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A Model of Endogenous Nontradability and its Implications for the Current Account*

Paul Bergin and Reuven Glick

Abstract

This paper studies how nontraded goods limit the ability of a country to finance current account deficits. It uses an intertemporal model of the current account for a small open economy where goods are endogenously nontraded due to explicit trade costs. The economy has an endowment of two goods with differing trade costs, either of which can be traded or nontraded in equilibrium. The model implies that current account deficits impose a cost, in the form of raising the effective interest rate in the country. The findings differ from some recent studies: first, in that the interest rate rises even for countries with modest current account deficits; secondly, the interest rate cost eventually reaches an upper bound as current account deficits grow, and progressively more nontraded goods become traded to service the debt. Panel regression analysis of interest rate and current account data is consistent with our conclusions.

1. Introduction

The ability of a country to finance a current account deficit can be limited by the presence of nontraded goods. Dornbusch (1983) demonstrated this point in the context of an intertemporal model for a small open economy, where a current account deficit generates a temporary rise in the relative price of nontraded goods, and thereby increases the effective real interest rate. This in turn makes it more costly for residents of that country to service debt resulting from current account deficits. Obstfeld and Rogoff (2000) extended this story by studying how the status of a good as traded or nontraded is endogenously determined by iceberg trade costs.[1] In the context of a small economy endowed with one representative home good also available abroad, they argue that interest rates rise only when the current account reaches a substantial share of the country's output, and is unaffected for countries with modest deficits. These authors also use this conclusion as an explanation for the puzzle of Feldstein and Horioka (1980): large current account imbalances are not observed since interest rate changes dampen them.[2]

In this paper we find that these conclusions change significantly if one considers a more general economic environment, in which there are multiple home goods with differing transport costs. In particular, we consider a simple two-period endowment model for a small open economy similar to Obstfeld and Rogoff (2000), but extend it to consider two home goods. These goods differ in terms of the costs of trading them internationally, so one good is relatively more tradable than the other. As the economy responds to shocks and begins trading progressively more or fewer goods, the model

* Bergin: University of California at Davis, One Shields Ave., Davis, CA 95616, USA. Tel: (530) 752-8398; Fax: (530) 752-9382; E-mail: prbergin@ucdavis.edu. Glick: Economic Research Department, Federal Reserve Bank of San Francisco, 101 Market Street, San Francisco, CA 96105, USA. Tel: (415) 974-3184; Fax: (415) 974-2168; E-mail: reuven.glick@sf.frb.org. The views expressed below do not represent those of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System. Research assistance by Marc Meredith is gratefully acknowledged.

implies a nonlinear relationship between the size of current account deficits and the cost of financing them.

Our model yields two main results. The first is that the costs of running a current account deficit commence even for small deficits, and are not just the concern of countries with large imbalances. This finding suggests that acknowledging the endogenous nature of nontraded goods as in Obstfeld and Rogoff (2000) does not inherently overturn the lessons of Dornbusch (1983), since their result is the product of a model with just one home good. The intuition is as follows: a model with only one exportable home good implies that in times of moderate current account imbalances, the home good is exported each period to pay for the imported foreign good. If there are no nontraded goods, then the Dornbusch mechanism working through nontraded prices does not apply; prices are fixed relative to the world market equilibrium, and the domestic interest rate equals the world rate.

However, data make clear that nontraded goods are an ever present feature of all economies. Our model with multiple home goods accommodates this fact under current account balance: the good with the higher transport cost can remain nontraded while the more tradable home good is exported to pay for imported foreign goods. With nontraded goods present, the Dornbusch mechanism is free to operate. In fact, we find that in an Obstfeld–Rogoff model augmented with a second home good, the Dornbusch model becomes a nested case. Ironically, it is situations near current account balance where the Dornbusch mechanism actually should apply best.

The second result is that the Dornbusch result can be weakened by the endogenous nature of decisions to trade goods, but this will tend to occur for cases of large rather than small current account imbalances. It is no longer true that the costs of running a current account deficit, in terms of a higher interest rate, can grow arbitrarily large as the current account deficit increases. If an economy can respond to interest rate incentives by beginning to trade goods not previously traded, it will do so in a manner that minimizes its exposure to these costs. The price of a nontraded good can only rise so high before it becomes optimal to begin importing it, and it ceases to be nontraded.

Finally, panel regression analysis, using current account and interest rate data for 21 industrial countries, suggests empirical support for our theoretical results.

2. The Model

Setup

Following Obstfeld and Rogoff (2000), we analyze a small open economy model with two periods. The model here differs primarily in considering the case of three goods (A, B, F), where the home country is endowed with two of them (A and B), rather than just one, as in Obstfeld–Rogoff. The home country's endowments of these two goods (y_A, y_B) may be exported, imported, or nontraded. The third good (F) is foreign, and can only be imported. The world has endowments of all three goods. The representative agent of the small country chooses consumption levels of the three goods (c_A, c_B, c_F), which take on the domestic prices (p_A, p_B, p_F). We consider an asset market where the representative agent of the country can trade a noncontingent bond (B) with the rest of the world, which pays off at rate i, denominated in the units of the foreign good.

The prices of goods in the domestic market are affected by the presence of good-specific iceberg costs (τ_A, τ_B, τ_F), where a certain fraction of each good disappears in transport. We assume that the home country pays for this cost, so that if the world price of good A is normalized to unity, the domestic price will be $p_A = 1/(1 + \tau_A)$ if the country exports good A, but $p_A = 1 + \tau_A$ if good A is imported, and $1/(1 + \tau_A) < p_A < 1 + \tau_A$ if good A is nontraded. The price of home good B is characterized by analogous price bounds. The price of the foreign good, which is always imported, is $p_F = 1 + \tau_F$. In proceeding, we will assume that the transportation cost for good A is at least as large as that for good B, i.e. $\tau_A \geq \tau_B$. As we shall see below, this implies A will be the "less tradable" good.

Home country consumption of the three goods is summarized by

$$c_t = \left(c_{Ht}^{(\theta-1)/\theta} + c_{Ft}^{(\theta-1)/\theta}\right)^{\theta/(\theta-1)} \quad \text{where} \quad c_{Ht} = \frac{c_{At}^{\alpha} c_{Bt}^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}}, \tag{1}$$

where θ is the elasticity of substitution between the foreign good and home good aggregate, while α denotes the expenditure share for good A in the home good aggregate.

The intratemporal optimization problem implies the following conditions for allocating consumption between the different goods for each period t, $t = 1, 2$:

$$c_{At}/c_{Ht} = \alpha\left(p_{At}/p_{Ht}\right)^{-1}, \quad c_{Bt}/c_{Ht} = (1-\alpha)\left(p_{Bt}/p_{Ht}\right)^{-1}, \tag{2}$$

$$c_{Ht}/c_t = \left(p_{Ht}/p_t\right)^{-\theta}, \quad c_{Ft}/c_t = \left(p_{Ft}/p_t\right)^{-\theta}, \tag{3}$$

where the minimum-expenditure consumption-based price indices are defined as:[3]

$$p_{Ht} \equiv \left(p_{At}\right)^{\alpha}\left(p_{Bt}\right)^{1-\alpha}, \tag{4}$$

$$p_t \equiv \left(\left(\left(p_{At}\right)^{\alpha}\left(p_{Bt}\right)^{1-\alpha}\right)^{1-\theta} + \left(p_{Ft}\right)^{1-\theta}\right)^{1/(1-\theta)}. \tag{5}$$

The intertemporal decision maximizes the two-period utility function

$$\frac{1}{1-\eta}\left[\left(c_1\right)^{1-\eta} + \beta\left(c_2\right)^{1-\eta}\right] \tag{6}$$

subject to the following intertemporal budget constraint:

$$c_1 = \left[\left(\frac{p_{A1}}{p_1}\right)y_{A1} + \left(\frac{p_{B1}}{p_1}\right)y_{B1}\right] + \left(\frac{p_2}{p_1(1+i)}\right)\left[\left(\frac{p_{A2}}{p_2}\right)y_{A2} + \left(\frac{p_{B2}}{p_2}\right)y_{B2} - c_2\right]. \tag{7}$$

This implies the intertemporal Euler equation:

$$\left(c_2/c_1\right)^{\eta} = \beta(1+i)\frac{p_1}{p_2} = \beta(1+r), \tag{8}$$

where the real interest rate $1 + r \equiv (p_1/p_2)(1 + i)$. Note that the relevant interest rate for this intertemporal decision is the real interest rate r, which is expressed in units of the home consumption index, rather than simply the world interest rate, i, which is expressed in units of the foreign good. Given that the world price level is normalized to unity, the domestic real exchange rate is $(1/p)$, and so (p_1/p_2) represents the real exchange rate depreciation over time. The right-hand side of condition (8) then simply represents the real interest rate parity condition. Movements in the real exchange rate then will influence the degree of borrowing or lending through their effect on the real interest rate. For simplicity, we normalize i to zero in the analysis below.

Solution

Solving the system is complicated by the presence of "kinks" in the price schedules where the home goods A and B switch between being exported, nontraded, and imported. To summarize the process of solving the model, we first follow Obstfeld and Rogoff (2000) in conjecturing a sequence of trade adjustment according to which the home goods switch between being exported, nontraded, and imported in each period as aggregate consumption in period 1 increases. (The foreign good is always imported in both periods by assumption.) Corresponding to this sequence of trade adjustment is a sequence of price adjustment for each of the two home goods that satisfies the conditions for their intratemporal allocation. Given this conjectured sequence of adjustment, we then solve analytically for the levels of period 1 aggregate consumption and the intertemporal aggregate price ratio in each of the regions that satisfy the intratemporal allocation conditions for the home and foreign goods as well as the intertemporal budget constraint. This permits us to determine the domestic consumption-based interest rate r, and, as in Obstfeld and Rogoff (2000), to trace out how this interest rate rises with current consumption (or current account deficits). This enables us to analyze how relative transport costs and the pattern of trade affect the level of intertemporal trade, which is our objective.[4] We verify the optimality of the conjectured sequence of adjustment by showing that it implies a monotonically increasing schedule for the real interest rate as first-period consumption rises. The discussion below explains this solution process in more detail.

Table 1 presents the conjectured adjustment of export and import behavior and the corresponding prices of goods A and B. (The price of the foreign good is constant at $1 + \tau_F$ throughout since it is always imported.) Thus in region I both of the home goods A and B are exported in period 1, implying $p_{A1} = 1/(1 + \tau_A)$, $p_{B1} = 1/(1 + \tau_B)$, and both are imported in period 2, implying $p_{A2} = 1 + \tau_A$, $p_{B2} = 1 + \tau_B$. In region IIa, A and B continue to be both exported in period 1, while in period 2 importing of A ceases and no trading occurs, but B is still imported. As a result of the switch from being imported to being nontraded in period 2, p_{A2} is no longer pinned down by foreign prices and trade costs, and consequently falls below $1 + \tau_A$. At the transition to region IIb, B ceases being imported and becomes nontraded in period 2 as well, and p_{B2} falls below $1 + \tau_B$. The price of A, still nontraded, continues to decline. At the transition to region IIc, when p_{B2} has fallen to $1/(1 + \tau_B)$, B starts being exported, while the price of A falls further. When in region III, $p_{A2} = 1/(1 + \tau_A)$, and A begins to be exported as well. The transitions between regions IVa, IVb, IVc, and V are analogous, as first A and then B stop being exported in period 1.

To better understand how the relative price of home goods varies within and across regions, it is useful to solve the home good allocation conditions (2):

$$\frac{p_{At}}{p_{Bt}} = \gamma_t\left(\frac{c_{Bt}/y_{Bt}}{c_{At}/y_{At}}\right), \tag{9}$$

where $\gamma_t \equiv (\alpha/(1-\alpha))(y_{Bt}/y_{At})$. Equation (9) describes how the relative prices of A and B in period t depend inversely on the relative consumptions of the two goods (expressed as ratios to their endowments), as well as on the parameter γ_t. When both goods are traded, as in regions I, III, and V, the prices of A and B are pinned down exogenously, and (9) determines the relative consumptions of the two goods. When one or both goods are nontraded, i.e. $c_{At}/y_{At} = 1$ and possibly $c_{Bt}/y_{Bt} = 1$, then (9) determines the relative prices of the goods in that period. For example, when both goods

Table 1. Sequence of Adjustment of Home Good Trade and Prices, Benchmark Case

	Period 1		*Period 2*		*Period 1*		*Period 2*	
Region	*Good A*	*Good B*	*Good A*	*Good B*	$p_{A1}\uparrow$	$p_{B1}\uparrow$	$p_{A2}\downarrow$	$p_{B2}\downarrow$
I	X	X	M	M	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$1+\tau_A$	$1+\tau_B$
IIa	X	X	NT	M	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\{1+\tau_A, \gamma_2(1+\tau_B)\}$	$1+\tau_B$
IIb	X	X	NT	NT	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\left\{\gamma_2(1+\tau_B), \frac{\gamma_2}{1+\tau_B}\right\}$	$\left\{1+\tau_B, \frac{1}{1+\tau_B}\right\}$
IIc	X	X	NT	X	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\left\{\frac{\gamma_2}{1+\tau_B}, \frac{1}{1+\tau_A}\right\}$	$\frac{1}{1+\tau_B}$
III	X	X	X	X	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
IVa	NT	X	X	X	$\left\{\frac{1}{1+\tau_A}, \frac{\gamma_1}{1+\tau_B}\right\}$	$\frac{1}{1+\tau_B}$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
IVb	NT	NT	X	X	$\left\{\frac{\gamma_1}{1+\tau_B}, \gamma_1(1+\tau_B)\right\}$	$\left\{\frac{1}{1+\tau_B}, 1+\tau_B\right\}$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
IVc	NT	M	X	X	$\{\gamma_1(1+\tau_B), 1+\tau_A\}$	$1+\tau_B$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
V	M	M	X	X	$1+\tau_A$	$1+\tau_B$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$

Notes: X = export, M = import, NT = nontraded; $\gamma_t \equiv (\alpha/(1-\alpha))(y_{Bt}/y_{At})$. See Bergin and Glick (2002, App. A) for derivations.

are nontraded, as in regions IIb for period 2 and IVb for period 1, then (9) implies $p_{At}/p_{Bt} = \gamma_t$, i.e. the relative price is equal to the constant γ_t. The parameter γ_t reflects the role of relative preferences and endowments on the relative price of the two home goods.

The consumption allocation conditions for good A and the home good composite—expressions (2) and (3), respectively—imply

$$c_t = (p_{Ht}/p_t)^{\theta} c_{Ht}, \quad c_{Ht} = (1/\alpha)(p_{At}/p_{Ht})c_{At}.$$

Substituting the latter into the former and multiplying and dividing by y_{At} gives

$$c_t = \left(\frac{1}{\alpha}\right)\left(\frac{p_{At}}{p_{Ht}}\right)\left(\frac{p_{Ht}}{p_t}\right)^{\theta}\left(\frac{c_{At}}{y_{At}}\right)y_{At}. \tag{10}$$

Note that this relationship holds for all regions as well as for each period t, $t = 1, 2$.

We next map the conjectured sequence of trade and price adjustment to the level of aggregate consumption by determining the lower and upper consumption bounds for which each of our regions applies. Denote the lower aggregate consumption bound in period 1 for regions IIa, IIb, . . . , V by $c_1^{\overline{IIa}}, c_1^{\overline{IIb}}, c_1^{\overline{IIc}}, c_1^{\overline{III}}, c_1^{\overline{IVa}}, c_1^{\overline{IVb}}, c_1^{\overline{IVc}}, c_1^{\overline{V}}$, respectively.[5] Hence $c_1^{I} \in \{0, c_1^{\overline{IIa}}\}, c_1^{IIa} \in \{c_1^{\overline{IIa}}, c_1^{\overline{IIb}}\}, \ldots, c_1^{V} \in \{c_1^{\overline{V}}, \infty\}$. We can derive analytic solutions for these consumption bounds by substituting the corresponding prices of goods A and B at these bounds from Table 1 into expression (10).[6] See Bergin and Glick (2002) for details.

Provided that the transportation cost on good A is at least as large as that on good B, i.e. $\tau_A \geq \tau_B$, we can show that the cutoffs between regions lie in the following order: $c_1^{\overline{IIa}} < c_1^{\overline{IIb}} < c_1^{\overline{IIc}} < c_1^{\overline{III}}$ and $c_1^{\overline{IVa}} < c_1^{\overline{IVb}} < c_1^{\overline{IVc}} < c_1^{\overline{V}}$. For all trade costs below a certain threshold, τ^*, we further can show that there exists a set of parameter values for which $c_1^{\overline{III}} < c_1^{\overline{IVa}}$. This means that first-period consumption rises as goods switch in and out of tradability in the conjectured order.

We next determine the schedule of real domestic interest rate and consumption levels that satisfy the intratemporal allocation conditions for home and foreign goods as well as the intertemporal budget constraint. That is, as we increase c_1, we determine the corresponding levels of p_1/p_2 (= r, since i is normalized to 0) that satisfy (2), (3), and (7). We do so by substituting the appropriate prices of goods A and B into the expression for the intertemporal price ratio and utilizing the definition of the aggregate price level (5):

$$\frac{p_1}{p_2} = \frac{\left(\left(p_{A1}^{\alpha} p_{B1}^{1-\alpha}\right)^{1-\theta} + \left(1+\tau_F\right)^{1-\theta}\right)^{1/(1-\theta)}}{\left(\left(p_{A2}^{\alpha} p_{B2}^{1-\alpha}\right)^{1-\theta} + \left(1+\tau_F\right)^{1-\theta}\right)^{1/(1-\theta)}}. \tag{11}$$

Note that $p_{Ft} = 1 + \tau_F$ since the foreign good is always imported in both periods. Glick and Bergin (2002, App. Table 2), gives expressions for the range of the intertemporal aggregate price ratio in each region.

It is readily apparent that the real interest rate is constant for regions I, III, and V since all goods are traded in both periods and their prices then are determined exogenously. Moreover, in the case of region III, where both home goods are exported in both periods, the composite home goods price and hence the aggregate price are constant across time as well, implying $p_1 = p_2$ and $r = 1$.

When A and possibly B are nontraded, however, their prices vary with consumption, and the real interest rate is no longer constant. To determine how p_{At} and p_{Bt} change with c_t, we make use of the following equation:

$$p_{At}^{\alpha} p_{Bt}^{1-\alpha} = p_{Ft} \left[\frac{1}{\left(c_t \Big/ \left[(c_{At}/y_{At})^{\alpha} (p_{At}/p_{Bt})^{1-\alpha} (y_{At}/\alpha) \right] \right)^{(\theta-1)/\theta} - 1} \right]^{1/(1-\theta)} . \tag{12}$$

See Bergin and Glick (2002, App. B) for the derivation. Condition (12) gives us a general expression for p_{At} and p_{Bt} as a function of aggregate consumption, c_t, and good A consumption, c_{At}, that holds for all regions and periods t. (Recall again that the price of the foreign good, p_{Ft}, is always exogenously determined.) When A is nontraded ($c_{At}/y_{At} = 1$), (12) reduces to an expression for p_{At} as a function of c_t, conditional on p_{Bt}. However, we know that when B is traded its price is determined exogenously as either $1/(1 + \tau_B)$ when exported or $1 + \tau_B$ when imported. When B as well as A are nontraded, expression (9) implies that the price of B is proportional to that of A: $p_{At} = p_{Bt}\gamma_t$. Consequently, in both cases (12) enables the determination of p_{At} and p_{Bt} as we vary c_t. Plugging these home good prices into expression (12) for the intertemporal price ratio as we increase aggregate consumption gives us our desired $p_1/p_2 - c_t$ schedule.

Given the assumption that A is the less tradable good ($\tau_A \geq \tau_B$), we can order the intertemporal aggregate price ratios in the various regions as follows:

$$\frac{p_1^{IIa}}{p_2^{IIa}} < \frac{p_1^{IIb}}{p_2^{IIb}} < \frac{p_1^{IIc}}{p_2^{IIc}} < \frac{p_1^{III}}{p_2^{III}} \quad \text{and} \quad 1 < \frac{p_1^{IVa}}{p_2^{IVa}} < \frac{p_1^{IVb}}{p_2^{IVb}} < \frac{p_1^{IVc}}{p_2^{IVc}} < \frac{p_1^{V}}{p_2^{V}}.$$

Moreover, when $\overline{c_1^{III}} < \overline{c_1^{IVa}}$ it will also be true that $(p_1^{III}/p_2^{III}) < (p_1^{IVa}/p_2^{IVa})$. This steady rise in the price level of period 1 relative to that of period 2 indicates a rise in the consumption-based real interest rate. Accordingly, the regions defined above describe a steadily rising path for the consumption-based real interest rate as one begins with low levels of period 1 consumption and then lets consumption rise. In this sense our conjectured trade adjustment path is verified.

3. Results

Benchmark Case

To develop intuition for the model above, consider a simple case where 10% of the foreign good disappears during international shipment. This is a modest and plausible value for many goods, and as this is the value assumed in Obstfeld and Rogoff (2000), it facilitates a comparison with their conclusions. Assume that the same iceberg cost applies to the home good B. But assume that the other class of home goods, A, is harder to transport, and a higher level of 25% disappears in shipment. These iceberg costs imply the following parameter values in our model: $\tau_A = 1/3$, $\tau_B = \tau_F = 1/9$. For the elasticity of substitution between the foreign good and the home composite, a value of $\theta = 6$ is a common choice in the literature, and is the value chosen by Obstfeld and Rogoff (2000) for their benchmark case. To focus the analysis on the role of transport costs and the elasticity of substitution, we assume a balanced preference and endowment path for home goods across time (i.e. $\alpha = 0.5$, $y_{At} = y_{Bt} = 0.5$), implying that the relative price parameter

$$\gamma_t \equiv (\alpha/(1-\alpha))(y_{Bt}/y_{At}) = 1 \quad \text{for } t = 1, 2.$$

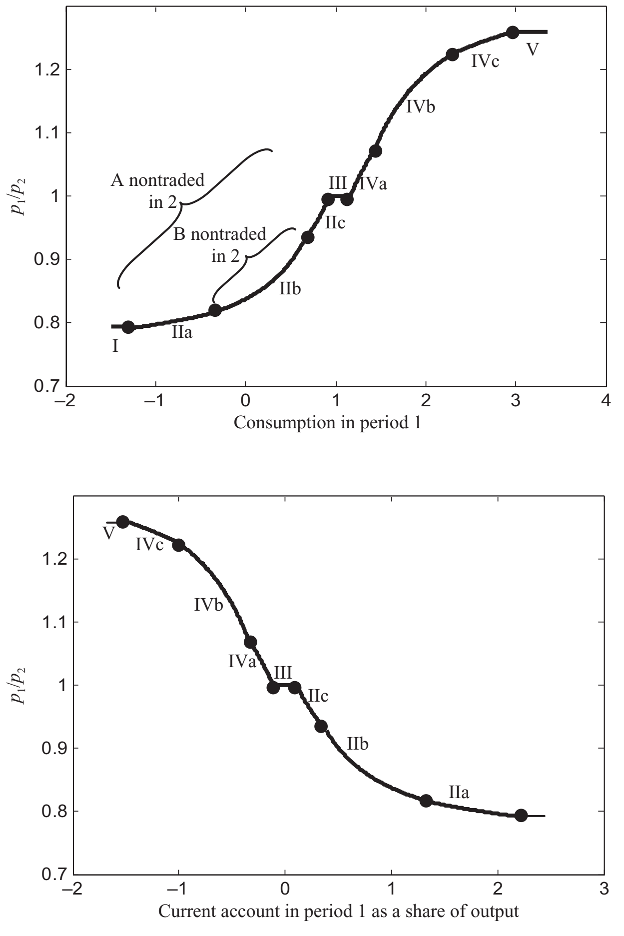

Figure 1. Benchmark Case

Note: Parameter values: $\tau_A = 1/3$, $\tau_B = \tau_F = 1/9$, $\alpha = 0.5$, $y_A = y_B = 0.5$, $\theta = 6$.

The implications of these transportation costs for the cost of intertemporal trade can be read easily by looking at Figure 1. This plots the ratio of the home price index in period 1 to that in period 2, which one may recall can be interpreted as the depreciation in the country's real exchange rate, given that the world price level is normalized to unity. Recall also that this ratio may be interpreted as the country's real interest rate, given that real interest rate parity holds and the world gross interest rate is normalized to unity. In the top panel, this price ratio is plotted against the level of period 1 consumption for which it prevails. In the bottom panel, it is plotted against the period 1 current account as a share of total output, which is $(y_{H1} - c_1)/y_{H1}$ where home output is defined as

$$y_{H1} \equiv \left(\frac{p_{A1}}{p_1}\right) y_{A1} + \left(\frac{p_{B1}}{p_1}\right) y_{B1}.$$

One observation from the graph is that as the level of consumption rises in period 1, the price index in period 1 rises steadily relative to that of period 2. This means that as the small open economy consumes progressively more and then begins to borrow in period 1, the domestic real interest rate progressively rises, making borrowing more expensive. Unlike the analysis of Dornbusch (1983), however, the cost of borrowing does not rise forever as borrowing rises. Once period 1 consumption rises to the point that both home goods are imported in period 1 and exported in period 2 (in region V), the domestic interest rate reaches its maximum deviation of 28% above the world interest rate level. Similarly, when consumption is very low (as in region I), the lower bound on the interest rate is 22% below the world interest rate. While bounded, the range in the domestic interest rate induced by the endogenously nontraded goods is clearly very wide.

A second general observation is that goods with higher transportation costs tend to become nontraded first and to stop being nontraded last. In the figure, good A becomes nontraded before good B does. At a very low level of consumption in period 1 and hence a high level of consumption in period 2 (region I), both goods A and B are imported in period 2. Given that good A has a higher transport cost than B, its price must be higher when both goods are imported. As a result, the consumption of good B is higher than that of A, given the intratemporal optimization conditions. That is, since under the calibration $\gamma_2 = 1$, (9) implies

$$\frac{c_{B2}/y_{B2}}{c_{A2}/y_{A2}} = \frac{p_{A2}}{p_{B2}} = \frac{1+\tau_A}{1+\tau_B} > 1,$$

it follows that $c_{A2}/y_{A2} < c_{B2}/y_{B2}$. Since the endowments of the two goods are assumed equal (i.e. $y_{A2} = y_{B2}$) it follows that $c_{A2} - y_{A2} < c_{B2} - y_{B2}$. Thus, as c_{H1} and c_1 rise and hence c_{H2} and c_2 fall, this will reduce consumption of both goods A and B in the second period by the same proportionate amount. If output endowments are equal, the country will stop importing good A first in period 2, as characterized in the transition to region IIa. By an analogous argument, it can be shown that not only does good B become nontraded *after* good A, but it also stops being nontraded and becomes exported in period 2 *before* good A, as characterized in the transition to region IIc.

A third general observation from Figure 1 is that for small current account imbalances, there is no intertemporal price effect that dampens intertemporal trade. Note that in region III goods A and B are both exported in each period, and there is never any reversal in the pattern of trade of either good. In this region, the aggregate price index is constant over time and trade costs have no effects on the real interest rate.

A final observation is that the cost of borrowing rises in a very nonlinear way, rising most steeply as goods first become nontraded. Note that the curves in Figure 1 become progressively steeper as they approach region III. This arises because the price index is concave in the price of home goods (see Bergin and Glick, 2002, App. C).

Nesting Obstfeld–Rogoff

Our benchmark case differs from that of Obstfeld and Rogoff (2000) most importantly in that their case had only one home good with a single transport cost. We can exactly replicate this result for comparison with our benchmark, simply by assuming that there is a 10% loss from shipping for all goods ($\tau_A = \tau_B = \tau_F = 1/9$).

In this case the flat region III becomes much wider than in the benchmark case of Figure 1. The current account must reach a level that is 35% of the country's output, either surplus or deficit, before the boundary of region III is reached. The reason is that with only one home good, for it to be nontraded requires that total gross exports be zero, i.e. that the country exports nothing at all. The implication is that the non-linear effects of nontraded goods highlighted by Obstfeld and Rogoff are likely never to be applicable for most countries, but only for those countries with extreme levels of current account imbalance.

However, the model discussed in the preceding section demonstrates that by adding a second good with a higher transport cost, we can narrow this middle region, and bring the curved regions of the path closer together. As a result, goods become nontraded and have effects on the real interest rate at more modest levels of the current account balance.

Nesting Dornbusch

For ever higher levels of transport cost, it is possible to bring the curved regions close enough together that the flat region III is eliminated altogether. Using the consumption bounds of region III ($c_1^{\overline{III}}$ and $c_1^{\underline{IVa}}$) we can compute the critical level of τ_A, τ_A^*, as that which satisfies the equation:

$$c_1^{\overline{III}} \equiv \left(\frac{(1/(1+\tau_A))y_{A1}+(1/(1+\tau_B))y_{B1}}{\Omega^{1/(1-\theta)}}\right)+\left(\frac{(1/(1+\tau_A))y_{A2}+(1/(1+\tau_B))y_{B2}}{\Omega^{1/(1-\theta)}(1+i)}\right)$$
$$-\left(\frac{\left(\frac{1}{\alpha}\right)\left(\frac{1}{1+\tau_A}\right)\left(1+\left(\frac{1+\tau_F}{1/(1+\tau_H)}\right)^{1-\theta}\right)y_{A2}}{\Omega^{1/(1-\theta)}(1+i)}\right)$$
$$=\left(\frac{1}{\alpha}\right)\left(\frac{1}{1+\tau_A}\right)\left(1+\left(\frac{1+\tau_F}{1/(1+\tau_H)}\right)^{1-\theta}\right)\left(\frac{1}{\Omega^{1/(1-\theta)}}\right)y_{A1} \equiv c_1^{\overline{IVb}},$$

where

$$\Omega \equiv \left(\frac{1}{1+\tau_H}\right)^{1-\theta}+(1+\tau_F)^{1-\theta} \quad \text{and} \quad 1+\tau_H \equiv (1+\tau_A)^{\alpha}(1+\tau_B)^{1-\alpha}.$$

For levels of trade cost that exceed the critical level τ_A^*, the curved regions begin to overlap, i.e. $c_1^{\overline{III}} - c_1^{\underline{IVa}} < 0$. See Figure 2 for an example, where we assume good A has an iceberg cost of 50%: $\tau_A = 1.0$ and $\tau_B = \tau_F = 1/9$. In this case, regions IIc and IVa overlap.

Given that region IIc implies that good A is nontraded in period 2, and region IVa implies that good A is nontraded in period 1, one might conjecture that good A would be nontraded in both periods here. This conjecture is indeed correct. Table 2 describes the sequence of adjustment of trade and prices when this new region is embedded in the benchmark case by "cutting into" regions IIc and IVa. We denote this case where A is nontraded while B is exported in both periods as region III′ (since region III no longer exists). Determining the equilibrium consumption bounds and corresponding intertemporal price ratios for region III′ requires the solution of nonlinear equations involving expression (12); see Bergin and Glick (2002, App. A) for details.

In one sense, region III′ is not really new. Recall that Dornbusch (1983) focused on this very case, in which a good was nontraded in both periods. He found that, as consumption rises, the price of the nontraded good alters the price index over time and raises the real interest rate. He also found that the interest rate rises in percentage terms in constant proportion to the rise in consumption in one period relative to

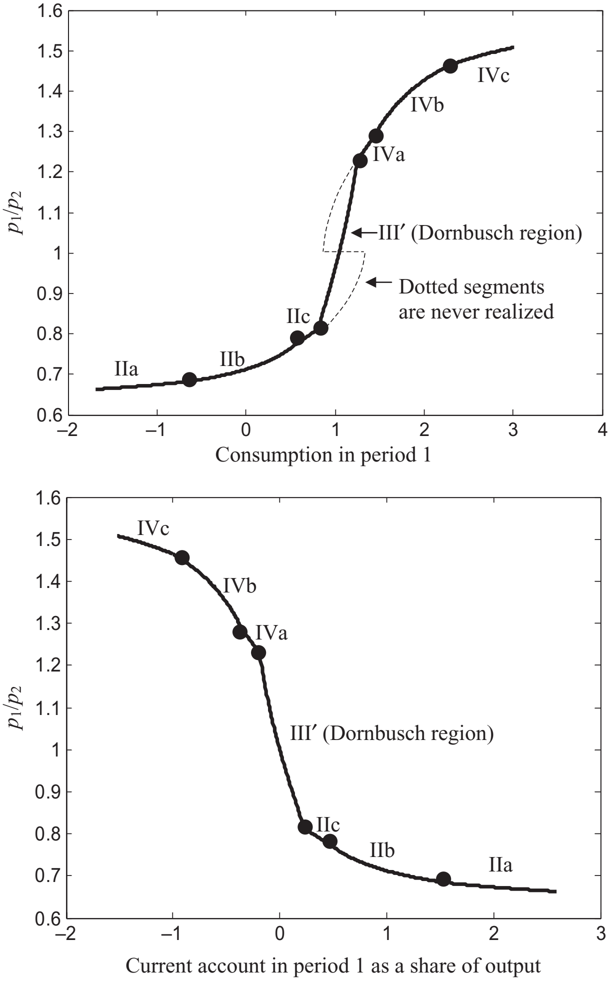

Figure 2. Nested Dornbusch Case

Note: Parameter values: $\tau_A = 1.0$, $\tau_B = \tau_F = 1/9$, $\alpha = 0.5$, $y_A = y_B = 0.5$, $\theta = 6$.

the other. This property characterizes our region III′ as well; we refer to it as the "Dornbusch region."

So what we have found is that, if the transportation cost of one of the goods rises sufficiently high, then we can create a case of our model which very neatly nests the analysis of Dornbusch within that of Obstfeld and Rogoff. This nesting of the traditional case within the cases suggested in recent theory, allows us to compare the two cases. This comparison leads to the conclusion that the slope of the line implied by the Dornbusch region in general will be steeper than the segments of the feasible Obstfeld–Rogoff regions. This is intuitively seen in Figure 2, since a nearly straight-line segment connecting two points must be steeper than the set of three zigzagging line segments that it replaces, and these latter segments are in turn the steepest of the Obstfeld–Rogoff regions.

It is easy to understand why the Dornbusch case implies a larger effect of consumption changes on the real interest rate. Recall that it is the prices of nontraded

Table 2. Sequence of Adjustment of Home Good Trade and Prices, Dornbusch Case

	Period 1		*Period 2*		*Period 1*		*Period 2*	
Region	*Good A*	*Good B*	*Good A*	*Good B*	$p_{A1}\uparrow$	$p_{B1}\uparrow$	$p_{A2}\downarrow$	$p_{B2}\downarrow$
I	X	X	M	M	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$1+\tau_A$	$1+\tau_B$
IIa	X	X	NT	M	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\{1+\tau_A, \gamma_2(1+\tau_B)\}$	$1+\tau_B$
IIb	X	X	NT	NT	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\left\{\gamma_2(1+\tau_B), \frac{\gamma_2}{1+\tau_B}\right\}$	$\left\{1+\tau_B, \frac{1}{1+\tau_B}\right\}$
IIc	X	X	NT	X	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$	$\left\{\frac{\gamma_2}{1+\tau_B}, p_{A2}^{\overline{III'}}\right\}$	$\frac{1}{1+\tau_B}$
III′	NT	X	NT	X	$\left\{\frac{1}{1+\tau_A}, p_{A1}^{\overline{IVa'}}\right\}$	$\frac{1}{1+\tau_B}$	$\left\{p_{A2}^{\overline{III'}}, \frac{1}{1+\tau_A}\right\}$	$\frac{1}{1+\tau_B}$
IVa	NT	X	X	X	$\left\{p_{A1}^{\overline{IVa'}}, \frac{\gamma_1}{1+\tau_B}\right\}$	$\frac{1}{1+\tau_B}$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
IVb	NT	NT	X	X	$\left\{\frac{\gamma_1}{1+\tau_B}, \gamma_1(1+\tau_B)\right\}$	$\left\{\frac{1}{1+\tau_B}, 1+\tau_B\right\}$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
IVc	NT	M	X	X	$\{\gamma_1(1+\tau_B), 1+\tau_A\}$	$1+\tau_B$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$
V	M	M	X	X	$1+\tau_A$	$1+\tau_B$	$\frac{1}{1+\tau_A}$	$\frac{1}{1+\tau_B}$

Notes: X = export, M = import, NT = nontraded; $\gamma_t \equiv (\alpha/(1-\alpha))(y_{Bt}/y_{At})$. See Bergin and Glick (2002, App. A) for derivations and determination of $p_{A1}^{\overline{IVa'}}$, $p_{A2}^{\overline{IIIa'}}$.

goods that are able to rise or fall (within the bounds of their transport costs) in response to consumption changes, and it is their effect on the overall price index that causes the real exchange rate and interest rate to move. This suggests that the impact on the real interest rate is greatest when the good with the highest transport costs is nontraded in both periods.[7]

Because in the Dornbusch region good A is nontraded in both periods, it may move in opposing directions between periods 1 and 2. Hence, because good A also has the highest transport costs and hence the widest bounds on its price each period, a simultaneous fall in the aggregate price one period and rise in the other allows large swings in the relative price between periods. In contrast, in the Obstfeld–Rogoff regions, either good A is nontraded in only one period, or goods A and B are both nontraded in only one period. Given that the transport cost on good B is smaller than that on good A, this implies smaller movements in aggregate prices between the two periods than in the Dornbusch region.

This suggests that the dampening effects of nontradability on intertemporal trade are greater in the Dornbusch case than are those that exist within the framework of Obstfeld and Rogoff. Further, these strong effects on the interest rate described by Dornbusch hit the country immediately as soon as it begins to move away from current account balance (since there is no flat region III). We would argue that the case supporting Dornbusch probably should be regarded as the more relevant, because it is consistent with the observation that the world appears to be characterized by the presence of many nontraded goods even in the presence of near current account balance.

Our model is also interesting because it suggests conditions under which Dornbusch's analysis may cease to apply. Because Dornbusch assumed that some goods were inherently nontradable, he could assume that his conclusions applied for any level of consumption, no matter how extreme. But if we acknowledge that goods are nontraded because of large but finite transport costs, then there is a limit to where his analysis applies. In particular, we find here that if agents wish to raise consumption enough, to the point that they begin to import the nontraded good, then Dornbusch's analysis no longer applies.

4. An Empirical Exploration

Our model has several testable implications. First, it predicts a negative association of current account balances and the real interest rate.[8] Secondly, it implies a nonlinear relationship, such that changes in the real interest rate are largest for current account levels nearer to a zero balance. (We share the first implication with Obstfeld and Rogoff, 2000, but the second implication stands in contrast to their model.) We test these hypotheses by extending the methodology in Obstfeld and Rogoff (2000) and Gordon and Bovenberg (1996), who conduct regressions of the real interest rate on the current account/GDP ratio.

The sample consists of annual data for 21 industrial countries (the 15 members of the European Union, except Luxembourg, plus Norway, Switzerland, Australia, Canada, Japan, New Zealand, and the United States) over the period 1975–98.[9] The real interest rate is constructed from a three-month nominal interest rate less the lagged annual inflation rate. All data are drawn from the IMF's *International Financial Statistics*. For the nominal interest rate we use the short-term Treasury bill rate (line 60c) or a money market rate (line 60b) if the former is not available. The inflation rate is calculated from the consumer price index (CPI) (line 64). The current account/GDP ratio was constructed by converting the current account balance in US

Table 3. Empirical Estimations: Real Interest Rate and the Current Account

Specification 1: Dummies included at breakpoints for various CA/GDP levels

Threshold for dummy (x)	$\frac{CA}{GDP}$	*High surplus dummy*[a]	*High deficit dummy*[b]	ρ	R^2
No dummy	–0.291 (0.055)	—	—	0.579	0.357
$x = 0.5\%$	–1.617 (0.829)	1.471 (0.836)	1.266 (0.829)	0.598	0.342
$x = 1\%$	–0.522 (0.313)	0.388 (0.332)	0.168 (0.313)	0.599	0.344
$x = 5\%$	–0.286 (0.075)	0.062 (0.119)	–0.022 (0.072)	0.585	0.352
$x = 10\%$	–0.342 (0.065)	0.190 (0.193)	0.120 (0.082)	0.572	0.328

Notes: Dummies enter regression as multiplying the CA/GDP term.
[a] High surplus dummy defined for $CA/GDP > x$, for the specified threshold x.
[b] High deficit dummy defined for $CA/GDP < -x$, for the specified threshold x.

Specification 2: Quadratic terms, rather than dummies, included

	$\frac{CA}{GDP}$	$\left(\frac{CA}{GDP}\right)^{2\,a}$	$-\left(\frac{CA}{GDP}\right)^{2\,b}$	ρ	R^2
	–0.445 (0.097)	0.043 (0.021)	0.053 (0.025)	0.589	0.325

Notes:
[a] Applies for cases where $CA > 0$; value set to 0 otherwise.
[b] Applies for cases where $CA < 0$; value set to 0 otherwise.

Dependent variable is the real interest rate. Numbers in parentheses are standard errors. The sample consists of annual data for 21 industrial countries over the period 1975–98, giving 471 observations. A fixed-effects panel estimator with an autoregressive error correction (ρ) is used (“xtregar” command in Stata); unreported constant term and annual time dummies are also included.

dollars (line 78ald) into local currency by the average dollar–local currency exchange rate (line rf) and dividing by nominal GDP (line 99b). We employ a fixed-effect panel estimator adjusted for autoregressive errors (“xtregar” in Stata) with annual time dummies to capture common determinants of the real interest rate. Table 3 reports our results.

As with Obstfeld and Rogoff, we find a highly significant negative correlation between the current account and the real domestic interest rate: a 1% of GDP rise in the current account surplus is associated with a roughly 30 basis point decline in the real interest rate.

We test for the presence of nonlinearities in the sample in two ways. First, we introduce interaction terms to assess the extent to which the association varies with the magnitude of the current account imbalance. We consider dummy variables in turn for break points where the current account surplus or deficit is 0.5%, 1%, 5%, and 10% of GDP. Obstfeld and Rogoff’s analysis suggests that there should be no discernible relation between the interest rate and current account for small imbalances. In fact,

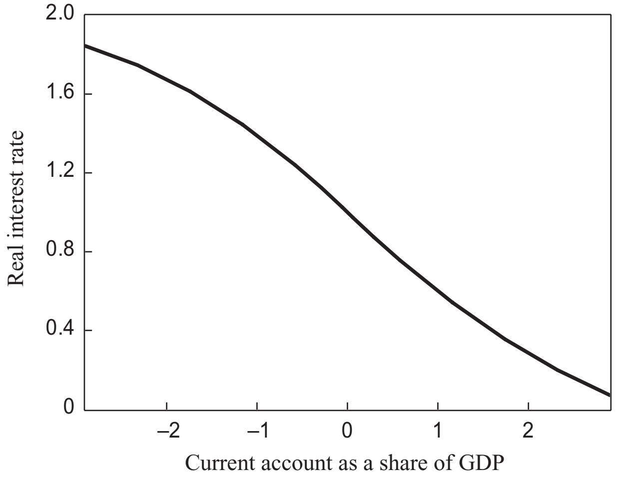

Figure 3. Estimated Relationship between Real Interest Rate and Current Account

Notes: Assumes a quadratic relationship, with estimated coefficient values shown in Table 3, Specification 2. To facilitate comparison with previous graphs, the real interest rate shown is with a mean value renormalized to unity rather than zero.

we find that the sensitivity of the interest rate to current account imbalances is quite sensitive even for small deficits or surpluses. Moreover, we find that the sensitivity is highest for imbalances in the range of –0.5% to 0.5% of GDP.

The second way in which we investigate nonlinearity is by including quadratic terms for current account surpluses and deficits. The coefficients on both quadratic terms are each significant, and their signs support the conclusion in the test above: the sensitivity of the interest rate is greatest near current account balance, and this sensitivity levels out for larger current account imbalances. This conclusion is seen clearly in Figure 3, which graphs the relationship estimated in the regression equation. Notably, this figure bears a resemblance to Figure 2, which was the theoretical relationship implied by the theoretical model for the augmented Dornbusch case. While the results of this brief empirical exploration are quite favorable to our theory, we caution that they are not a rigorous test, and should be interpreted merely as suggestive.

5. Conclusions

This paper has analyzed how trade costs and nontraded goods limit intertemporal trade. It showed how the effects found in past studies change if one does not assume *a priori* that some goods are nontradable, but instead one allows nontradedness to arise endogenously because of large but finite transportation costs. In particular, a small open economy model with two home goods and one foreign good is used, where one of the two home goods is more costly to transport than the other.

The main implication is that even modest current account imbalances will induce movements in the real exchange rate and real interest rate, which will impose a cost on intertemporal trade. Such a finding may be helpful in explaining the observation that current account fluctuations tend to be small empirically relative to real exchange rate fluctuations. This stands in contrast to some recent research analyzing a special case where these costs take effect only for very large current account deficits. Our result implies that all countries, including those with small current account imbalances, may be affected by rising intertemporal prices.

Possible extensions to the analysis include increasing the number of goods to a full continuum. But increasing goods from one to two was sufficient to make our points above. A benefit of a finite number of goods is that it permitted us to identify a case where the model nests the conclusion of Dornbusch (1983), i.e. where there was exactly one good that is consistently nontraded while the other good is consistently traded.

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Notes

1. See Dumas (1992) and Sercu et al. (1995) for early papers using transportation costs. Obstfeld and Rogoff (2000) also consider implications for the gross volume of trade.
2. These papers abstract from investment dynamics, which appear in data to be strongly associated with current account variations (e.g. see Sachs, 1981).
3. The normalizing constant of $(\alpha^{\alpha}(1-\alpha)^{1-\alpha})^{-1}$ is assigned to the consumption aggregate.
4. The resulting locus of r and c_1 can be interpreted as a (partial) equilibrium "supply" schedule of foreign borrowing/lending. The Euler condition implies a corresponding "demand" schedule that could be used to determine the general-equilibrium solution.
5. For increasing levels of c_1, the upper consumption bound of each region is equivalent to the lower consumption bound of the next region in the sequence.
6. For example, for regions IVa, IVb, and IVc where A is nontraded in period 1 (i.e. $c_{A1}/y_{A1} = 1$), substituting the corresponding period 1 prices of goods A and B into expression (10) for $t = 1$ determines $c_1^{\overline{IVa}}$, $c_1^{\overline{IVb}}$, $c_1^{\overline{IVc}}$, respectively. The corresponding c_2 levels are derived by substituting the period 1 consumption level and the relevant prices into the budget constraint (7). For regions IIa, IIb, IIc, where A is nontraded in period 2 (i.e. $c_{A2}/y_{A2} = 1$), $c_2^{\overline{IIa}}$, $c_2^{\overline{IIb}}$, $c_2^{\overline{IIc}}$, are obtained by substituting the relevant period 2 prices into expression (10) for $t = 2$, with the corresponding c_1 levels obtained from (7).
7. This could be reversed if the less tradable good is a very small share of consumption.
8. This relationship would also be consistent with the theory that a country with lower interest rates has more incentive to invest abroad, resulting in net capital outflows.
9. We end the sample in 1998 just prior to formal adoption of the euro in 1999.