



Endogenous trade policy and the gains from international financial markets

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Abstract

This paper examines the interaction between international financial markets and trade policy. When trade policy is endogenous, there is a secondary gain from opening up financial markets, in addition to the direct risk-sharing benefits. By breaking the direct link between the terms of trade and welfare, international portfolio diversification can allow for a lower level of trade protection in a tariff game between governments. We apply the model to an estimation of the welfare gains from international financial markets. Our results show that these indirect ‘trade’ gains from financial markets are likely to be much larger than the direct ‘risk-sharing’ gains. In the tariff game with financial markets however, there are multiple equilibria. While one equilibrium allows for complete diversification and complete free trade, there are other equilibria in which there is limited diversification and a high level of average protection. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

How important are financial markets in the international economy? In recent years a large literature has developed that investigates the effects of increasing

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financial market interaction between countries.¹ By allowing for cross-country consumption risk-sharing, financial market trade can increase welfare of all countries. As shown by Svensson (1988) for instance, the exploitation of the gains from financial markets can be thought of as an extension of the classic ‘gains from trade results’ to the case of trade in securities.

This paper revisits the question of the nature and quantitative importance of the integration of international financial markets. Our intention is to focus on an interaction between financial markets and international trade in commodities. In particular, we show that when trade policy is set endogenously in strategic interaction between governments, the presence of financial markets has an important effect on the outcome of the trade policy decision.

Our results show that in an environment of endogenous trade policy, the gains from the integration of financial markets may be considerably higher than those suggested in some previous literature. Despite this, our model provides a partial conjecture for why in fact financial markets may not be more fully integrated.

The basic intuition behind our results is quite simple. In the model of endogenous trade policy, benevolent national governments choose a level of protection (here thought of as tariffs) to maximize domestic welfare. The equilibrium level of protection is determined in a Nash equilibrium of tariff game between governments. Financial markets are important because the degree of international portfolio diversification will directly effect the outcome of the tariff game. With greater and greater portfolio diversification, the standard terms-of-trade improvement motivation for a tariff diminishes, since when countries are more diversified, there is a weaker link between terms-of-trade movements and welfare (as first shown by Stockman and Dellas (1986)). In the limit, as portfolios are fully diversified, there is no welfare gain at all to a tariff. Accordingly, in this situation, in a Nash equilibrium of a tariff game between national governments, tariffs will be zero. Free trade is an optimal individually rational policy in an environment of full international portfolio diversification.

The fact that financial markets have repercussions for endogenous trade policy has a direct implication for the assessment of the welfare gains from international financial markets. Many previous estimates suggest that these gains are rather modest. For instance, Cole and Obstfeld (1991) suggest that the gains are far less than half of one percent of permanent consumption. In their model, the endogenous response of the terms of trade to country-specific productivity shocks allows for a lot of endogenous risk-sharing, even in the absence of international financial markets. Broadly, similar conclusions regarding small benefits from risk-sharing have been drawn by Tesar (1995) and

¹ See Stockman (1987), Cole (1988), Feeney (1994), Obstfeld (1994), Tesar (1995), Lewis (1995), and references therein.

Mendoza (1995), although other papers, including Obstfeld (1994), Lewis (1995) and Van Wincoop (1996) report much larger gains from international risk-sharing.

In our framework, through the endogenous response of trade policy, international financial market integration can have a 'trade dividend'. For a given distribution of tariffs, financial markets allow for an optimal degree of consumption risk-sharing. But through the secondary impacts of endogenous trade policy, they also allow for an exploitation of the classic welfare gains from international commodity trade. Therefore, the gains from trade in financial markets are higher than estimated in previous literature, which held trade policy constant.

We provide a quantitative assessment of the extent of these secondary welfare gains. In principle, these gains may be considerably larger than the direct gains from risk-sharing. Under a reasonable calibration, given observed measures of trade protection, we suggest that these secondary welfare gains are about fifteen times the direct gains to risk-sharing. Therefore, the total gain to risk-sharing in the presence of endogenous trade policy goes up by an order of magnitude.

The mechanism through which financial markets affect trade policy in our model suggests that there is an important interaction between trade in securities and trade in goods. Stockman (1987) explores the interactions between goods and assets markets in open economies. Feeney (1994) makes the point that the risk-sharing effects of securities trade can lead to enhanced commodity trade through the reallocation of domestic factors of production; thus trade in securities and commodity trade are complements rather than substitutes. A similar process is behind the model of Obstfeld (1994). Our model suggests a further mechanism by which financial markets may complement trade in commodities; the effect of international diversification on trade policy choices. In Section 3, we present some brief cross-country evidence suggesting that countries that pursuing a greater degree of financial openness also tend to have a lower degree of trade protection.

Our finding is also related to the literature on international policy coordination. Essentially, we suggest that the presence of financial markets can eliminate the need for international policy coordination in trade. In this sense, we provide an interesting contrast to Chang (1997), who shows in quite a different environment that financial market integration increases the need for international policy coordination, by exacerbating the negative spillovers of independent fiscal policy in a world economy.

Finally, our model also has implications for the literature on the 'order of liberalization' of external markets for developing economies. McKinnon (1991) makes a case that for reforming economies, trade liberalization should precede the opening of capital markets. McDonald and Hallward (1994) survey this literature. Our results suggest that the full benefit of trade

liberalization may be exploited only in the presence of liberalized financial markets.

But while the presence of financial markets can lead to an endogenous fall in protection, in the environment where international financial markets operate with endogenous trade policy, there are multiple equilibria. One equilibrium is as described above; full international portfolio diversification with zero tariffs. There are other equilibria however, where even in the presence of open financial markets, portfolios are not fully diversified, and tariffs are positive.

The reason for multiple equilibria is simple. In an economy with an endogenous terms of trade, trade in ex-post spot markets may substitute for trade in ex-ante financial markets. Equivalently, commodity trade is a substitute for asset trade, as noted by Cole and Obstfeld (1991). The degree to which risk-sharing is supported by each type of trade is indeterminate. But equilibrium tariffs will depend critically upon the breakdown of trade between the two types. As a result, while there is an equilibrium with full diversification and zero tariffs, there are also equilibria with limited insurance and positive tariffs. These equilibria can be Pareto-ranked. It is in fact possible to have equilibria with financial markets and endogenous trade policy that are *inferior* to financial market autarky, in welfare terms.

The paper is structured as follows. Section 2 spells out the model. Section 3 looks at the effects of financial markets on equilibrium trade policy. Section 4 provides a quantitative assessment of the impact of financial markets in the model. Section 5 illustrates the presence of multiple equilibria and Section 6 concludes.

2. The model

In this section we sketch out a simple two-period model in which the main results are derived. In Section 4 below the results are extended to more general infinite horizon framework.

In order to derive analytical results we rely on strong symmetry and functional form assumptions.² Let there be two countries, Home and Foreign, with a measure 1 of consumers in each country. Foreign variables are designated with an asterisk. Each country produces two goods, good 1 and good 2. Good 1 (2) is the exportable good for the home (foreign) country, and good 2 (1) is the importable good for the home (foreign) country. Preferences are identical across countries. Home country residents have expected utility function

$$EU = E(\ln C_1 + \ln C_2). \quad (1)$$

² Some of these assumptions are relaxed in the numerical computations below.

There is no production in the model. We denote output levels of goods 1 and 2 in state s in the home and foreign countries as

$$\text{Home country: } y_1(s) \quad y_2(s),$$

$$\text{Foreign country: } y_1^*(s) \quad y_2^*(s).$$

The opportunity sets of countries are entirely symmetric. It is assumed that the joint distribution of world endowment processes is such that consumers in each country will face ex ante identical budget constraints.

The probability distribution of shocks is also restricted so that in the equilibrium without financial markets, the home (foreign) country always exports good 1 (good 2) and imports good 2 (good 1). For this we need $y_1(s)/y_1^*(s) > 1$ and $y_2^*(s)/y_2(s) > 1$ for each s .

2.1. No financial markets

Without financial markets home consumers face the following budget constraint, for each state s :

$$p(s)C_1(s) + \tau(s)C_2(s) = p(s)y_1(s) + \tau(s)y_2(s) + R(s). \quad (2)$$

In Eq. (2), $p(s)$ represents the world price of the home country's exportable good (good 1), $\tau(s)$ represents (one plus) the tariff rate levied on the importable good 2. We model trade protection by a tariff, but we think of this as representing the total degree of protection imposed by the home country, encompassing non-tariff barriers. $R(s)$ is a lump-sum transfer given by the home government to the home consumer. This is just the rebated tariff revenue, $(\tau(s) - 1)(C_2(s) - y_2(s))$, and is taken as exogenous by the home consumer.

Foreign consumers face an analogous budget constraint, where the foreign tariff is levied on imports of good 1 from the home country. Optimal consumption of home and foreign consumers in state s may easily be shown as:

$$C_1(s) = \frac{\tau(s)}{1 + \tau(s)} \left(y_1(s) + \frac{y_2(s)}{p(s)} \right), \quad (3)$$

$$\tau(s)C_2(s) = p(s)C_1(s), \quad (4)$$

$$C_1^*(s) = \frac{1}{1 + \tau^*(s)} \left(y_1^*(s) + \frac{y_2^*(s)}{p(s)} \right), \quad (5)$$

$$C_2^*(s) = p(s)\tau^*(s)C_1^*(s). \quad (6)$$

In a competitive equilibrium of the world economy for state s , the relative price of good 1, $p(s)$ is determined as

$$p(s) = \frac{\tau(s)(1 + \tau^*(s))y_2(s) + (1 + \tau(s))y_2^*(s)}{(1 + \tau^*(s))y_1(s) + \tau^*(s)(1 + \tau(s))y_1^*(s)}. \quad (7)$$

Using Eq. (1), Eqs. (3)–(7) give levels of utility as a function of tariffs; $U(\tau(s), \tau^*(s))$ and $U^*(\tau(s), \tau^*(s))$. A Nash equilibrium of the tariff game between governments is defined as the values $\tau^N(s)$ and $\tau^{N*}(s)$ which solve

$$\max_{\tau(s)} U(\tau(s), \tau^{N*}(s)) \quad \max_{\tau^*(s)} U^*(\tau^N(s), \tau^*(s)). \tag{8}$$

Appendix A shows that the Nash equilibrium values of $\tau(s)$ and $\tau^*(s)$ are

$$\tau^N(s) = \sqrt{\frac{y_2^*(s)}{y_2^*(s) + y_2(s)} \frac{y_1(s) + y_1^*(s)}{y_1^*(s)}}, \tag{9}$$

$$\tau^{N*}(s) = \sqrt{\frac{y_1(s)}{y_1(s) + y_1^*(s)} \frac{y_2(s) + y_2^*(s)}{y_2(s)}}. \tag{10}$$

Tariffs will depend upon the degree of specialization in international income. As Eq. (9) shows, the greater the share of the home country in the total output of good 1 at state s , the higher is the home country tariff. The same holds true for the foreign country’s tariff with respect to good 2.

2.2. International financial markets

Now we introduce international financial markets. Consumers in each country can trade in state-contingent commodities prior to the realization of uncertainty. A financial contract stipulates that the owner will be delivered a specific quantity of one or other of the goods in a particular state. State-contingent contract prices are determined in competitive markets.

The home consumer now faces the follows budget constraints.

$$\sum_s q_1(s)\omega_1(s) + \sum_s q_2(s)\omega_2(s) = 0, \tag{11}$$

$$p(s)C_1(s) + \tau(s)C_2(s) = p(s)y_1(s) + \tau(s)y_2(s) + p(s)\omega_1(s) + \omega_2(s) + R(s), \tag{12}$$

$$R(s) = (\tau(s) - 1)(C_2(s) - y_2(s)). \tag{13}$$

In the above equations, $\omega_1(s)$ represents the quantity of good 1 that the home consumer is delivered in state s , and $\omega_2(s)$ is the delivery of good 2. These contracts are purchased at world state prices $q_1(s)$ and $q_2(s)$.³

³ Note that good 2 deliveries are assumed not to be subject to the home import tariff. Were this to be the case arbitrage opportunities arise since the ex ante cost of good 1 is the same for all consumers, equal to $q_1(s)/q_2(s)$, but the benefit, in terms of ex post delivery of goods, is $p(s)/\tau(s)$ for the home country and $p(s)\tau^*(s)$ for the foreign country. Thus the relative cost cannot equal the relative benefit for both countries. One or both of the countries then has an arbitrage opportunity available to it. To avoid this, we either have to allow for delivery of the goods exempt from tariffs, or have tariffs levied also on the purchase of state contingent commodities. We take the former approach. One way to interpret it is that a tariff is equivalent to a production subsidy and a consumption tax on the import good. In this environment, the production subsidy is not offered to the delivery of importable goods. Note that consumers must always pay the tariff on their consumption of the import good.

In the appendix it is shown that as a consequence of ruling out arbitrage, Eqs. (11)–(13) can be collapsed down to the following constraint.

$$\sum_s q_2(s)[p(s)C_1(s) + \tau(s)C_2(s) - y_1(s) - \tau(s)y_2(s) - R(s)] = 0. \quad (14)$$

Using the same procedure for the foreign country gives its constraint as

$$\sum_s q_2(s)[p(s)\tau^*(s)C_1^*(s) + C_2^*(s) - \tau^*(s)y_1^*(s) - y_2^*(s) - R^*(s)] = 0 \quad (15)$$

Home consumers maximize expected utility subject to Eq. (14) while foreign consumers maximize expected utility subject to Eq. (15). First-order conditions are

$$\pi(s) = \lambda q_2(s)p(s)C_1(s), \quad (16)$$

$$\pi(s) = \lambda \tau(s)q_2(s)C_2(s), \quad (17)$$

$$\pi(s) = \lambda^* p(s)\tau^*(s)q_2(s)C_1^*(s), \quad (18)$$

$$\pi(s) = \lambda^* q_2(s)C_2^*(s), \quad (19)$$

where $\pi(s)$ is the probability of state s occurring, and $C_i(s)$ and $C_i^*(s)$, for $i = 1, 2$, represent the optimal home and foreign consumption allocations, respectively, with financial markets.

Given the symmetric distributional assumptions on endowments, and assuming (as will be the case) that this leads to symmetry in endogenous tariff setting, home and foreign consumers face identical ex-ante budget constraints (14) and (15). It therefore follows that $\lambda = \lambda^*$. Thus the first order conditions above imply that:

$$C_1(s) = \tau^*(s)C_1^*(s), \quad (20)$$

$$C_2(s)\tau(s) = C_2^*(s). \quad (21)$$

The presence of stochastic tariffs imposes a wedge between foreign and domestic consumption. To determine the actual state consumption allocations we only need to combine Eqs. (20) and (21) with the ex-post world resource constraints:

$$C_1(s) + C_1^*(s) = y_1(s) + y_1^*(s), \quad (22)$$

$$C_2(s) + C_2^*(s) = y_2(s) + y_2^*(s), \quad (23)$$

which gives the solutions:

$$C_1(s) = \frac{\tau^*(s)}{1 + \tau^*(s)} (y_1(s) + y_1^*(s)), \quad (24)$$

$$C_2(s) = \frac{1}{1 + \tau(s)} (y_2(s) + y_2^*(s)), \quad (25)$$

$$C_1^*(s) = \frac{1}{1 + \tau^*(s)} (y_1(s) + y_1^*(s)), \quad (26)$$

$$C_2^*(s) = \frac{\tau(s)}{1 + \tau(s)} (y_2(s) + y_2^*(s)). \quad (27)$$

Note that the Eqs. (25)–(27) indicate that the presence of state varying tariffs limits the degree of international risk-sharing, even in the presence complete financial markets. For a given level of world output, the movement of tariffs alone will induce a negative cross country correlation of consumption of each good across countries.

These consumption allocations are supported by the optimal state contingent deliveries which must satisfy Eq. (12) for the home country and the analogous constraint for the foreign country.

3. The tariff game with financial markets

It is assumed that governments choose tariffs after the state of the world has been realized. This corresponds to an environment where governments lack power to precommit in advance to particular levels of protection.⁴

A competitive equilibrium with financial markets and endogenous tariff setting is described as follows. (a) Households choose optimal portfolios of assets and optimal consumption of each good to maximize expected utility, given their budget constraints. (b) For each state s , governments choose tariffs to maximize national welfare, conditional on the ex-post portfolios of households. (c) The market for state contingent securities clears; $\omega(s) + \omega^*(s) = 0$, for each s , and the goods market clears, i.e. Eqs. (22) and (23) hold. The timing sequence is such that (i) financial markets first open and trade in securities occurs, (ii) state s is realized, (iii) government choose optimal tariffs, and finally, (iv) goods trade occurs.

An equilibrium must have the property that the state contingent deliveries of goods $\omega_1(s)$, $\omega_2(s)$ are such that, in the ex-post competitive equilibrium where consumers maximize utility state by state, governments will choose tariffs so that the consumption allocations $C_1(s)$, $C_2(s)$, $C_1^*(s)$, and $C_2^*(s)$ are realized. Thus, governments choose tariffs so that, in equilibrium, the constrained optimal risk-sharing implied by Eqs. (24)–(27) is sustained.

The structure of the ex-post competitive equilibrium with financial markets, for any state s , is identical to that without financial markets, except for the

⁴ The importance of this in other contexts has been noted by Staiger and Tabellini (1987). It could alternatively be assumed that tariffs are determined in a repeated game between governments. In this case, lower tariff rates might be supported.

presence of the deliveries of commodities from the financial contracts. The equilibrium relative price of good 1 is

$$p(s) = \frac{\tau(s)(1 + \tau^*(s))\tilde{y}_2(s) + (1 + \tau(s))\tilde{y}_2^*(s)}{(1 + \tau^*(s))\tilde{y}_1(s) + \tau^*(s)(1 + \tau(s))\tilde{y}_1^*(s)} \tag{28}$$

where $\tilde{y}_1(s) = y_1(s) + \omega_1(s)$, $\tilde{y}_1^*(s) = y_1^*(s) - \omega_1(s)$, and so on.

The tariff game is the same as that described above. Given total income, which now includes state contingent deliveries of goods, the governments of each country choose tariffs to maximize domestic welfare, taking as given the tariff of the other governments. In a Nash equilibrium of the tariff game, with financial markets, the tariff rates will be

$$\tau^N(s) = \sqrt{\frac{\tilde{y}_2^*(s)}{y_2^*(s) + y_2(s)} \frac{y_1(s) + y_1^*(s)}{\tilde{y}_1^*(s)}}, \tag{29}$$

$$\tau^{N^*}(s) = \sqrt{\frac{\tilde{y}_1(s)}{y_1(s) + y_1^*(s)} \frac{y_2(s) + y_2^*(s)}{\tilde{y}_2(s)}}. \tag{30}$$

We can now establish the following proposition.

Proposition 1. *There is an equilibrium of the tariff-setting game with financial markets in which tariffs are zero and full international consumption risk-sharing is realized.⁵*

Proof. For any state s , we may describe an equilibrium with financial markets and endogenous tariff setting by combining Eqs. (24)–(27) with the optimal ex-post consumption rules for consumers. This gives

$$\begin{aligned} & \frac{\tau^{N^*}(s)}{1 + \tau^{N^*}(s)} p(s)(y_1(s) + y_1^*(s)) \\ &= \frac{\tau^N(s)}{1 + \tau^N(s)} (p(s)(y_1(s) + \omega_1(s)) + y_2(s) + \omega_2(s)), \end{aligned} \tag{31}$$

$$\frac{1}{1 + \tau^N(s)} \frac{(y_2(s) + y_2^*(s))}{p(s)} = \frac{1}{1 + \tau^N(s)} \left(y_1(s) + \omega_1(s) + \frac{y_2(s) + \omega_2(s)}{p(s)} \right), \tag{32}$$

where

$$p(s) = \frac{\tau^N(s)(1 + \tau^{N^*}(s))(y_2(s) + \omega_2(s)) + (1 + \tau^N(s))(y_2^*(s) - \omega_2(s))}{(1 + \tau^N(s))(y_1(s) + \omega_1(s)) + \tau^{N^*}(s)(1 + \tau^N(s))(y_1^*(s) - \omega_1(s))}. \tag{33}$$

Eq. (31) says that for the home country, the constrained optimal consumption of good 1 must be equal to the optimal ex-post consumption, given tariffs, the

⁵ This is also shown in Lee (1996).

terms of trade, and contract deliveries. Eq. (32) has a similar interpretation. If Eqs. (31) and (32) are satisfied for the home economy, then analogous conditions must be satisfied for the foreign economy, given Walras' law.

The system (29)–(33) contains five equations and may be solved for the five variables $\tau(s)$, $\tau^*(s)$, $\omega_1(s)$, $\omega_2(s)$ and $p(s)$. To prove the proposition, just set

$$\omega_1(s) = \frac{1}{2}(y_1^*(s) - y_1(s)), \quad (34)$$

$$\omega_2(s) = \frac{1}{2}(y_2^*(s) - y_2(s)). \quad (35)$$

Substituting Eqs. (34) and (35) into Eqs. (29) and (30), we get $\tau(s) = 1$ and $\tau^*(s) = 1$. This also satisfies Eqs. (31)–(33) with $p(s) = (y_2(s) + y_2^*(s))/(y_1(s) + y_1^*(s))$.

This establishes that there is an equilibrium with financial markets where tariffs are zero and optimal risk-sharing is achieved. The key reason is that in the economy with complete financial markets and full diversification, in the sense of Eqs. (34) and (35), welfare is independent of the terms of trade. Thus, there is no available terms of trade gain to any one government from imposing tariffs. Rather, the only welfare effect of tariffs is negative, since they drive a wedge between the world price and the marginal rate of substitution in consumption between exportable and importable. This latter point has been made before by Stockman and Dellas (1986).

Financial markets have two effects in this model. They first achieve optimal constrained risk-sharing given a stochastic distribution of tariffs. But secondly, they affect the motivation for tariff setting itself, and given the financial contracts (34) and (35), they actually eliminate the ex-post gain from tariffs, leading governments to endogenously choose a free trade policy. It is in this sense that financial markets have a 'trade dividend'. In the Section 4 below we attempt to quantify the magnitude of this secondary effect of financial market integration, for a more general infinite horizon model.

3.1. Discussion

In the equilibrium of the tariff game identified by Proposition 1, the presence of financial markets encourages trade, through endogenous trade liberalization. This suggests that trade in financial markets and trade in commodities are complementary. This contrasts with the well known result in many real trade models, that capital flows and goods market trade are substitutes. Feeney (1994) and Obstfeld (1994) identify market mechanisms by which financial market integration encourages reallocation of domestic factors of production, thereby stimulating international trade. Proposition 1 specifically predicts that countries which liberalize financial markets should also have low degrees of trade protection.

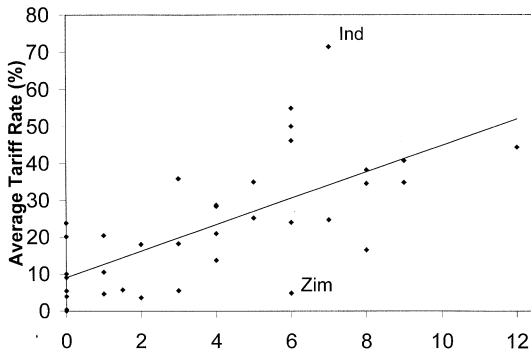


Fig. 1. Index of capital market restrictions and average tariff rates.

Some evidence for the link between financial openness and trade policy is presented in Fig. 1. The figure shows the relationship between the degree of capital market restrictions and the average tariff rates for a sample of developed and developing economies.⁶ We measure capital market restrictions by using the IMF measure of restrictiveness of capital flows from the annual publication *Exchange Agreements and Exchange Restrictions* (1990). This publication reports a series of country indicator variables based on the presence or absence of multiple exchange rate regimes, restrictions on export proceeds, and various other international payments impediments. Lewis (1997) uses these indicators as a measure of country specific limitations on access to capital markets.⁷ We use tariff rates reported in OECD (1996). These are national average, pre-Uruguay round tariff rates. It is apparent from the Figure that on average, countries that employ high degrees of capital market restrictiveness also have high rates of tariff protection. The OLS fitted regression line is illustrated in the Figure. Two outliers are Zimbabwe, which has a high degree of capital market restrictiveness, but very low average tariff rates, and India, which has a very high average tariff rate, relative to its degree of capital market restrictions. Nevertheless, the Figure seems to provide some support for the prediction that financial market liberalization and trade liberalization may be complementary.

⁶ The countries are US, Japan, Canada, Australia, Austria, Finland, Iceland, New Zealand, Norway, South Africa, Sweden, European Community (average), Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Hong Kong, India, Indonesia, Jamaica, South Korea, Malaysia, Mexico, Peru, Philippines, Senegal, Singapore, Sri Lanka, Thailand, Tunisia, Turkey, Uruguay, Venezuela and Zimbabwe.

⁷ These indicators are inevitably imprecise, as argued in Lewis (1997), since they do not measure the degree to which the various restrictions bind in reality. However, they do not exist better cross-country estimates of capital market restrictions.

Proposition 1 has more general implications for a number of areas in international macroeconomics. It suggests that financial markets may have an important effect on the desirability of international policy coordination. In much of this literature, inefficiencies arise due to the effect of national fiscal or commercial policies on the terms of trade (see Chari and Kehoe, 1990), Turnovsky, 1988, Devereux, 1989). With international financial market integration, the terms of trade motive for policy setting tends to be eliminated. So international financial markets may eliminate the need for international policy coordination. This results provides an interesting contrast to Chang (1997), who finds that international capital mobility makes policy coordination more desirable. In Chang's model however, the policy game is defined over the government's choice of debt, which would primarily affect interest rates rather than the terms of trade. Thus, opening up to international capital markets will exacerbate the welfare spillovers of non-coordinated debt policies.

A second issue that proposition 1 applies to is the debate concerning the 'order of liberalization' of the external accounts for reforming economies. McKinnon (1990) argues that trade liberalization should precede capital market liberalization, because liberalized capital markets with distorted domestic prices may lead to, resource misallocation. Our results suggest that financial market integration may in fact enhance the credibility of trade liberalization, in a setting where governments interact strategically.

4. The gains from international financial markets

In this section we reassess the quantitative gains to international financial markets in the environment of endogenous trade policy:

4.1. A simple example

Table 1 provides an example of how the welfare effects of financial markets differ with endogenous tariffs. This table takes a simple two state distribution in which

$$y_1(1) = y_2^*(2) = x_l \quad y_1(2) = y_2^*(1) = x_h,$$

$$y_2(1) = y_1^*(2) = m_l \quad y_2(2) = y_1^*(1) = m_h,$$

where both states are equally likely.

The parameters are chosen so that the standard deviation of consumption is 2 percent. As we move down the rows of the table, countries are getting increasingly specialized in their endowments (x_i/m_i is rising). The second and third columns in Table 1 reports the percentage of average consumption that an agent of either country would sacrifice to achieve full risk-sharing, starting

Table 1

Welfare gains from risk-sharing (in percentage) in the one-period model with logarithmic preferences

Average importable to exportable ratio	Exogenous free trade policy	Endogenous trade policy	Gains from trade	Tariff (%)
1	0.0050	0.0050	0	0
0.9	0.0050	0.0397	0.0347	5
0.8	0.0049	0.1606	0.1557	12
0.7	0.0047	0.4027	0.3980	20
0.6	0.0044	0.8214	0.8170	29
0.5	0.0040	1.5098	1.5054	41
0.4	0.0033	2.6396	2.6363	58
0.3	0.0025	4.5683	4.5658	83
0.2	0.0015	8.2080	8.2065	124
0.1	0.0005	17.0337	17.0332	216

Notes: The standard deviation of consumption is calibrated to be 2%. Under the exogenous trade policy, the tariffs are set to zero. The tariff level reported in the fourth column is obtained from Eqs. (29) and (30) in our model. The welfare gain from trade or 'trade dividend' reported in the third column is obtained by taking the difference in welfare under endogenous trade policy (column 3) and that under exogenous free trade (column 2).

without financial markets. In the case of exogenous trade policy (second column) average tariffs are set at zero under both regimes, while in the case of endogenous trade policy (third column), tariffs are as in the model above.

As countries become more specialized, the gains from financial markets under exogenous trade policy falls. As Cole and Obstfeld (1991) show, with greater product specialization the terms of trade can achieve some risk-sharing. But as specialization increase with endogenous trade policy, the gains from financial markets *increase*, and become increasingly larger and larger as the country becomes more and more specialized. This is because the endogenous tariff rates become very large as each country becomes more specialized. Thus, as an interesting contrast to Cole and Obstfeld (1991), our model predicts that the gains to international financial market integration is *greater*, the *more* specialized are countries in their production structure.

4.2. An infinite horizon model

To provide a quantitative comparison of the gains from financial markets, we now extend the model to an infinite horizon, and allow for more general preferences. Preferences are now given by

$$E \sum_0^{\infty} \beta^t \frac{(C_{1t}^{1-(1/\rho)} + C_{2t}^{1-(1/\rho)})^{(1-\sigma)/1-(1/\rho)}}{(1-\sigma)}, \quad (36)$$

where ρ represents the elasticity of substitution between commodities, and σ represents the relative risk aversion parameter.

In the absence of international financial markets, the world equilibrium price is determined as in Section 2.1 in every period, with tariff being determined by a Nash equilibrium of the tariff game between governments.⁸ For any period, in state s , the consumption decision is determined as

$$C_{1t}(s) = \frac{\tau_t(s)^\rho}{p_t(s)^{\rho-1} + \tau_t(s)^\rho} \left(y_{1t}(s) + \frac{y_{2t}(s)}{p_t(s)} \right), \tag{37}$$

$$\tau_t(s)^\rho C_{2t}(s) = p_t(s)^\rho C_{1t}(s), \tag{38}$$

$$C_{1t}^*(s) = \frac{1}{1 + \tau_t^{*\rho}(s)p_t(s)^{\rho-1}} \left(y_{1t}^*(s) + \frac{y_{2t}^*(s)}{p_t(s)} \right), \tag{39}$$

$$C_{2t}^*(s) = p_t(s)^\rho \tau_t(s)^{* \rho}(s) C_{1t}^*(s). \tag{40}$$

The relative price, $p_t(s)$ is implicitly determined by

$$y_{1t}(s) + y_{1t}^*(s) = \frac{\tau_t(s)^\rho}{p^{\rho-1} + \tau_t(s)^\rho} \left(y_{1t}(s) + \frac{y_{2t}(s)}{p} \right) + \frac{1}{1 + \tau_t(s)^{* \rho} p^{\rho-1}} \left(y_{1t}^*(s) + \frac{y_{2t}^*(s)}{p} \right). \tag{41}$$

Appendix A shows that the Nash equilibrium values of $\tau_t(s)$ and $\tau_t^*(s)$ are implicitly determined by

$$\tau_t^N(s) = 1 + \frac{1}{\gamma^*(p_t(s), \tau_t^N(s), \tau_t^{*N}(s))}, \tag{42}$$

$$\tau_t^{*N}(s) = 1 + \frac{1}{\gamma(p_t(s), \tau_t^N(s), \tau_t^{*N}(s))}, \tag{43}$$

where $\gamma(p_t(s), \tau_t^N(s), \tau_t^{*N}(s)) = \frac{d\Gamma(p_t(s), \tau_t^N(s), \tau_t^{*N}(s))}{dp_t(s)} \frac{p_t(s)}{\Gamma}$, and $\Gamma(p_t(s), \tau_t^N(s), \tau_t^{*N}(s))$ is the home country ‘offer curve’. Thus, Eqs. (42) and (43) represents the optimal tariff formula, indicating that the tariff should equal the inverse of the elasticity of the other country’s offer curve. The appendix gives the exact expression for $\Gamma(p_t(s), \tau_t^N(s), \tau_t^{*N}(s))$.

For each period t and state s , Eqs. (37)–(43) determine the equilibrium consumption rates, terms of trade, and tariff rates that constitute an equilibrium under financial market autarky.

⁸ If limited financial markets were allowed, such as a market for risk-free bonds, the tariff game would become more complicated, as governments would have to consider the current account implications of their tariff actions. Also note that since individuals within a country are identical in all respects, the presence of financial markets within a country has no consequences for our results.

With complete financial market diversification and when agents in each country are ex-ante identical, a perfect pooling equilibrium will be reached in the first period. In the absence of tariffs, this will be maintained forever. But it follows immediately from the arguments of the previous section that optimal tariffs in a perfect pooling equilibrium will be zero, since in this equilibrium, the terms of trade has no direct effect on direct effect on welfare. Thus, even for this extended model, the equilibrium with complete financial markets and perfect pooling entails zero tariffs and each country consuming half of world output of each good in every state.

We now use this extended model to compute the welfare gains to financial market integration, with and without endogenous trade policy. In order to motivate comparison, we calibrate the model in a similar way to that of Cole and Obstfeld (1991). The output processes in the home and foreign countries have growth rates determined by a two-state Markov chain. Thus, let endowment of good i , for $i = 1, 2$, in each sector in the home country be

$$y_{it+1}(s) = y_{it}\mu_t(s).$$

The joint distribution of the home and foreign growth rates μ_t and μ_t^* are assumed to be completely symmetric, and are calibrated to the average growth of US GDP per capita from 1960 to 1992; 1.7%, with a standard deviation of the growth rate equal to 2.6%. In addition, we set the correlation coefficient between μ_t and μ_t^* equal to that between US and Japanese growth over the same interval; 0.29.⁹ The ratio of the average endowment of importables to exportables is set so as to match the average export–GDP ratio for the US economy over the 1960–92 interval, which is 8.2%.

This gives the following parameters of the distribution

$$\text{State 1 } \mu = 1.043, \mu^* = 1.043$$

$$\text{State 2 } \mu = 1.043, \mu^* = 0.991$$

$$\text{State 3 } \mu = 0.991, \mu^* = 1.043$$

$$\text{State 4 } \mu = 0.991, \mu^* = 0.991$$

with the probability vector $\{0.3225, 0.1775, 0.1775, 0.3225\}$.

Table 2 gives the welfare gains to financial market integration with and without endogenous trade policy based on this calibration. In each case, the welfare gains correspond to the percentage of permanent consumption that an agent (in either country) would be willing to forego in order to move to a regime of full risk-sharing from a regime of financial market autarky. Utilities are estimated from 1000 replications of 50 periods. Again, as in Section 4, welfare

⁹ These numbers are from the Penn World Tables.

Table 2

Welfare gains from risk-sharing (in percentages) in a multi-period model with CES utility

	$\rho = 1.5$ (Tariff = 26%)	$\rho = 3$ (Tariff = 12%)	$\rho = 4.5$ (Tariff = 8%)	$\rho = 6$ (Tariff = 6%)
$\sigma = 0.5$				
Exogenous free trade	0.0178	0.0188	0.0191	0.0192
Endogenous tariffs	1.0028	0.5020	0.3394	0.2587
Gain from trade	0.9850	0.4832	0.3203	0.2395
$\sigma = 2$				
Exogenous free trade	0.0325	0.0346	0.0354	0.0357
Endogenous tariffs	1.0194	0.5189	0.3563	0.2757
Gain from trade	0.9869	0.4843	0.3209	0.2400
$\sigma = 4$				
Exogenous free trade	0.0530	0.0557	0.0570	0.0576
Endogenous tariffs	1.0415	0.5413	0.3788	0.2983
Gain from trade	0.9885	0.4856	0.3218	0.2407
$\sigma = 8$				
Exogenous free trade	0.0904	0.0973	0.0996	0.1008
Endogenous tariffs	1.0850	0.5855	0.4232	0.3428
Gain from trade	0.9946	0.4882	0.3236	0.2420
$\sigma = 20$				
Exogenous free trade	0.1952	0.2107	0.2160	0.2187
Endogenous tariffs	1.2038	0.7061	0.5444	0.4643
Gain from trade	1.0086	0.4954	0.3284	0.2456

Notes: σ is the relative risk aversion parameter, ρ is the elasticity of substitution between good 1 and good 2. Numbers in the cells are computed by 1000 replications of 50 periods for each case, given the distribution of output reported in the text. For these computations, the mean GDP growth is set at 1.7%, the standard deviation is 2.6%, and the cross-country correlation of GDP is 0.29. The export–GDP ratio is set at 8.2%. Under the exogenous trade policy, the tariffs are set to zero. The tariff level reported in the second row is obtained from Eqs. (42) and (43) in our model. The welfare gain from trade or ‘trade dividend’ is obtained by taking the difference in welfare under endogenous trade policy and that under exogenous free trade.

gains are reported both with exogenous trade policy and with endogenous trade policy. The estimates are reported for a range of values of σ and ρ .

As expected, the welfare gains are increasing in σ , the degree of relative risk aversion. For the case of exogenous tariffs, welfare gains are increasing in the elasticity of substitution between goods. This result is familiar to Cole and Obstfeld (1991). The greater is ρ , the less the terms of trade can respond to national endowment shocks, and the less potential there is for movement in the terms of trade to achieve effective risk sharing. Note however, that the under endogenous trade policy, welfare gains are declining in the elasticity substitution between goods. This is because, as ρ rises, the equilibrium average tariff rates endogenously fall.

In relative terms, the gains from international financial markets in the presence of endogenous trade policy dramatically exceed those under exogenous trade policy. We can think of the difference between the two as the ‘trade dividend’ effect of financial markets. While the size of the trade dividend is sensitive to the parameters, for values of relative risk aversion less than 4, the gains from financial markets under endogenous trade policy are never less than six times the gains under exogenous trade policy, and may be up to 50 times as great.

The table also reports the average tariff rates for the endogenous trade policy case, under each parameterization. With elasticity of substitution between goods equal to 1.5, average tariffs are 26%. While tariff rates among OECD economies are only about 4% (Laird and Yeats, 1990), it is more relevant to interpret the trade policy in this model as capturing a wider measure of governmental barriers to trade including regulatory controls, and non-tariff barriers. Wei (1996) reports a tariff-equivalent measure of barriers to trade for OECD economies of 10%. For a value of $\rho = 3$, and a coefficient of relative risk aversion of 2, we obtain approximately this level of protection. Thus, the model suggests that the gains from financial markets contains a ‘trade dividend’ somewhere around half a percent of permanent consumption, which, although relatively small, is about 16 times the direct gains from risk-sharing.

5. Multiple equilibrium

We have identified one equilibrium of the tariff game with financial markets. We have not however established the uniqueness of the equilibrium. In fact the financial contracts given in (34) and (35) are not unique, as is shown in the following proposition.

Proposition 2. *There is a continuum of equilibria which satisfy the system (29), (30), (31), (32) and (33). In all equilibria except that of Proposition 1, equilibrium tariff rates are positive.*

Proof. We first show that there is a continuum of values of $\omega_1(s)$ and $\omega_2(s)$ satisfying Eqs. (29)–(33), for any given state s . For simplicity, we drop the state notation for the rest of this section.

From Eq. (33), substituting in for the optimal tariffs from Eqs. (29) and (30), after some rearrangement, we may express the relative price p as

$$p = \left(\frac{(y_2 + \omega_2)(y_2^* - \omega_2)}{(y_1^* - \omega_1)(y_1 + \omega_1)} \right)^{0.5}. \quad (44)$$

From the definition of τ^N and τ^{N*} , we have

$$\frac{\tau^N}{\tau^{N*}} = \left(\frac{(y_2 + \omega_2)(y_2^* - \omega_2)}{(y_1^* - \omega_1)(y_1 - \omega_1)} \right)^{0.5} \frac{(y_1 + y_1^*)}{(y_2 + y_2^*)} = p \frac{(y_1 + y_1^*)}{(y_2 + y_2^*)}. \quad (45)$$

Rearranging Eqs. (31) and (32), and substituting for Eq. (45), we have the equations

$$\left(\frac{1 + \tau^N}{1 + \tau^{N*}} \right) \frac{(y_2 + y_2^*)}{p} = y_1 + \omega_1 + \frac{y_2 + \omega_2}{p}, \quad (46)$$

$$\frac{(y_2 + y_2^*)}{p} = y_1 + \omega_1 + \frac{y_2 + \omega_2}{p}. \quad (47)$$

Now substituting Eqs. (44), (29) and (30) and Eqs. (46) and (47) gives two equations in the two variables ω_1 and ω_2 .

It is apparent from looking at Eqs. (46) and (47) that a solution must imply that $\tau^N = \tau^{N*}$. From Eqs. (29) and (30) this gives the quadratic equation

$$y_1^* y_1 + \omega_1 (y_1^* - y_1) - \omega_1^2 = \phi^2 (y_2^* y_2 + \omega_2 (y_2^* - y_2) - \omega_2^2), \quad (48)$$

where $\phi = (y_1 + y_1^*) / (y_2 + y_2^*)$. Eq. (48) gives a relationship between ω_1 and ω_2 that satisfies the tariff game in the presence of complete markets. Holding ω_2 fixed, we may solve Eq. (48) for ω_1 as a function of endowments, and ω_2 . The general form of the solution is

$$\omega_1 = \tilde{\omega}_1 \pm \phi(\omega_2 - \tilde{\omega}_2), \quad (49)$$

where $\tilde{\omega}_i$ represents the complete diversification solution of proposition 1, i.e. $\tilde{\omega}_1 = 0.5(y_1^* - y_1)$, etc. Note that this still remains a solution for Eq. (49). Now pick the smaller root of (49) (the larger root is not a solution of Eqs. (30)–(32); see the discussion below). Thus, we let

$$\omega_1 = \tilde{\omega}_1 - \phi(\omega_2 - \tilde{\omega}_2). \quad (50)$$

Without loss of generality, let $\omega_2 = \tilde{\omega}_2 - k$, where k is a positive constant such that $k \leq \tilde{\omega}_2$. Intuitively, we wish to set ω_2 below the full risk-sharing point, and show that in conjunction with Eq. (50), this gives an equilibrium of the tariff game with financial markets that leads to positive tariff rates.¹⁰ Together with Eq. (50), this gives the pair

$$\{\tilde{\omega}_1 + \phi k, \tilde{\omega}_2 - k\} \quad (51)$$

¹⁰ It is possible that $k < 0$, but this would involve each country reversing the order of their exportable goods; i.e. the home country would export good 2 and import good 1 in a state where $k < 0$, because it receives more of good 2 than required for complete risk-sharing. Tariffs will again be positive in this case, but since it seems relatively uninteresting, we instead focus on the $k > 0$ case.

as a candidate solution. Substituting both into (29) and (30) gives

$$\tau = \tau^* = \sqrt{\frac{\left(0.5 + \frac{k}{y_2 + y_2^*}\right)}{\left(0.5 - \frac{k}{y_2 + y_2^*}\right)}} > 1. \quad (52)$$

Therefore, for $k > 0$, tariff rates are positive. To finally establish that Eq. (51) is indeed a solution, it is easy to check that both Eqs. (46) and (47) are satisfied. Thus, since choice of k in Eq. (51) was arbitrary, this establishes that there exists a continuum of solutions to Eqs. (30)–(33) that can be indexed by the size of the equilibrium tariff rates.

Finally, to show that the positive root of Eq. (49) is not relevant, it is straightforward to show that using the same procedure, but letting $\omega_1 = \tilde{\omega}_1 + \phi(\omega_2 - \tilde{\omega}_1)$, the resultant candidate solutions for $\{\omega_1, \omega_2\}$ does not satisfy Eqs. (46) and (47). Thus, this does not represent a solution to Eqs. (30)–(33).

The intuitive explanation of multiple equilibria is that trade in financial markets is a substitute for trade in commodities, given that part of the risk-sharing itself may be borne by terms of trade fluctuations.¹¹ If consumers choose to purchase a set of securities so that they need to engage in a lot of ex-post spot trade, for a given distribution of tariffs, then governments will set positive tariffs to exploit the terms of trade in ex-post commodity trade. But we know that there is another equilibrium, which Pareto dominates this, which has full international risk-sharing, and free trade. The key reason for multiple equilibrium then, is twofold. First, tariffs will depend on the breakdown of risk-sharing between trade in goods and trade in financial markets. Secondly, consumers take the distribution of tariffs as given in their portfolio decisions. When consumers rely more on trade in goods ex-post rather than portfolio diversification ex-ante, the terms of trade motivation for tariff setting is more important, and in the game between national governments, tariffs will be positive. The strategic situation is like that in Calvo (1988), where the decisions of private agents in assets markets will critically affect the actions of governments. But, since private agents do not take account of this link, there are multiple equilibria, indexed by the degree of international portfolio diversification and the level of tariffs.

It is possible to show that welfare may be *lower* in an equilibrium with financial markets than without financial markets. Intuitively, financial markets could lead countries to trade in securities such that there is even more ex-post

¹¹ In the absence of tariffs, trade in commodities is a perfect substitute for trade in securities whenever countries are completely specialized, and the elasticity of substitution between goods is unity, as noted by Cole and Obstfeld (1991).

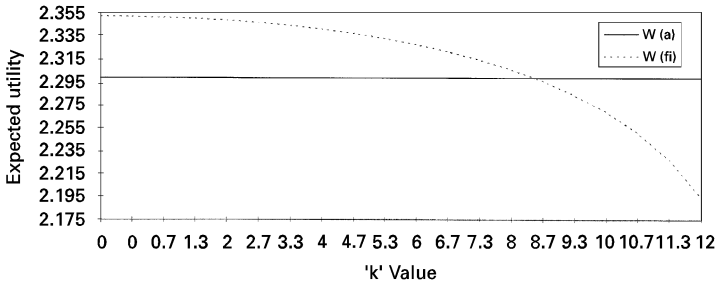


Fig. 2. Welfare under financial autarky and financial markets.

trade in the spot commodity market that in the absence of financial markets. Take the simple two state example given in Section 3 above. Fig. 2 depicts the value of expected utility for either country in the economy without financial markets, and in the economy with financial markets, as a function of k . The numerical values used for this example are given below the figure. As shown in the figure, for k sufficiently large, utility may be lower in the economy with financial markets. The benefit from risk sharing in this case is actually more than offset by the cost in terms of higher average tariffs.

The results are suggestive for the ‘puzzle’ of the observed lack of cross country portfolio diversification, a fact noted by Tesar and Werner (1995) and French and Poterba (1991), among many others. Our results suggest that even with relatively large gains from financial markets, there may be equilibria where full portfolio diversification is not attained.

6. Conclusions

This paper has shown that there can be an important interaction between the degree of openness in financial markets and trade policy. We here discuss some of the important limitations of our analysis and provide suggestions for future work. First, we have taken the presence or absence of financial markets as exogenous. This accords with the experiments carried out in the current literature on the welfare gains from international financial markets. A more general analysis would simultaneously address the motivation for choosing both financial market restrictions and trade policy together. While we have shown above that governments who commit to a policy of open financial markets may endogenously follow a policy of free trade, it is unclear if the former policy is necessarily self enforcing.

A second feature of our model that warrants discussion is the particular model of tariff setting we use. It might be suggested that there are a host of reasons that governments interfere with international trade that are unrelated to the classic optimal tariff argument. The profit-shifting motive of Brander and

Spencer (1984), or the political economy models of Brock et al. (1989) are examples.

In response to this, there are two points to make. Firstly, it is well known that the only theoretically consistent argument for the use of a tariff is as an instrument to affect the terms of trade (as in this paper). In all other cases, there exists a better instrument to achieve the given objectives. Second, and most importantly, the mechanism of the paper is likely to be robust to different models of the tariff setting process, so long as tariffs are chosen in some way to improve the welfare of domestic residents relative to foreign residents. For instance, if tariffs are set primarily to benefit domestic workers at the expense of foreigners, then financial market diversification would entail all these workers to hold foreign claims, and would thus reduce the contribution to tariffs to domestic workers welfare. Thus, the statement that greater portfolio diversification may lessen the severity of trade protectionism would seem to be robust to at least some permutations of our particular model of trade policy.

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Appendix A.

A.1. Derivation of combined budget constraint in Eq. (14)

If the portfolio choices available to residents of either country are not to allow for arbitrage, it must be that $q_1(s)/q_2(s) = p(s)$. If this were not the case, then individuals would have an incentive to sell one good infinitely short in securities markets, and make unbounded profits. Then substituting $q_1(s)$ in terms of $q_2(s)$ into the self-financing constraint at time 0 gives

$$\sum_s q_2(s)p(s)\omega_1(s) + \sum_s q_2(s)\omega_2(s) = 0. \quad (\text{A.1})$$

Multiply the time 1 state s budget constraint by $q_2(s)$, sum the resulting equation over all states yields the following

$$\begin{aligned} & \sum_s q_2(s)p(s)C_1(s) + \sum_s q_2(s)\tau(s)C_2(s) \\ &= \sum_s q_2(s)p(s)y_1(s) + \sum_s q_2(s)\tau(s)y_2(s) + \sum_s q_2(s)R(s) \\ &+ \sum_s q_2(s)p(s)\omega_1(s) + \sum_s q_2(s)\omega_2(s). \end{aligned} \quad (\text{A.2})$$

From, the above constraint (A.1), the last two terms on the right hand side of (A.2) equals zero, and (A.2) simplifies to the combined budget constraint (14) in the text.

A.2. Derivation of optimal tariffs

A.2.1. Logarithmic utility

The maximization problem of the home government gives the following first-order condition:

$$\frac{1}{C_1(s)} \frac{\partial C_1(s)}{\partial \tau(s)} + \frac{1}{C_2(s)} \frac{\partial C_2(s)}{\partial \tau(s)} = 0. \quad (\text{A.3})$$

From the household's maximization problem, we know that the marginal rate of substitution between goods 1 and 2 is

$$\frac{C_2(s)}{C_1(s)} = \frac{p(s)}{\tau(s)}. \quad (\text{A.4})$$

Substituting the marginal condition (A.4) into (A.3) gives and after some manipulation, the following equation is obtained:

$$\frac{1}{1 + \tau(s)} \left(1 - \frac{1}{\tau(s)} \right) (p(s)y_1(s) + y_2(s)) = \left(y_1(s) - \frac{y_2(s)}{p(s)} \right) \frac{\partial p(s)}{\partial \tau(s)}. \quad (\text{A.5})$$

Similarly for the foreign country, the first order condition from the maximization problem can be simplified to

$$\frac{1}{1 + \tau^*(s)} \left(1 - \frac{1}{\tau^*(s)} \right) (p(s)y_1^*(s) + y_2^*(s)) = \left(y_1^*(s) - \frac{y_2^*(s)}{p(s)} \right) \frac{\partial p(s)}{\partial \tau^*(s)}, \quad (\text{A.6})$$

where $p(s)$ is given by Eq. (7) in the text. The partial derivatives of $p(s)$ are given by

$$\frac{\partial p(s)}{\partial \tau(s)} = \frac{(1 + \tau^*(s))^2 y_1(s)y_2(s) + (1 + \tau^*(s))y_1(s)y_2^*(s) + \tau^*(s)(1 + \tau^*(s))y_1^*(s)y_2(s)}{(1 + \tau^*(s))y_1(s) + \tau^*(s)(1 + \tau(s))y_1^*(s)} \quad (\text{A.7})$$

$$\frac{\partial p(s)}{\partial \tau^*(s)} = - \frac{(1 + \tau(s))^2 y_1^*(s) y_2^*(s) + (1 + \tau(s)) y_1(s) y_2^*(s) + \tau(s) (1 + \tau(s)) y_1^*(s) y_2(s)}{(1 + \tau^*(s)) y_1(s) + \tau^*(s) (1 + \tau(s)) y_1^*(s)^2} \tag{A.8}$$

Substitute (A.7), (A.8) and (7) into (A.5) and (A.6), and after some algebraic manipulation, the following two simultaneous equations are obtained:

$$\begin{aligned} &\tau^*(s) y_1^*(s) (\tau(s)^2 (y_2(s) + y_2^*(s)) + \tau(s)^2 \tau^*(s) y_2(s) - y_2^*(s)) \\ &= (1 + \tau^*(s)) y_1(s) y_2^*(s), \end{aligned} \tag{A.9}$$

$$\begin{aligned} &\tau(s) y_2(s) (\tau^*(s)^2 (y_1(s) + y_1^*(s)) + \tau^*(s)^2 \tau(s) y_1^*(s) - y_1(s)) \\ &= (1 + \tau(s)) y_1(s) y_2^*(s). \end{aligned} \tag{A.10}$$

Solving the two above Eqs. (A.9) and (A.10) gives six solutions to the tariff problem. However, only one solution yields 2 positive roots for both home and foreign tariffs. This solution is reported in Eqs. (9) and (10) in the text.

A.2.2. General CES utility

After the state is realized, the ex-post trade balance has to hold in each country. This implies the following relation:

$$p_t(s) X_{1t}(s) = M_{2t}(s), \tag{A.11}$$

$$X_{2t}^*(s) = p_t(s) M_{1t}^*(s), \tag{A.12}$$

where $X_{1t}(s)$ and $M_{2t}(s)$ are the home country's export of good 1 and import of good 2, respectively, and $X_{2t}^*(s)$ and $M_{1t}^*(s)$ are the foreign country's export of good 2 and import of good 1, respectively. The maximization problem of the home government gives the following first order condition

$$\begin{aligned} &\left[C_{1t}(s)^{1-\frac{1}{\rho}} + C_{2t}(s)^{1-\frac{1}{\rho}} \right]^{(1-\rho)(1-(1/\rho))-1} \\ &\times \left[C_{1t}(s)^{-\frac{1}{\rho}} \frac{\partial C_{1t}(s)}{\partial \tau_t(s)} C_{2t}(s)^{-(1/\rho)} \frac{\partial C_{2t}(s)}{\partial \tau_t(s)} \right] = 0. \end{aligned} \tag{A.13}$$

We can re-write the above equation as

$$\left(\frac{C_{1t}(s)}{C_{2t}(s)} \right)^{-(1/\rho)} \frac{\partial X_{1t}(s)}{\partial p_t(s)} \frac{\partial p_t(s)}{\partial \tau_t(s)} = \frac{\partial M_{2t}(s)}{\partial p_t(s)} \frac{\partial p_t(s)}{\partial \tau_t(s)}. \tag{A.14}$$

From the household's maximization problem, we know that the marginal rate of substitution between goods 1 and 2 is

$$\left(\frac{c_{1t}(s)}{C_{2t}(s)} \right)^{(1/\rho)} = \frac{p_t(s)}{\tau_t(s)}. \quad (\text{A.15})$$

Substituting the marginal condition (A.15) into (A.14) gives

$$\frac{p_t(s)}{\tau_t(s)} \frac{\partial X_{1t}(s)}{\partial p_t(s)} = \frac{\partial M_{2t}(s)}{\partial p_t(s)}. \quad (\text{A.16})$$

Differentiating the trade balance condition (A.11) yields the following:

$$P_t(s) \frac{\partial X_{1t}(s)}{\partial p_t(s)} = \frac{\partial M_{2t}(s)}{\partial p_t(s)} - X_{1t}(s). \quad (\text{A.17})$$

Substitute the above relation into (A.16) and apply the ex-post trade balance constraint (A.11) and market clearing condition that $M_{2t}(s) = X_{2t}^*(s)$ to the resulting equation will give the expression for Nash home tariff:

$$(\tau_t(s) - 1) = - \left[\frac{\partial X_{2t}^*(s)}{\partial p_t(s)} \frac{p_t(s)}{X_{2t}^*(s)} \right]^{-1}. \quad (\text{A.18})$$

The offer curve of the foreign country is the export function of good 2 at the Nash equilibrium. Therefore,

$$\begin{aligned} \Gamma^*(p_t(s), \tau_t^N(s), \tau_t^{*N}(s)) &\equiv X_{2t}^*(s) \\ &= \frac{p_t(s)}{p_t(s)^{1-p} + \tau_t^{*N}(s)^p} [p_t(s)^{-p} y_{2t}^*(s) - \tau_t^{*N}(s)^p y_{1t}^*(s)]. \end{aligned} \quad (\text{A.19})$$

Similarly, the Nash foreign tariff can be derived:

$$(\tau_t^*(s) - 1) = \left[\frac{\partial X_{1t}(s)}{\partial p_t(s)} \frac{p_t(s)}{X_{1t}(s)} \right]^{-1}, \quad (\text{A.20})$$

and the offer curve of the home country is the export function of good 1 at the Nash equilibrium. Therefore,

$$\begin{aligned} \Gamma(p_t(s), \tau_t^N(s), \tau_t^{*N}(s)) \\ \equiv X_{1t}(s) = \frac{1}{p_t(s)(\tau_t^N(s)^p + p_t(s)^{p-1})} [p_t(s)^p y_{1t}(s) - \tau_t^{*N}(s)^p y_{2t}(s)]. \end{aligned} \quad (\text{A.21})$$

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