (that is, when the Marshall-Lerner-Robinson conditions hold), *the Periphery*

costs of a devaluation since a fall in the price of foreign currency raises the real burden of country B's external debt.

Table 4: International effects of country A's devaluation

MST regime

$$\bar{e}^A_{\mathbf{MST}} = \left[\gamma_A \Pi(\rho) + (1-\gamma_A)\Pi(\psi)\right]\bar{m}^A > 0$$
$$\bar{e}^B_{\mathbf{MST}} = \left[\Pi(\rho) - \Pi(\psi)\right]\gamma_A \bar{m}^A > 0$$
$$\bar{e}^A_{\mathbf{MST}} - \bar{e}^B_{\mathbf{MST}} = \Pi(\psi)\bar{m}^A > 0$$
$$\frac{\bar{b}^P_{\mathbf{MST}}}{1-\gamma_P} = \frac{2\beta(\rho-1)}{1+\beta+\rho(1-\beta)}\gamma_A \bar{m}^A, \;\; \bar{b}^A_{\mathbf{MST}} - \bar{b}^B_{\mathbf{MST}} > 0$$

PEG regime

$$\bar{m}^B_{\mathbf{PEG}} = -\frac{\Pi(\rho) - \Pi(\psi)}{\gamma_A \Pi(\psi) + (1-\gamma_A)\Pi(\rho)}\gamma_A \bar{m}^A < 0$$
$$\bar{e}^A_{\mathbf{PEG}} = \frac{\Pi(\psi)}{\gamma_A \Pi(\psi) + (1-\gamma_A)\Pi(\rho)}\Pi(\rho)\bar{m}^A$$
$$\frac{\bar{b}^P_{\mathbf{PEG}}}{1-\gamma_P} = \frac{2\beta(\rho-1)}{1+\beta+\rho(1-\beta)}\frac{\Pi(\psi)}{\gamma_A \Pi(\psi) + (1-\gamma_A)\Pi(\rho)}\gamma_A \bar{m}^A, \; \bar{b}^A_{\mathbf{PEG}} - \bar{b}^B_{\mathbf{PEG}} > 0$$

DEV regime

$$\bar{m}^B_{\mathbf{DEV}} = \bar{m}^A > 0$$
$$\bar{e}^A_{\mathbf{DEV}} = \bar{e}^B_{\mathbf{DEV}} = \Pi(\rho)\bar{m}^A$$
$$\frac{\bar{b}^P_{\mathbf{DEV}}}{1-\gamma_P} = \frac{2\beta(\rho-1)}{1+\beta+\rho(1-\beta)}\bar{m}^A, \quad \bar{b}^A_{\mathbf{DEV}} = \bar{b}^B_{\mathbf{DEV}}$$

Notes : The function Π is defined as:

$$\Pi(x) = \frac{1}{x}\frac{1-\beta+x(1+\beta)}{1+\beta+x(1-\beta)} > 0$$

Observe that $\Pi(\rho) > \Pi(\psi)$ if $\rho < \psi$.

as a whole runs a current account surplus vis-à-vis the Center when country A devalues. The larger is the monetary expansion in the Periphery, the larger is its current account surplus. Therefore, as shown in Table 4, when $\rho > 1$ *the current account balance of the Periphery is larger under the* ***DEV*** *regime, and smaller under the* ***PEG*** *regime.* Opposite results hold for $\rho \leq 1$.

How is the Periphery current account surplus allocated between countries A and B? Formally we have:

$$\frac{\bar{b}^A - \bar{b}^P}{1 - \gamma_A} \equiv \bar{b}^A - \bar{b}^B = \frac{2\beta (\psi - 1)}{1 + \beta + (1 - \beta) \psi} \left(\bar{m}^A - \bar{m}^B \right)$$

Since $\psi > 1$, *it is never the case that the current account of country A increases by less than the current account of country B.* Under the **DEV** regime both Periphery countries increase symmetrically their net asset positions against the Center. Under both the **MST** and the **PEG** regimes the current account effect is stronger for country A than for country B.

Focusing on the case $\rho > 1$, does a current account deficit in the Center imply that the Center is experiencing a welfare loss when country A devalues? The answer is no, under reasonable parameter assumptions. Computing intertemporal welfare levels,[27] we find that the Center country benefits from the monetary expansion in the Periphery in every regime provided that the following inequality holds:

$$u^C = \frac{1}{\theta} \left[1 - \frac{\rho - \theta}{\rho} \frac{1 + \rho}{1 + \beta + \rho (1 - \beta)} \right] \gamma_P \bar{m}^P > 0$$

A sufficient condition for the expression in square brackets to be positive is that $\rho \leq \theta$, that is, that goods are more substitutable within a country than between Center and Periphery.[28] Intuitively, in the short run the monetary expansion of the Periphery increases the availability of Periphery goods to the Center and contemporaneously improves the purchasing power of the Center's consumers. To take full advantage of the short-term improvements

[27] As customary in the literature, throughout the paper we only refer to welfare effects unrelated to liquidity services, implicitly assuming that χ is relatively small.

[28] The assumption that $\rho \leq \theta$ implies that by expanding its output the Periphery is not better off relatively to the Center, because the additional consumption financed by the additional sales revenue is not large enough to outstrip the additional cost of effort. Obstfeld and Rogoff (1995) consider the case $\rho = \theta$. Corsetti and Pesenti (1997) consider the case $1 = \rho < \theta$. Tille (1998) studies the general case.

in their terms of trade, if $\rho > 1$ country C's agents borrow from the Periphery to finance a higher consumption level.[29]

Instead, it is the Periphery itself that can gain or lose according to the particular values of the elasticities: evaluating u^P, the weighted average of welfare levels in countries A and B, we obtain

$$u^P \lesseqgtr 0 \ \text{ if } \ \gamma_P \lesseqgtr \frac{\theta - \rho}{\rho\left(1 + \beta\frac{1-\rho}{1+\rho}\right) + \theta - \rho}$$

The important result that, in an open economy, a monetary expansion can have a *beggar-thyself* effect rather than a *beggar-thy-neighbor* one has been emphasized in the models of Corsetti and Pesenti (1997) and Tille (1998). In the short run an inflationary shock leads Periphery agents to supply more labor and produce more goods, but the induced terms of trade deterioration reduces the purchasing power of their incomes: the benefits from higher consumption accrue principally to the rest of the world, while the costs from additional labor efforts are concentrated in the Periphery.

In the context of our analysis, the possibility of a *beggar-thyself* devaluation arises when γ_P is relatively small (that is, the effective economic 'size' of the Periphery as measured by the share of Periphery goods in world consumption is negligible), when θ is relatively large (that is, the Periphery economy is sufficiently close to its competitive level, so that unanticipated monetary expansions cause the terms of trade to deteriorate with little improvement in efficiency), and when ρ is sufficiently small (that is, there is little substitutability between Center and Periphery, so that a devaluation by the Periphery increases the relative price of imports in the Periphery itself but has a limited impact on the Center's demand for Periphery goods).

3.3 *Beggar-thy-neighbor* vs. *beggar-thyself* policies: a welfare ranking

As in the simple model of section 2, the main focus of our analysis is the conditions under which a devaluation by A deteriorates national welfare in B, and **PEG** is the worst option in country B's welfare ranking of the three policy alternatives. After some algebra, we can show that country B prefers

[29] Similar considerations hold if $\rho \leq 1$, noting that in this case the Center can achieve a higher level of consumption without becoming a net borrower.

a regime $\mathcal{X}$ over a regime $\mathcal{Z}$ if the following condition holds:

$$\left\{(1-\gamma_A)\left[\gamma_P + (1-\gamma_P)\frac{\rho-\theta}{\rho}\frac{1+\rho}{1+\beta+\rho(1-\beta)}\right] + \right.$$

$$\left. +\gamma_A \frac{\psi-\theta}{\psi}\frac{1+\psi}{1+\beta+(1-\beta)\psi}\right\}\left(\bar{m}^B_{\mathcal{X}} - \bar{m}^B_{\mathcal{Z}}\right) > 0 \tag{5}$$

Therefore, if the expression in curly brackets is positive, country B always prefers the regime involving the largest monetary expansion, which is **DEV**. If the inequality sign is reversed, the best option for B is instead to maintain the peg with the Center. Not surprisingly, doing nothing (**MST**) is always dominated, by either **PEG** or **DEV**.

To interpret the inequality above, first observe that the sign of expression in square brackets is the same sign of u^P, as analyzed in the previous paragraph. If $u^P \geq 0$ and $\psi > \theta$ — *i.e.,* if Periphery goods are more substitutable between countries than within countries — country B's best option is to devalue: $u^B_{\mathbf{DEV}} > u^B_{\mathbf{MST}} > u^B_{\mathbf{PEG}}$. This is because the Periphery *beggar-thyself* effect relative to the Center ($u^P - u^C \leq 0$) is offset by the beneficial effect of a monetary expansion worldwide ($u^w > 0$) and by the intra-Periphery *beggar-thy-neighbor* effect ($u^A - u^B > 0$).[30]

If instead $u^P < 0$, a devaluation may not be a good idea for country B. This is the case when γ_A is small and country B is relatively 'large' in terms of the weight of its goods in world consumption (so that the *beggar-thyself* effect $u^P < 0$ falls almost exclusively on country B), or when θ is relatively large (so that the world economy is already close to its efficient level and a monetary expansion in the Periphery has little impact on world output and consumption).

We conclude that *accounting for the intra-Periphery effects of a devaluation there is a non-negligible range of elasticity values for which country A's devaluation need not lead to a competitive — and contagious — 'retaliation' by country B.*

[30] Note that a monetary expansion by the Periphery always increases world welfare: $u^w \equiv \gamma_P u^P + (1-\gamma_P) u^C = (\gamma_P/\theta)\,\bar{m}^P > 0$.

3.4 The role of deviations from the law of one price revisited

The dynamic model can also be solved for the case in which prices are set in the buyer's currency, rather than the seller's currency. In this case *country B has always an incentive to abandon its peg to the Center in response to country A's devaluation, as its consumption utility does not change but its labor effort disutility worsens.*

Following the steps presented in the Appendix, we can show that there are no effects in the long run.[31] Since there are no relative price effects, in the short run domestic consumption moves in tandem with domestic money supply, while a monetary shock anywhere in the world economy affects short-run output symmetrically in each country:

$$c^i = \bar{m}^i \qquad y^i = y^w = \bar{m}^w \qquad i = A, B, C$$

The welfare effect is then, simply,

$$u^i = \bar{m}^i - \frac{\theta - 1}{\theta}\bar{m}^w$$

If all countries expand their money supply by the same extent, they all benefit by an amount $\bar{m}^w/\theta$. If a country does not expand its money supply along with the others, that country is unambiguously worse off, as its residents work more and consume less.

We can show that under all regimes:

$$e^i = \bar{m}^i$$

The **MST** and **PEG** regimes are then identical, and if country B pursues either of these policy options it is unambiguously worse-off:

$$u^B_{\mathbf{MST},\,\mathbf{PEG}} = -\frac{\theta - 1}{\theta}\gamma_A\gamma_P\bar{m}^A < 0$$

[31] Formally, $\bar{b}^A = \bar{b}^B = \bar{b}^C = 0$, $\bar{c}^P - \bar{c}^C = \bar{p}^P_P - \bar{p}^C_C - \bar{e}^P = \bar{y}^P - \bar{y}^C = 0$, $\bar{c}^A - \bar{c}^B = \bar{p}^A_A - \bar{p}^B_B - \left(\bar{e}^A - \bar{e}^B\right) = \bar{y}^A - \bar{y}^B = 0$. It is worth emphasizing that this result is a consequence of our assumption of a logarithmic utility for consumption. Together with several other generalizations, the extension of our framework to an elasticity of intertemporal substitution different from unity is left to future contributions.

By contrast, the option **DEV** ($\bar{m}^A = \bar{m}^B$) is always preferred by country B:

$$u^B_{\mathbf{DEV}} = \bar{m}^A - \frac{\theta - 1}{\theta}\gamma_P \bar{m}^A > \frac{1}{\theta}\bar{m}^A > 0$$

Intuitively, the consumption gains from a devaluation accrue exclusively to the country that devalues (because of the increase in the real value of its export revenues), while the costs of a devaluation in terms of increased labor effort are spread worldwide. Country A's devaluation is *beggar-thy-neighbor* as it reduces revenues and profits of producers abroad. The non-devaluing countries whose export revenues fall are required to work more to sustain the initial level of consumption. The conclusions are more striking than the ones derived under the law of one price: *the optimal response for country B is always to devalue*, and both Periphery countries increase their welfare at the expense of the Center.[32]

4 Conclusions

This paper has studied the mechanism of international transmission of exchange rate shocks, providing a cohesive choice-theoretic framework for the policy analysis and empirical assessment of competitive devaluations. We summarize here our main results.

If the law of one price holds internationally, a devaluation by one country (A) is *beggar-thy-neighbor* relative to another country (B) mainly through its effects on cost-competitiveness in a third market (C). The manifestation of such *beggar-thy-neighbor* channel is a fall in consumption in country B.

In the presence of intra-Periphery trade, however, there is a large range of elasticity values for which country B is better off by maintaining a peg in response to country A's devaluation, especially when country B is large and the Periphery (country A and B together) as a whole is small relative to country C.

[32] As in the 'extreme' model above, we could also consider the case where the law of one price holds, except for goods produced in the Periphery and sold in the Center, the price of which is set in the Center's currency. The analysis of the dynamic model under these assumptions is rather complex. Focusing on a static setup with balanced trade ($\beta = 0$), it can be shown that the Center is completely insulated from the Periphery's monetary policy, and that the Periphery as a whole is always better off, as there is no *beggar-thyself* problem *vis-à-vis* the Center anymore. In response to country A's devaluation, country B always chooses the regime with the largest monetary expansion, which is **DEV**.

If the law of one price does not hold, the intra-Periphery *beggar-thy-neighbor* effect based on competition in a third market disappears. However, there is a different intra-Periphery *beggar-thy-neighbor* effect via a deterioration of country B's terms of trade. The manifestation of the latter *beggar-thy-neighbor* channel is the increase in disutility from higher labor effort in country B for any level of consumption.

Thus, if deviations from the law of one price are to be considered the dominant empirical paradigm, then direct bilateral trade links may play a more important role than competition in the world market in determining the welfare effects of exchange rate shocks. Nonetheless, if relative prices and terms of trade exhibit some flexibility conforming to the law of one price, a high share of bilateral trade within a region can actually limit the extent of *beggar-thy-neighbor* policies.

Appendix: Solution of the dynamic model

The model is linearized around a symmetric steady state where $B^A = B^B = B^P = B^C = 0$.

Long-run equilibrium Once prices have adjusted, the economy reaches a new steady state that can be characterized in terms of log-deviations from the initial symmetric equilibrium. From the Euler equations, the money market equilibrium conditions and the long run consumption-effort trade-off conditions we obtain $\beta(1+i) = 1$ and

$$\begin{aligned} \bar{m}^i - \bar{p}^i &= \bar{c}^i \\ \bar{p}_i^i - \bar{p}^i &= \bar{c}^i + \bar{y}^i \end{aligned}$$

The output demand faced by a representative firm in each country is obtained by aggregating the relevant consumption allocation equations across consumers worldwide. The resulting expression can be linearized as:

$$\begin{aligned} \bar{y}^A &= -\psi\left(\bar{p}_A^A - \bar{p}_P^A\right) + \bar{y}^P,\ \bar{y}^B = -\psi\left(\bar{p}_B^B - \bar{p}_P^B\right) + \bar{y}^P \\ \bar{y}^P &= -\rho\left(\bar{p}_P^C - \bar{p}^C\right) + \bar{c}^w,\ \bar{y}^C = -\rho\left(\bar{p}_C^C - \bar{p}^C\right) + \bar{c}^w \end{aligned}$$

The current account equations are linearized as:

$$\begin{aligned} 0 &= \frac{1-\beta}{\beta}\bar{b}^A - \bar{c}^A + \bar{p}_A^A - \bar{p}^A + \bar{y}^A \\ 0 &= \frac{1-\beta}{\beta}\bar{b}^B - \bar{c}^B + \bar{p}_B^B - \bar{p}^B + \bar{y}^B \\ 0 &= \frac{1-\beta}{\beta}\bar{b}^C - \bar{c}^C + \bar{p}_C^C - \bar{p}^C + \bar{y}^C \\ 0 &= \gamma_A\gamma_P\bar{b}^A + \gamma_B\gamma_P\bar{b}^B + \gamma_C\bar{b}^C = \gamma_P\bar{b}^P + \gamma_C\bar{b}^C \end{aligned}$$

where : $\bar{b}^i = dB^i/C^iP^C$. The long run equilibrium is solved by combining the current account equations, the output demands and the consumption-effort trade-off conditions.

Center *vs.* Periphery Some algebra leads to:

$$\begin{aligned}
\bar{c}^P - \bar{c}^C &= \frac{1+\rho}{2\rho}\frac{1-\beta}{\beta}\frac{\bar{b}^P}{1-\gamma_P} \\
\bar{p}_P^P - \bar{p}_C^C - \bar{e}^P &= \frac{1}{2\rho}\frac{1-\beta}{\beta}\frac{\bar{b}^P}{1-\gamma_P} \\
\bar{y}^P - \bar{y}^C &= -\frac{1}{2}\frac{1-\beta}{\beta}\frac{\bar{b}^P}{1-\gamma_P}
\end{aligned}$$

and the worldwide effects are:

$$\bar{c}^w = \bar{y}^w = 0$$

where a worldwide value is defined as: $x^w = \gamma_P x^P + \gamma_C x^C$.

Intra-Periphery We can derive:

$$\begin{aligned}
\bar{c}^A - \bar{c}^B &= \frac{1+\psi}{2\psi}\frac{1-\beta}{\beta}\frac{\bar{b}^A - \bar{b}^P}{1-\gamma_A} \\
\bar{p}_A^A - \bar{p}_B^B - \left(\bar{e}^A - \bar{e}^B\right) &= \frac{1}{2\psi}\frac{1-\beta}{\beta}\frac{\bar{b}^A - \bar{b}^P}{1-\gamma_A} \\
\bar{y}^A - \bar{y}^B &= -\frac{1}{2}\frac{1-\beta}{\beta}\frac{\bar{b}^A - \bar{b}^P}{1-\gamma_A}
\end{aligned}$$

where the Periphery variables are given by:

$$x^P = \gamma_A x^A + \gamma_B x^B$$

Short-run equilibrium We now turn to the equilibrium in the short run, when prices do not adjust. From the Euler equations and money market equilibrium conditions it is possible to show that there is no exchange rate under- or over-shooting, and there cannot be anticipated changes in relative consumption:

$$\begin{aligned}
e^A &= \bar{e}^A,\ e^B = \bar{e}^B \\
\bar{c}^P - \bar{c}^C &= c^P - c^C \\
\bar{c}^A - \bar{c}^B &= c^A - c^B
\end{aligned}$$

As prices are preset, the short-run current account equations are written as:

$$\begin{aligned}
\bar{b}^A + c^A &= y^A - p^A \\
\bar{b}^B + c^B &= y^B - p^B \\
\bar{b}^C + c^C &= y^C - p^C
\end{aligned}$$

The short run solution is obtained by combining the money market equilibrium conditions, the output demands and the current account equations along with the long-run equilibrium.

Center *vs.* Periphery After some algebra, we can establish:

$$\begin{aligned}
\bar{c}^P - \bar{c}^C &= \frac{\rho - 1}{\rho} \frac{(1-\beta)(1+\rho)}{1+\beta+\rho(1-\beta)} \left(\bar{m}^P - \bar{m}^C\right) \\
\bar{e}^P &= \frac{1}{\rho} \frac{1-\beta+\rho(1+\beta)}{1+\beta+\rho(1-\beta)} \left(\bar{m}^P - \bar{m}^C\right) \\
y^P - y^C &= \frac{1-\beta+\rho(1+\beta)}{1+\beta+\rho(1-\beta)} \left(\bar{m}^P - \bar{m}^C\right) \\
\frac{\bar{b}^P}{1-\gamma_P} &= \frac{2\beta(\rho-1)}{1+\beta+\rho(1-\beta)} \left(\bar{m}^P - \bar{m}^C\right)
\end{aligned}$$

where the worldwide effects are:

$$c^w = y^w = \bar{m}^w$$

Intra-Periphery We can similarly derive:

$$\begin{aligned}
\bar{c}^A - \bar{c}^B &= \frac{\psi - 1}{\psi} \frac{(1-\beta)(1+\psi)}{1+\beta+(1-\beta)\psi} \left(\bar{m}^A - \bar{m}^B\right) \\
\bar{e}^A - \bar{e}^B &= \frac{1}{\psi} \frac{1-\beta+\psi(1+\beta)}{1+\beta+(1-\beta)\psi} \left(\bar{m}^A - \bar{m}^B\right) \\
y^A - y^B &= \frac{1-\beta+\psi(1+\beta)}{1+\beta+(1-\beta)\psi} \left(\bar{m}^A - \bar{m}^B\right) \\
\frac{\bar{b}^A - \bar{b}^P}{1-\gamma_A} &= \frac{2\beta(\psi-1)}{1+\beta+(1-\beta)\psi} \left(\bar{m}^A - \bar{m}^B\right)
\end{aligned}$$

Overall effects We define the overall (net present value) effect of monetary shocks as $x_{npv} = x + \frac{\beta}{1-\beta}\bar{x}$. The Center *vs.* Periphery effects are:

$$\begin{aligned} c^P_{npv} - c^C_{npv} &= \frac{\rho - 1}{\rho} \frac{1+\rho}{1+\beta+\rho(1-\beta)} \left(\bar{m}^P - \bar{m}^C\right) \\ y^P_{npv} - y^C_{npv} &= \frac{1+\rho}{1+\beta+\rho(1-\beta)} \left(\bar{m}^P - \bar{m}^C\right) \end{aligned}$$

and at the worldwide level we have:

$$c^w_{npv} = y^w_{npv} = \bar{m}^w$$

while the intra-Periphery effects are:

$$\begin{aligned} c^A_{npv} - c^B_{npv} &= \frac{\psi - 1}{\psi} \frac{1+\psi}{1+\beta+(1-\beta)\psi} \left(\bar{m}^A - \bar{m}^B\right) \\ y^A_{npv} - y^B_{npv} &= \frac{1+\psi}{1+\beta+(1-\beta)\psi} \left(\bar{m}^A - \bar{m}^B\right) \end{aligned}$$

Welfare effects The welfare effect for country i is given by:

$$u^i = c^i_{npv} - \frac{\theta - 1}{\theta} y^i_{npv}$$

Combining this expression with our results, we can easily show that:

$$\begin{aligned} u^w &= \frac{1}{\theta}\bar{m}^w \\ u^P - u^C &= \frac{\rho - \theta}{\rho\theta} \left(y^P_{npv} - y^C_{npv}\right) \\ u^A - u^B &= \frac{\psi - \theta}{\psi\theta} \left(y^A_{npv} - y^B_{npv}\right) \end{aligned}$$

Deviations from the law of one price The model can also be solved for the case where prices are set in the buyer's currency and the law of one price does not necessarily hold. As prices are flexible in the long run, the steady-state effects (as functions of $\bar{b}^P$ and $\bar{b}^A - \bar{b}^P$) are as before. There is also no real worldwide effect in the long run: $\bar{c}^w = \bar{y}^w = 0$.

In the short run, the Euler equations and the money market equilibrium conditions imply that the nominal exchange rate immediately reaches its long run value: $e^i = \bar{e}^i$. As the purchasing power parity condition does not hold in the short run, the consumption differentials across countries are no longer constant:

$$\begin{aligned}\bar{c}^A - \bar{c}^C &= \left(c^A - c^C\right) - \bar{e}^A \\ \bar{c}^B - \bar{c}^C &= \left(c^B - c^C\right) - \bar{e}^B\end{aligned}$$

Consumer prices being fixed, the short-run output effect exactly reflects the worldwide output expansion in each country:

$$y^i = y^w = \bar{m}^w$$

Considering the net asset position of the Periphery *vis-à-vis* the Center, the current account relations in the short run imply that:

$$\frac{1}{1-\gamma_P}\bar{b}^P = -\left(\bar{c}^P - \bar{c}^C\right)$$

Combining this expression with the long-run results, we see that $\bar{b}^P = 0$ and there are no long run effects: $\bar{c}^P - \bar{c}^C = \bar{p}^P_P - \bar{p}^C_C - \bar{e}^P = \bar{y}^P - \bar{y}^C = 0$. A devaluation then has exclusively short run effects:

$$c^P - c^C = \bar{e}^P = \bar{m}^P - \bar{m}^C$$

Similarly, we can show that the effects on the intra-Periphery differentials are limited to the short run:

$$c^A - c^B = \bar{e}^A - \bar{e}^B = \bar{m}^A - \bar{m}^B$$

$$\frac{\bar{b}^A - \bar{b}^P}{1-\gamma_A} = \bar{c}^A - \bar{c}^B = \bar{p}^A_A - \bar{p}^B_B - \left(\bar{e}^A - \bar{e}^B\right) = \bar{y}^A - \bar{y}^B = 0$$

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