Saving Distortions, Undervalued Exchange Rates, and Protectionism

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Policies that distort domestic saving decisions have general equilibrium effects on trade flows and the real exchange rate. In particular, increasing domestic savings keeps the real exchange rate undervalued, depressing imports and increasing exports. However, there are important differences between saving distortions and standard protectionist trade policies like tariffs. We use a simple two-period model to illustrate these differences by comparing a saving subsidy, which keeps the exchange rate undervalued, and a temporary import tariff. Both policies reduce current imports. However, the first policy entails short-run welfare losses for the domestic country and short-run welfare gains for its trading partners; the second policy has opposite welfare effects.

There is a wide range of policy choices in emerging economies that affect the net saving rate of the country. All these policy choices have side effects on the trade balance and on the real exchange rate. Some policies are more directly oriented at affecting the exchange rate. For example, increased savings by the official sector in the form of reserves accumulation may be directly oriented at keeping the exchange rate low, but many other policy decisions are not primarily geared towards the exchange rate, and yet have general equilibrium effects on it. For

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example, a decision to put a better social insurance system in place will affect the precautionary savings of domestic households and thus affect the domestic saving rate. In this paper, we look at the trade implications of this broad class of policies, putting them under the general heading of "saving distortions," leaving aside the specifics of each policy and focusing on the general equilibrium channel for which these policies affect trade and international relative prices.

The objective of this paper is to clarify the differences between these policies and traditional protectionist policies like tariffs that differentially affect imported and exported goods. In particular, in the public debate, a common claim is that policies that keep the exchange rate undervalued are analogous to protectionist policies because they discourage the imports of foreign goods and encourage exports by the country that puts them in place. For example, Fred Bergsten commented on China's exchange rate policy in 2010 saying, "Such currency manipulation is a blatant form of protectionism. It subsidizes all Chinese exports 25 to 40 percent. It places the equivalent of a 25 to 40 percent tariff on all Chinese imports, sharply discouraging purchases from other countries."[1]

Here we use a simple model to argue that the analogy between exchange rate policy and trade policy can be misleading. In particular, we focus on comparing a saving subsidy and a tariff. The main difference is that, in a benchmark neoclassical framework, the terms-of-trade effects associated to a saving distortion favor a country's trading partner in the short run, while the terms-of-trade effects associated with a tariff increase domestic welfare at the expense of foreign welfare. The intuition behind this difference is as follows: A tariff reduces the relative demand for foreign goods, which worsens foreign terms of trade and welfare. The tariff discourages purchases of foreign goods by introducing a wedge so the tax-inclusive price of the foreign good goes up for the individual consumer, but the country as a whole faces a *lower* international price. In contrast, a subsidy on savings acts like a transfer to foreigners in the first period, which, given home bias, increases the relative demand for foreign goods as in the classic transfer problem of Keynes (1929). This increases the price of the foreign good for domestic consumers and discourages purchases of foreign goods. But now there is no wedge between the price perceived by individual consumers and the price faced by the country as a whole. So an increase in the price of the foreign good

1. See Bergsten (2010) for a more detailed discussion of this comment in section 4.

is just a worsening of the domestic terms of trade, leading to lower welfare. The opposite effects take place in future periods, when foreigners pay back home.

The analysis of the relative price effects of saving distortions builds on Costinot, Lorenzoni and Werning (2014). Here, we focus on a simple two period setting and add the possibility of good-specific taxes or subsidies so we can compare saving distortions and protectionist policies.

1. A Model

Consider a two period model. There are two countries, domestic and foreign, and two goods, good , produced in the domestic country, and good , produced in the foreign country. For ease of exposition, we make specific functional form assumptions on preferences. The preferences of the domestic consumer are represented by the utility function

$$U(C_1) + \beta U(C_2)$$

where $U(C) = C^{1-\gamma}/(1-\gamma)$. The consumption index C_t is a Cobb-Douglas composite of consumption of good 1 and 2 according to

$$C_t = c_{1t}^{\alpha} c_{2t}^{1-\alpha} .$$

The preferences of the foreign consumer are analogous, but with a discount factor β^* possibly different from β and with the role of the two goods reversed, so the consumption index is

$$C_t^* = \left(c_{1t}^*\right)^{1-\alpha} \left(c_{2t}^*\right)^{\alpha} .$$

We assume that $\alpha > 1/2$ to capture home bias in consumption.

The budget constraint of the domestic consumer is

$$p_{11}c_{11} + p_{21}c_{21} + q\left(p_{12}c_{12} + p_{22}c_{22}\right) = a_{01} + p_{11}y_{11} + q\left(a_{02} + p_{12}y_{12}\right), \qquad (1)$$

where y_{11} and y_{12} are endowments of good 1 produced in the two periods, p_{jt} is the price of good j at time t, and q is the price of a one period bond (related to the interest rate r by the equation $q=1/(1+r)$). The domestic country starts with an initial foreign asset position given

by the vector (a_{01}, a_{02}), where a_{0t} are financial claims in terms of the numeraire, to be paid at date t. Since there are no real assets the net foreign asset position of the foreign consumer is $a^*_{0t} = a_{0t}$.

The budget constraint for the foreign consumer is analogous. Given the preferences above the price indices for the domestic and foreign consumer are given by

$$P_t = \left(1-\alpha\right)^{-(1-\alpha)} \alpha^{-\alpha} p_{1t}^{\alpha} p_{2t}^{1-\alpha}, \tag{2}$$

and

$$P_t^* = \left(1-\alpha\right)^{-(1-\alpha)} \alpha^{-\alpha} p_{1t}^{1-\alpha} p_{2t}^{\alpha}. \tag{3}$$

We use world total output as the numeraire. Since world output is equal to world consumption in each period, we have

$$P_t C_t + P_t^* C_t^* = 1.$$

We define the fraction of world spending realized by domestic consumers:

$$x_t \equiv P_t C_t.$$

We will consider the effect of introducing a small distortion, starting at a competitive equilibrium. So let us first derive some necessary equilibrium conditions.

For a given value of x_t it is easy to characterize the equilibrium in the two goods markets in period t. Given Cobb-Douglas preferences, domestic consumers allocate a fraction α of their spending to the domestic good, while foreigners allocate a fraction $1-\alpha$. So, by market clearing, the domestic good price satisfies

$$p_{1t} y_{1t} = \alpha x_t + \left(1-\alpha\right)\left(1-x_t\right), \tag{4}$$

and the foreign good price satisfies

$$p_{2t} y_{2t} = \left(1-\alpha\right) x_t + \alpha\left(1-x_t\right). \tag{5}$$

Intertemporal optimality conditions determine the values of x_1 and x_2 in equilibrium. In particular, the Euler equation for the domestic and foreign consumers are, respectively,

$$U'(C_1) = \beta(1+r)\frac{P_1}{P_2}U'(C_2), \tag{6}$$

where $C_t = x_t/P_t$, and

$$U'(C_1^*) = \beta^*(1+r)\frac{P_1^*}{P_2^*}U'(C_2^*), \tag{7}$$

where $C_t^* = (1-x_t)/P_t^*$. Notice that the real interest rates faced by the two consumers are different because they consume different consumption baskets.

Equations (2) to (7) will be all we need to analyze the effect of intertemporal policies on domestic and foreign welfare.

2. Effects of a Saving Distortion

2.1 The Policy

We want to study the effects of a small distortion in favor of saving introduced by country 1. We want to distinguish the effects of this inter-temporal disortion among the effects of an intra-temporal distortion that affects the two goods differentially. So we assume that the government of country 1 cannot impose good-specific taxes or subsidies, but can only introduce a tax/subsidy on total savings that distorts the choice of C_1 and C_2. To be specific, the government introduces a proportional subsidy τ to net lending in period 1, which is financed by lump-sum taxation.[2] This means that the domestic consumer faces the budget constraint

$$p_{11}c_{11} + p_{21}c_{21} + \frac{q}{1+\tau}(p_{12}c_{12} + p_{22}c_{22}) = a_{01} + p_{11}y_{11} + \frac{q}{1+\tau}(a_{02} + p_{12}y_{12}) - \frac{T}{1+\tau}.$$

2. τ is a saving subsidy if $p_{11}c_{11} + p_{21}c_{21} < a_0 + p_{11}y_{11}$ and a borrowing tax if $p_{11}c_{11} + p_{21}c_{21} > a_0 + p_{11}y_{11}$.

Notice that the tax τ does not change the equilibrium conditions (4) and (5). It also does not affect the Euler equation and the intertemporal budget constraint of the foreign consumer. In particular the latter can be written as

$$1 - x_1 + q\left(1 - x_2\right) = a_{01}^* + p_{21} y_{21} + q\left(a_{02}^* + p_{22} y_{22}\right). \tag{8}$$

Therefore, a convenient way to analyze the effects of the tax is to choose a pair of spending levels x_1 and x_2 such that (8) is satisfied, taking into account that the prices q, p_{21} and p_{22} depend on the choice of x_1 and x_2. Then we can show that there exists a tax τ that implements a competitive equilibrium with spending levels x_1, x_2.[3]

Differentiating (8) we get

$$-dx_1 - q dx_2 = y_{21} dp_{21} + q y_{22} dp_{22} + \left(a_{02}^* + p_{22} y_{22} - \left(1 - x_2\right)\right) dq. \tag{9}$$

Recall that the price p_{2t} only depends on the spending level x_t. Then, using conditions (4) and (5) to express dp_{21} and dp_{22} in terms of dx_1 and dx_2, we can rewrite (9) as

$$2\left(1 - \alpha\right) dx_1 + 2\left(1 - \alpha\right) q dx_2 = \left(1 - x_2 - a_{02}^* - p_{22} y_{22}\right) dq. \tag{10}$$

To simplify the analysis we restrict attention, from now on, to economies that feature no borrowing or lending at the undistorted competitive equilibrium, that is, $x_1 = a_{01} + p_{11} y_{11}$. In the appendix we show how to choose the economy's primitive parameters so that this property holds. Zero borrowing implies that small changes in the interest rate (i.e., in the bond price q), have no redistribution effects on domestic and foreign consumers. With this assumption, we are muting the interest rate channel that is the focus of section 3 of Costinot, Lorenzoni and Werning (2014), and focusing on the effects of inter-temporal distortions on intra-temporal relative prices, i.e., the relative price of the domestic good in terms of the foreign good at time t.

Assuming zero borrowing in equilibrium implies $1 - x_2 = a_{02}^* + p_{22} y_{22}$, so equation (10) yields

$$\frac{dx_2}{dx_1} = -\frac{1}{q}. \tag{11}$$

3. A similar approach is developed in section 4 of Costinot, Lorenzoni and Werning (2014) to analize optimal policy.

Near the competitive equilibrium, the locus of feasible pairs of spending levels x_1, x_2 have a slope equal to the equilibrium interest rate. In other words, if we introduce a saving subsidy that decreases by ε domestic spending in t =1, this increases domestic spending by $(1 + r)$ ε in t =2.

2.2 Welfare Effects

We can now look at the effect of the policy described on the welfare of domestic and foreign consumers. The total change in welfare for domestic consumers is given by

$$\frac{dW}{dx_1} = U'(C_1)\frac{dC_1}{dx_1} + \beta U'(C_2)\frac{dC_2}{dx_2}\frac{dx_2}{dx_1}.$$

Using $C_t = x_t / P_t$ and equation (11) we can rewrite the expression on the right-hand side as

$$\frac{dW}{dx_1} = \frac{U'(C_1)}{P_1}\left[1 - \frac{dP_1}{dx_1}C_1\right] - \frac{\beta}{q}\frac{U'(C_2)}{P_2}\left[1 - \frac{dP_2}{dx_2}C_2\right].$$

The interpretation is straightforward. The direct effect of an intertemporal shift in spending is given by the two terms equal to in the bracketed expressions. The remaining terms have to do with the effects of the spending shift on the relative prices of the two goods.

Since we start at an undistorted competitive equilibrium, the domestic consumer's Euler equation implies that the two direct effects cancel out, so we are left with

$$\frac{dW}{dx_1} = \frac{U'(C_1)}{P_1}\left[\frac{dP_2}{dx_2}C_2 - \frac{dP_1}{dx_1}C_1\right]. \tag{12}$$

In the appendix we prove that $dP_t / dx_t > 0$. This result follows from the assumption of home bias in consumption (α>1/2): an increase in domestic spending increases the demand for the domestic good relatively more than the demand for the foreign good. This raises the price of the domestic good and reduces the price of the foreign good. Since the domestic consumption basket contains relatively more of

the home good, the net effect is an increase in the domestic price index. We can then use equation (12) to interpret the welfare effect of a saving subsidy. A saving subsidy reduces domestic spending at date 1 and increases it at date 2. The domestic consumer gains if the current reduction in the price of the domestic consumption basket, weighted by the current consumption level, more than offsets the future increase in the same variable. The following result shows that depending on the model parameters, a saving subsidy can either increase or decrease domestic welfare. The proof is in the appendix.

Proposition 1 *Suppose at the undistorted competitive equilibrium there is zero borrowing. A small saving subsidy increases domestic welfare if* $x_2 < x_1 \leq 1/2$ *or* $1/2 \leq x_1 < x_2$. *It decreases domestic welfare if* $x_1 < x_2 \leq 1/2$ *or* $1/2 \leq x_2 < x_1$.

While the total welfare effect of a saving subsidy can go in either direction, the short-run effects are unambiguous. The effect of a saving subsidy is always to decrease current utility, since $dx_1<0$ and

$$\frac{dU_1}{dx_1} = \frac{U'^{(C_1)}}{P_1}\left[1 - \frac{dP_1}{dx_1}C_1\right]dx_1 > 0.$$

The inequality is proved in the appendix, but the intuition is very simple: reducing current spending reduces current utility. The effect is mitigated but never overturned by the fact that the domestic consumption basket gets cheaper. Notice that we are moving on the Pareto frontier within each period, so a reduction in domestic utility corresponds to an increase in foreign utility. We then get the following result.

Claim 2 *In the short run, foreign consumers always gain from a saving subsidy imposed by the domestic country.*

It is also possible to decompose the welfare effects in a different manner, looking at the redistribution generated by term-of-trade adjustments. The envelope theorem implies that the total change in welfare for the domestic consumer can also be computed as follows:

$$\frac{dW}{dx_1} = \frac{U'(C_1)}{P_1}\left[\left(y_{11} - c_{11}\right)\frac{dp_{11}}{dx_1} - c_{21}\frac{dp_{21}}{dx_1} + q\left(y_{12} - c_{12}\right)\frac{dp_{12}}{dx_1}\right]$$
$$\left[-q\frac{dp_{22}}{dx_1}c_{22} + \left(a_{02} + p_{12}y_{12} - x_2\right)\frac{dq}{dx_1}\right]$$

In an equilibrium with zero borrowing the last term inside the

square brackets is zero, so the change in welfare is purely due to the changes in relative prices of the two goods in the two periods. Equations (4) and (5) imply that $dp_{11}/dx_1>0$ and $dp_{21}/dx_1>0$, as an increase in domestic spending shifts world demand towards the domestic good. Moreover, the same decomposition can be done for the foreign consumer, leading to the same exact expressions, but with the opposite sign. We then have the following result.

Claim 3 *A saving subsidy generates short-run changes in the static terms of trade that increase the utility of the foreign consumer and reduce the utility of the domestic consumer.*

The interpretation is also straightforward. A temporary reduction in domestic spending leads to a worsening of domestic terms of trade, so domestic consumers sell domestic goods at a lower price and purchase foreign goods at a higher price. Notice that this leads domestic consumers to buy less foreign goods for two reasons: because they are more expensive and because domestic consumers are spending less overall. This reduction in imports suggests a similarity with a tariff, but, as we shall see in a moment, the analogy is misleading.

3. Comparison with a Tariff

Consider now a different policy experiment. Suppose we start at an equilibrium with zero borrowing, as we have done so far. Suppose at $t=1$ the domestic country imposes an ad valorem tariff on foreign goods μ and, at the same time, introduces an intertemporal tax τ that ensures that we stay at zero borrowing. Then the effects of the tariff can be analyzed exactly as in a static model. The tariff now distorts the share of domestic spending going to the two goods. The fraction spent on domestic goods is now

$$\frac{\alpha(1+\mu)}{\alpha(1+\mu)+1-\alpha}.$$

Market clearing in the domestic good market yields

$$p_{11}y_{11} = \frac{\alpha(1+\mu)}{\alpha(1+\mu)+1-\alpha}\left(a_{01}+p_{11}y_{11}\right)+\left(1-\alpha\right)\left(1-p_{11}y_{11}-a_{01}\right),$$

where we are using the fact that the economy is kept at zero borrowing so $x_1 = a_{01} + p_{11} y_{11}$. Differentiating shows that a tariff increases the price of the domestic good

$$\frac{dp_{11}}{d\mu} > 0.$$

Similarly we can show that $dp_{21}/d\mu < 0$.

Given the way we have designed the policy, it only affects the allocation and welfare in period 1. Moreover, an envelope argument implies

$$\frac{dW}{d\mu} = \frac{U'(C_1)}{P_1}\left[(y_{11} - c_{11})\frac{dp_{11}}{d\mu} - c_{21}\frac{dp_{21}}{d\mu}\right].$$

So a tariff always increases the welfare of the country imposing it and always reduces the welfare of the trading partner. By construction, the welfare gain is only showing in the short run.

We can now clearly see the difference between the two policy experiments considered. The immediate effect of a saving subsidy is to worsen the terms of trade of the country imposing it. A saving subsidy can only yield benefits in the future, when the country will be spending more and increasing its terms of trade. A tariff, on the other hand, always improves the terms of trade of the country imposing it and that is what makes it desirable.

A source of confusion comes from the fact that under both policies domestic consumers are encouraged to shift their spending from foreign goods to domestic goods. Namely, the ratio

$$\frac{c_{21}}{c_{11}}$$

goes down under both policies. However, under a saving subsidy this ratio is decreasing only because, in general equilibrium, the foreign good is getting relatively more expensive. The condition of equality between marginal rate of substitution and relative price,

$$\frac{\alpha}{1-\alpha}\frac{c_{21}}{c_{11}} = \frac{p_{11}}{p_{21}},$$

holds undistorted under a saving subsidy. Under a tariff, instead, the foreign good is only perceived to be more expensive because of

the tariff and the condition above is replaced by

$$\frac{\alpha}{1-\alpha}\frac{c_{21}}{c_{11}} = \frac{p_{11}}{(1+\mu)p_{21}}.$$

The price cum tariff of the foreign good $(1+\mu)p_{21}/p_{11}$ has gone up, but the world price p_{21}/p_{11} has gone down, that is what is benefitting the domestic consumer. Consumers are buying less of good 2 only because they have to pay the tariff on top of the world price. But the country as a whole is paying less for good 2.

4. Neutrality Results and Equivalence Results

Now consider a policy of imposing both an import tariff and an export subsidy in period 1, of equal size, in percentage terms. Suppose the intertemporal effects of the policy are muted by imposing a saving tax, as we did in the case of a tariff alone. Then the effect of the policy is completely neutral. The import tariff makes foreign goods more expensive in terms of the numeraire, the export subsidy makes the domestic good more expensive. Their relative price is unchanged. This is simply a consequence of Lerner's symmetry theorem (Lerner, 1936), with the two interventions exactly canceling each other. Neutrality also follows if the tariff and subsidy are permanent, i.e., if they are equal in the two periods.

If the intertemporal effects are not neutralized, a temporary import tariff plus export subsidy are equivalent to a saving subsidy since they introduce an equal wedge on both period-1 goods for domestic consumers. The general equilibrium effect of the policy is to make domestic goods cheaper in period 1 and, as we saw above, it has detrimental welfare effects in the short run. Notice that there is no mechanical relation between the size of the tariff plus subsidy, and the size of the exchange rate devaluation achieved with this policy. To see this in an extreme case notice that if α=1/2 the effect on relative prices is completely absent.

We can now go back to the remark by Bergsten (2010), cited in the introduction. Under the right *ceteris paribus* assumptions, the remark is mechanically true. For example, for a domestic firm competing with imported goods, who faces given prices of domestic inputs in domestic currency and given prices of competing imports in foreign currency, a tariff or an exchange rate devaluation are equivalent. However, once

the exchange rate is determined in equilibrium, one has to specify what policy instruments are used to achieve the exchange rate devaluation and to make assumptions on the adjustment of domestic and foreign prices. In a simple neoclassical environment with flexible prices, in which the exchange rate is manipulated solely via saving distortions, this leads to very different conclusions.

5. Concluding Remarks

This paper leaves aside an important open question: what is the rationale for policies that distort the saving rate of a country? Proposition 1 provides a potential rationale by which the country imposes a distortion because it will reap welfare gains in the long run, while its exchange rate appreciates. Since this channel seems poorly understood and rarely made in policy circles, it's important to consider alternative explanations.

One possibility is that an increase in the saving rate may be simply the side effect of policies of precautionary reserve accumulation. Another possibility is that the real devaluation and expansion of the export sector generated by a high-saving policy are an explicit objective of the policy maker. From a terms-of-trade point of view, the argument in this paper shows that the real devaluation, per se, leads to welfare losses in the short run. However, it is possible that the policy is beneficial in terms of social welfare because it internalizes some externality associated to an expansion of the export sector. Maybe export volumes affect learning-by-doing and other forms of knowledge accumulation. This is the argument pursued in Rodrick (2008). On the other hand, it is also possible that these policies are simply not maximizing social welfare, but responding to political-economy pressures.

Finally, a depressed economy may like to devalue its currency to boost external demand. However, that does not seem to make a case for distortions that increase domestic savings, given that these distortions are likely to be overall contractionary in a depressed economy. Discussing these channels requires a richer monetary model with price stickiness where exchange rate policy is achieved

with different instruments.[4] In any event, it is useful to separate medium-run considerations that apply to countries that keep their exchange rate undervalued over long periods of time, from short-run considerations related to volatile capital flows and cyclical shocks, where nominal rigidities are more likely to play an important role.

A better understanding of the rationale behind high-saving policies is clearly needed to assess their overall welfare consequences, both on the countries imposing them and on their trading partner. This paper only provides a clarification of a basic difference in the terms-of-trade implications of these policies relative to traditional protectionist tools.

4. Stager and Sykes (2010) analyze the effect of nominal undervaluation achieved by monetary policy in a sticky price environment. Farhi and Wering (2013) analyze the role of capital controls in responding to volatile capital flows in sticky-price models.

APPENDIX

Derivations for section 2.2

First, we prove the following inequalities

$$0 < \frac{dP_t}{dx_t} C_t < 1,$$

which are stated in section 2.2. Derive the equilibrium prices p_{1t} and p_{2t} from (4) and (5) and substitute in the domestic CPI (2) to get

$$P_t = \alpha^{-\alpha}\left(1-\alpha\right)^{-(1-\alpha)}\left(\frac{\alpha x_t + \left(1-\alpha\right)\left(1-x_t\right)}{y_{1t}}\right)^{\alpha}\left(\frac{\left(1-\alpha\right)x_t + \alpha\left(1-x_t\right)}{y_{2t}}\right)^{1-\alpha}.$$

Differentiating this expression and rearranging gives

$$\frac{1}{P_t}\frac{dP_t}{dx_t} = \alpha\frac{2\alpha-1}{\alpha x_t + \left(1-\alpha\right)\left(1-x_t\right)} - \left(1-\alpha\right)\frac{2\alpha-1}{\left(1-\alpha\right)x_t + \alpha\left(1-x_t\right)}. \tag{13}$$

It is easy to check that $\alpha>1/2$ implies $dP_t/dx_t>0$. Moreover

$$\frac{dP_t}{dx_t} C_t = \frac{x_t}{P_t}\frac{dP_t}{dx_t} < \left(2\alpha-1\right)\frac{\alpha x_t}{\alpha x_t + \left(1-\alpha\right)\left(1-x_t\right)} < 1,$$

where the last inequality follows since the two factors before the inequality are both smaller than 1.

Proof of Proposition 1

Define the function

$$f(x) \equiv \alpha\frac{x}{\alpha x + \left(1-\alpha\right)\left(1-x\right)} - \left(1-\alpha\right)\frac{x}{\left(1-\alpha\right)x + \alpha\left(1-x\right)}.$$

A saving subsidy reduces x_1, so it leads to a welfare gain iff $dW/dx_1<0$. By equation (12), this happens iff

$$\frac{x_1}{P_1}\frac{dP_1}{dx_1} > \frac{x_2}{P_2}\frac{dP_2}{dx_2},$$

that is, iff $f(x_1) > f(x_2)$. It can be shown that the function f is increasing in [0,1/2] and decreasing in [1/2,1]. The two cases in the Proposition follow.

Constructing examples

Examples of competitive equilibria with $x_1 > x_2$ and $x_1 < x_2$ can be constructed by reverse engineering. Zero borrowing in equilibrium requires

$$1 - x_2 = p_{22} y_{22} = (1 - \alpha) x_2 + \alpha (1 - x_2),$$

which implies $x_2 = 1/2$. Choose a value for $x_1 \neq 1/2$ and choose a bond price q. Find the levels of $p_{1t}, p_{2t}, P_t, P_t^*$ using equations (2) to (5). Then consumption levels are obtained from $C_t = x_t / P_t$ and $C_t^* = (1 - x_t) / P_t^*$. Choose the discount factors β and β^* to satisfy the Euler equations (6) and (7) (choosing q small enough ensures that both discount factors are smaller than 1). Finally, choose the initial net asset position a_0 so that the domestic budget (1) constraint holds. The foreign budget constraint holds by Walras' Law.

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