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Why Open Regionalism Is Not Always Good

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Abstract:

When the Asia Pacific Economic Cooperation (APEC) formally adopted the principle of 'open regionalism' (OR) in its trade liberalisation in 1991, many were optimistic that this approach suggested the bloc as a stepping stone toward global free trade. This optimistic view was reinforced by the economic theorising of Yi (1996).

This paper shows formally why OR may fail using a simple model and simulation. We unpick Yi (1996) systematically and explain that OR works in his model because of quasilinear preferences and Ricardian technology assumptions. Once these assumptions are replaced with CES preferences and increasing marginal costs, OR fails to ensure global free trade as an equilibrium when the world consists of a country that is sufficiently larger than the rest of the world.

Key Words: Regional integration, equilibrium coalition structure, welfare.
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1. Introduction

One question that is often asked in relation to the resurgence of regionalism in recent years is 'Are regional trading blocs stepping stones or stumbling blocks toward global free trade?' This question leads to the next question: 'Is it possible to design a rule for trading bloc formation that will sustain global free trade as a stable equilibrium coalition structure?'

Prior to the 1997/98 Asian Financial crisis, open regionalism was seen as the right approach in the 1980s and 90s. The Asia Pacific Economic Cooperation (APEC) adopted it as the key principle of trade liberalisation in 1991. It was much discussed, with supporters as well as critics. Supporters (Bergstern (1997) for example) view this approach as a recipe for building non-discriminating regional trade blocs, hence believe that regional liberalisation can be achieved without undermining efforts at the multilateral level. This optimistic view was reinforced by the economic theorising of Yi (1996a)[1].

Yi (1996) addressed these questions in a model with closed form solutions and produced neat analytical results which conclude that if we adopt 'open regionalism' as a rule for trade bloc formation, global free trade can be a stable equilibrium outcome.

While the view on 'open regionalism' is less discussed among trade economists in more recent years, some economists, including Bhagwati (2006) and Garnaut (2004), still hold the view that APEC should continue to embrace open regionalism in its pursuit of trade liberalisation. Given the current spaghetti-bowl phenomenon that results from having many overlapping FTAs, some experts have suggested a modified version of the open regionalism as a possible way out. For example, Garnaut and Vines (2007) proposed - open trading arrangements (OTA), which contains the key element of the original concept of open regionalism – open membership. The details of the OTA are not clear at this stage, but Garnaut (2004) suggests that OTA are best initiated among 'economies of substantial size' and that once one is established by two or more economies, it may become attractive to new members in the Asia Pacific region and beyond.

The model in this paper suggests that a key challenge to the success of OTA is to generate sufficient interest among 'economies of substantial size' to take the first step initiation. 'Economies of substantial size', as demonstrated in this paper, may well not wish to get seriously involved in a trading arrangement with open membership as a rule.

This paper shows formally why open regionalism may fail, based on theory and simple simulation modelling. We unpick Yi (1996) systematically and explain that open regionalism works in his model only because of quasilinear preferences and

[1] Google Scholar recorded that Yi (1996a) has been cited by 190 articles (as at 16 Dec 2010). Examples of two recent works that cited Yi (1996) are Chen & Joshi (2010) and Seidmann (2009).

Ricardian technology assumptions. Once these assumptions are replaced with CES preferences and a concave production possibility curve, OR fails to ensure global free trade as an equilibrium in a world of different sized countries if one of them is sufficiently larger than the rest of the world combined. Global free trade is not the equilibrium outcome, even if the rest of the world adopts open regionalism rule as a strategy.

The remainder of the paper is organised as follows: A detailed review of Yi's model (1996) and explanations on why open regionalism can ensure global free trade in his model in Section 2. Section 3 demonstrates how Yi's claims about open regionalism rule collapse when his assumptions of quasi-linear preferences and Ricardian technology are replaced with CES utility function and a non-Ricardian technology. Section 4 examines the effects of varying the slope of marginal cost on the modified model and on the relative size of larger country. Section 5 concludes.

2. Open regionalism is good: Yi's model

Yi (1996a) considers rules for enlarging a customs union. He provides a formal analysis of two different membership rules: 'open regionalism' and 'unanimous regionalism', on the equilibrium structure of customs union[2]. 'Open regionalism' is interpreted as a rule where a nonmember country can join a customs union without having to obtain the consent of the existing members of the union. In other words, 'open regionalism' is defined as 'open membership'. As for the 'unanimous regionalism rule, a nonmember country can only join a customs union when all existing members agree.

An open regionalism rule prevents existing member countries from rejecting outsiders for the fear of possible worsening of their own welfare. He finds that this leads customs unions to expand until they include all countries in the world – the 'grand coalition' – and thus he claims that it renders customs unions stepping stones to global trade liberalisation.

Yi's model assumes a world with N countries symmetric in all aspects. Each country is endowed with some amount of a numeraire good that can be transformed into a non-numeraire good at a constant marginal cost. The non-numeraire goods are differentiated between countries, with each country producing precisely one. There is only one firm in each country producing the non-numeraire good. Firms are assumed to be in Cournot competition. Consumers are assumed to have quasi-linear preferences. The numeraire good is traded freely across countries while the trade in the differentiated good is subject to tariff.

[2] In another paper, Yi has used a simple four-country example to illustrate his model in comparing the effects of the two membership rules on the equilibrium customs union structure (Yi, 1996b).

2.1 Quasilinear preferences

(a) Demand is independent of income

Yi assumes that the utility function of a representative consumer in country *i* has the form of

$$u^i(\mathbf{q}_i; M) = v(\mathbf{q}_i) + M_i = aQ_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 + M_i$$

where q_{ij} is country *i*'s consumption of country *j*'s product, $\mathbf{q}_i \equiv (q_{i1}, q_{i2}, \ldots, q_{iN})$ is country *i*'s consumption profile, $Q_i \equiv \sum_{j=1}^{N} q_{ij}$, γ is a substitution index between goods, and M_i is country *i*'s consumption of the numeraire good. The numeraire good will be transferred across countries to settle, if there is any, the balance of trade. The model further assumes that each country's endowment of the numeraire good is sufficient to guarantee a positive consumption of the numeraire good in each country. The maximization problem is reduced to an unconstrained maximization problem (Varian, 1992):

$$M_i = Y^i - \sum_{j=1}^{N} p_{ij} * q_{ij}$$

$$\max \quad u^i = aQ_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 + Y^i - \sum_{j=1}^{N} p_{ij} * q_{ij} \qquad (1)$$

where Y^i is the income of country *i*

The first order condition for good q_{i1}, for example, is:

$$\partial u^i / \partial q_{i1} = a - (1-\gamma)q_{i1} - \gamma Q_i - p_{i1} = 0$$

The inverse demand function for good q_{i1} is therefore:

$$p_{i1} = a - (1-\gamma)q_{i1} - \gamma Q_i \qquad (2)$$

The demand function above shows that demand for q_{i1} depends on p_{i1}, i.e. its own price in country i, and Q_i, i.e. $\sum_{j=1}^{N} q_{ij}$. It is independent of income, Y. Hence there is zero income effect on good q_{i1} (and also all other non-numeraire goods). Any increase in income will be used to consume the numeraire good, M.

A zero income effect on the non-numeraire good also means that changes in tariffs will not have income effects on the consumption of the non-numeraire goods.

This zero income effect is useful for Yi to solve his model analytically as it means that optimal tariffs are independent across countries (this is shown in the following sub-section) and hence that the optimal tariffs of a customs union are dependent only on the size of the customs union relative to the rest of the world and not on the coalition structures in the world.[3]

(b) No strategic interdependence of optimal tariffs across countries/customs unions

Yi assumes no transportation costs and non-negative specific tariffs, τ_{ij}. The effective marginal cost of the good from country *j* in country *i* is therefore

$$c_{ij} = c + \tau_{ij} \qquad (3)$$

where c_{ij} : effective marginal cost
c : marginal cost (assumed common to all producers)
τ_{ij} : tariff

The model further assumes that markets are segmented and that firms compete by choosing quantities in each country. Markets between countries are completely separated, which, given the assumption of constant marginal cost, means that changes in demand for a differentiated good in one country have no effect on marginal costs of production anywhere. In country *i*, country *j*'s firm will solve

$$\underset{\{q_{ij}\}}{Max}\,\pi^{ij} = (p_{ij} - c_{ij})q_{ij}$$

The first order condition for profit maximisation is therefore

$$p_{ij} - c_{ij} - q_{ij} = 0$$

which can be rewritten (using Eq. (2) and Eq. (3)) as

$$\alpha - \tau_{ij} - (2 - \gamma)\, q_{ij} - \gamma Q_i = 0 \qquad (4)$$

where $\alpha \equiv a - c$. Normalising $\alpha = 1$ and summing the first order conditions over j, j=1, 2, .., N, in the Cournot equilibrium[4],

$$Q_i = \frac{N - T_i}{\Gamma(N)},\ \text{and}\ q_{ij} = \frac{\Gamma(0) + \gamma T_i - \Gamma(N)\tau_{ij}}{\Gamma(0)\Gamma(N)} \qquad (5)$$

[3] We show later in the paper that this quasi-linear utility assumption is necessary but not sufficient to produce independent optimal tariffs among customs unions. The assumption of constant marginal cost in Yi's model is also crucial in order to arrive at this result.

[4] The value of α actually has an effect on the value of equilibrium quantities and optimal tariffs but it does not affect the signs of these variables. Normalising $\alpha = 1$ makes equation (5) neat without changing the signs of these variables in subsequent equations (7) and (8) and hence does not change the qualitative results.

where $T_i \equiv \sum_{j=1}^{N} \tau_{ij}$ is the sum of tariffs, and

$$\Gamma(k) \equiv 2 - \gamma + k\gamma,\ k = 1, 2, \ldots, N \qquad (6)$$

Equations (4) and (5) show that the equilibrium q_{ij} depends only on country *i*'s tariffs, i.e. product market equilibrium in country *i* depends only on country *i*'s tariffs. A change in country *i*'s tariffs on imports from country *j* does not affect product market equilibria in any other countries. The effects of the tariff on country *j* occur solely on the numeraire good, as transfers of numeraire good from country *j* to country *i* settle the balance of trade. As a result, the optimal tariff of a country/customs union does not depend on the tariffs of the rest of the world. That is, there is no strategic interdependence of optimal tariffs across countries/customs unions.

To illustrate in a two-country model, equation (4) becomes:

$\alpha - \tau_{12} - (2 - \gamma)\, q_{12} - \gamma Q_1 = 0$ (4a) where $Q_1 = q_{11} + q_{12}$ for country 1, and

$\alpha - \tau_{21} - (2 - \gamma)\, q_{21} - \gamma Q_2 = 0$ (4b) where $Q_2 = q_{22} + q_{21}$ for country 2

Say there is an increase in tariff τ_{12} by country 1 on q_{12}, i.e. imports from country 2. From eq.(4a), we can see that this will reduce the amount of q_{12}. But the increase of τ_{12} does not affect the consumption of q_{21}, i.e. country 2's import of the non-numeraire good from country 1, even though country 2's exports to country 1 is reduced due to the rise in τ_{12}. This is evident from eq.(4b) which shows that the equilibrium amount of q_{21} is independent of the equilibrium amount of q_{12}.

(c) Effects of tariff on consumption of home and imported goods, and on home and foreign firms' profits

From eq(5),

$$\frac{dQ_i}{d\tau_{ij}} = -\frac{1}{\Gamma(N)} < 0 \qquad (7)$$

$$\frac{dq_{ik}}{d\tau_{ij}} = \frac{\gamma}{\Gamma(0)\Gamma(N)} > 0, \text{ for } k \neq j, \text{ and } \quad \frac{dq_{ij}}{d\tau_{ij}} = \frac{\gamma - \Gamma(N)}{\Gamma(0)\Gamma(N)} < 0 \qquad (8)$$

Equations (7) and (8) show that if country *i* raises its tariffs on imports from country *j*, then consumption of good *j* and total consumption in country *i* falls, and consumption of all other goods increases. Country *j*'s Cournot equilibrium export profit to country *i* is given by

$$\pi_{ij} = (p_{ij} - c_{ij})q_{ij} = q^2_{ij} \qquad (9)$$

using the first order condition. Hence,

$$\frac{d\pi^{ik}}{d\tau_{ij}} = 2q_{ik} \qquad \frac{dq_{ik}}{d\tau_{ij}} = \frac{2\gamma q_{ik}}{\Gamma(0)\Gamma(N)} > 0, \quad \text{for } k \neq j, \qquad (10)$$

$$\frac{d\pi^{ij}}{d\tau_{ij}} = \frac{2[\gamma - \Gamma(N)]q_{ik}}{\Gamma(0)\Gamma(N)} < 0 \qquad (11)$$

Equations (10) and (11) show that when country *i* raises tariffs on imports from country *j*, then country *j*'s export profit to country *i* falls, and country *i*'s home firm profit and all other countries' export profits to country *i* rise. Hence, when country *i* raises its tariffs on imports from country *j*, country *j*'s terms of trade with country *i* deteriorates and all other countries' terms of trade with country *i* improve.

2.2 Constant marginal cost

The second critical assumption regards the production technology. Yi assumes each country is endowed with equal amounts of numeraire good which can be transformed into a non-numeraire good at constant marginal cost. This is essentially a model with Ricardian technology. The production possibility frontier of a country is therefore a downward sloping straight line. With Ricardian technology where all countries face horizontal marginal cost curves, the terms of trade are fixed between countries and hence the rationale for an optimal tariff based on the ability of the home country to influence its terms of trade disappears.

2.3 Replicating Yi's model with numerical simulations

This section provides numerical simulations that replicate Yi's results. Setting up Yi's framework in a numerical model provides the basis for modifications in subsequent section.

From equation (1), we set the model's parameter values as follows:

a = 2; c = 1; γ = 0.5; E = 10;

where a: utility function parameter
c: marginal cost
γ: substitution index; a value of 0.5 indicates imperfect substitution between goods
E: endowment of numeraire good in each country

We conduct two simulations: (i) a world model with only 2 symmetric countries; country 1 being the active country, setting an optimal tariff, while country 2 is passive, i.e. its tariff on imports is zero, (ii) a world with 5 countries where all countries are active with tariff as a policy tool. The results are shown in Tables 1 and 2.

Table 1 Optimal tariff of country 1 when country 2 is passive

Trade Scenario	Country	Welfare	Tariff on Good 1	Tariff on Good 2	Price of good 1	Price of good 2	Consumption of good 1	Consumption of good 2
Free trade	1	10.560	0	0	1.400	1.400	0.400	0.400
	2	10.560	0	0	1.400	1.400	0.400	0.400
Country 1 sets optimal tariff only	1	10.604	0	0.333	1.444	1.556	0.444	0.222
	2	10.449	0	0	1.400	1.400	0.400	0.400

When country 1 sets a tariff on imports from country 2, country 2's consumption of good 1 and 2 remains unchanged. This outcome is due to the assumption of a constant marginal cost in the model[5]. The effects of relaxing the assumption of constant marginal cost on consumption of good 1 and 2 are shown in the next section.

With constant marginal cost, optimal tariffs are also independent across countries. The absence of interdependence of optimal tariffs is shown in Table 2. The optimal tariff of a country/customs union depends only on its size relative to the world but there is no strategic interdependence of optimal tariffs across countries.

[5] Yi claims, incorrectly, that this is due to the quasi-linear preferences in the model.

Table 2 A world with 5 symmetric countries: all countries are active

Trade Scenario	Country	Utility	Tariff on good				
			1	2	3	4	5
No CU	1	10.6944	0	0.2500	0.2500	0.2500	0.2500
	2	10.6944	0.2500	0	0.2500	0.2500	0.2500
	3	10.6944	0.2500	0.2500	0	0.2500	0.2500
	4	10.6944	0.2500	0.2500	0.2500	0	0.2500
	5	10.6944	0.2500	0.2500	0.2500	0.2500	0
CU (1,2)	1	10.735	0	0	0.2658	0.2658	0.2658
	2	10.735	0	0	0.2658	0.2658	0.2658
	3	10.678	0.2500	0.2500	0	0.2500	0.2500
	4	10.678	0.2500	0.2500	0.2500	0	0.2500
	5	10.678	0.2500	0.2500	0.2500	0.2500	0
CU (1,2,3)	1	10.761	0	0	0	0.2647	0.2647
	2	10.761	0	0	0	0.2647	0.2647
	3	10.761	0	0	0	0.2647	0.2647
	4	10.653	0.2500	0.2500	0.2500	0	0.2500
	5	10.653	0.2500	0.2500	0.2500	0.2500	0
CU(1,2,3,4)	1	10.776	0	0	0	0	0.256
	2	10.776	0	0	0	0	0.256
	3	10.776	0	0	0	0	0.256
	4	10.776	0	0	0	0	0.256
	5	10.624	0.2500	0.2500	0.2500	0.2500	0
Grand customs	1	10.781	0	0	0	0	0
union	2	10.781	0	0	0	0	0
	3	10.781	0	0	0	0	0
	4	10.781	0	0	0	0	0
	5	10.781	0	0	0	0	0
CU(1,2,3) &	1	10.745	0	0	0	0.265	0.265
CU(4,5)	2	10.745	0	0	0	0.265	0.265
	3	10.745	0	0	0	0.265	0.265
	4	10.693	0.266	0.266	0.266	0	0
	5	10.693	0.266	0.266	0.266	0	0

Table 2 reports outcomes in a 5-country world in which various combination of countries create customs unions. All countries choose the optimum tariff for their circumstances. It shows that in the 'No CU' scenario, each country sets its own optimal tariff. When a customs union of country 1 and 2, CU(1,2) is formed, members determine a common external tariff, 0.2658 that maximizes the CU's welfare. When the coalition structure changes from CU(1,2) to CU(1,2,3), optimal tariffs of members of the enlarged customs union fall from 0.2658 to 0.2647 but the optimal tariffs of non-members, i.e. countries 4 and 5 remain unchanged at 0.2500[6]. Optimal tariffs of countries 4 and 5 change only when they form a customs union.

[6] The optimal tariff of a customs union is not a monotonic function of the number of members due to two conflicting effects on optimal tariffs when a customs union expands. On the one hand an individual country would want to reduce its external tariffs since it eliminates tariffs on more imported goods as the CU expands and because it prefers a balanced consumption bundle to an unbalanced one. This is basically the 'import sourcing' condition explained by Sinclair and Vines (1995). On the other hand, this country also considers other members' export profits to this country in the determination of the external tariff since it maximises the joint welfare of member countries and hence would increase its external tariffs so that other members benefit through higher export profits to this country. Whether

Table 2 also provides an example where a grand customs union is a stable outcome even without the open regionalism rule since existing members of a customs union of any size would welcome new members because this will increase their welfare levels (a case where the rule is not binding). As Yi has pointed out, whether open regionalism rule is crucial depends on the number of countries in the world as well as the substitution parameter, γ. Sensitivity analysis on the maximum number of countries in the world with different values of γ and slopes of marginal cost curve are shown in Appendix 1[7].

3. Open regionalism is not always good

We demonstrate now how the open regionalism rule may fail to work. To do so, we make changes to Yi's model in three stages (Table 3).

Table 3 Varying Yi's model in 3 stages

Stage	Consumer preferences	Production technology	Type of competition
(Yi's model)	Quasilinear preferences	Constant marginal costs	Cournot competition
1	Quasilinear preferences	**Increasing marginal costs**	Cournot competition
2	**Constant elasticity of substitution preferences**	Constant marginal costs	Cournot and **Bertrand** competition
3	**Constant elasticity of substitution preferences**	**Increasing marginal costs**	Cournot and **Bertrand** competition

optimal tariffs of members fall or rise as a customs union enlarges depends on the number of countries in the world. A detailed explanation is found in Yi (1996a).

[7] Yi assumes that countries are ex ante identical in endowment size. We found that even when countries are asymmetric in endowment size, results on tariffs, prices and quantities will be identical to the symmetric case. The only changes are on the utility levels and the consumption of numeraire good by larger country. This is because with quasilinear preferences, a larger country, i.e. one with more endowment of the numeraire good, will not be any different from a smaller country in its demand for the non-numeraire good since demand for the non-numeraire good is independent of income. And with a Ricardian technology in the model, a large country behaves exactly like a small country since the terms of trade are fixed between countries, as it does not have any ability to affect its terms of trade. As a result, Yi's claim that open regionalism is good under the symmetric case will continue to hold under asymmetric endowment size, provided that all other assumptions in the model are retained.

3.1 Stage1 – Increasing marginal costs

Yi assumes a constant marginal cost of production in his model. We remove this Ricardian technology assumption (but retaining the quasilinear preferences assumption) and replace it with an upward sloping marginal cost function, c = x + b* Q_j (where $Q_j = \sum_{i=1}^{N} q_{ij}$, i.e. total output of good j by country j)[8]. Putting an increasing MC function into this model is a convenient way to convert the straight production possibility frontier (PPF) line in Yi's model into a concave PPF in order to reflect an increasing rate of product transformation (RPT) between the numeraire good and the differentiated good.[9]

The optimal tariff of a country/customs union is no longer independent of other countries'/customs union's tariff when marginal cost is upward sloping, even though consumer preferences are still quasilinear. Table 4 shows that when country 1 is allowed to set its optimal tariff, country 2's consumption of good 1 and 2 changes. Consumption of good 1 by country 2 falls due to the tariff and consumption of the home good increases.

Table 4 Optimal tariff of country 1 when country 2 is passive – increasing marginal costs

Trade Scenario	Country	Welfare	Tariff on Good 1	Tariff on Good 2	Price of good 1	Price of good 2	Consumption of good 1	Consumption of good 2
Free trade	1	10.592	0	0	1.400	1.400	0.400	0.400
	2	10.592	0	0	1.400	1.400	0.400	0.400
Country 1 sets optimal tariff	1	10.637	0	0.343	1.445	1.553	0.442	0.226
	2	10.482	0	0	1.3995	1.393	0.396	0.409

Optimal tariffs are dependent in this case because, given that the marginal cost of producing the non-numeraire good is a positive function of output. When, say country 1 sets a tariff on its imports from country 2, its consumption of imports falls while consumption of its home good rises. A fall in country 1's demand for good 2 reduces country 2's total output and its marginal cost of production. This leads to a fall in its price and hence good 2 becomes relatively cheaper than good 1 in country 2. Country 2's consumption adjusts to this relative price change. Country 2's optimal tariff therefore depends on country 1's tariff level since it affects country 2's production equilibrium, not through income effect but through the effects on marginal cost and hence prices.

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[8] Recalibration is made in the simulation so that the same free trade equilibrium quantities of differentiated goods as in Yi's model are retained even with this upward sloping marginal cost curve.

[9] A concave PPF captures the characteristics of most production situations: either diminishing returns, specialised inputs or differing factor intensities between goods.

When marginal cost is upward sloping, the first order condition for profit maximisation, i.e. equation (4) becomes:

$$\alpha - \tau_{ij} - (2 - \gamma)\, q_{ij} - \gamma Q_i = 0 \qquad (4)$$

where $\alpha = a - c$ and $c = x + b(\sum_i q_{ij})$

$$\Rightarrow \quad a - x - b(\textstyle\sum_i q_{ij}) - \tau_{ij} - (2 - \gamma)\, q_{ij} - \gamma Q_i = 0 \qquad (4^*)$$

In a two-country world, equation (4*) becomes:

$$a - x - b(q_{11} + q_{21}) - \tau_{12} - (2 - \gamma)\, q_{12} - \gamma Q_1 = 0 \qquad (4^*a) \quad \text{for country 1}$$

$$a - x - b(q_{22} + q_{12}) - \tau_{21} - (2 - \gamma)\, q_{21} - \gamma Q_2 = 0 \qquad (4^*b) \quad \text{for country 2}$$

With marginal costs as a function of total output, equations (4*a) and (4*b) become interdependent. The equilibrium of q_{21} and q_{12} are now interdependent, as well as τ_{12} and τ_{21}. When say country 1 raises its tariff, τ_{12} on q_{12}, from equation (4*a), this will reduce q_{12}. When q_{12} falls, equation (4*b) shows that variables q_{21}(country 2's import from country 1), q_{22} (country 2's consumption of home good) and τ_{21} will adjust in order to reach a new equilibrium.

Table 5 shows simulation results of a world with five countries, all of which are active with tariffs as a policy tool.

Table 5 Five countries in the world, countries are symmetric, increasing marginal costs

Trade Scenario	Country	Utility	Tariffs on Good				
			1	2	3	4	5
No CU	1	10.779	0	0.256	0.256	0.256	0.256
	2	10.779	0.256	0	0.256	0.256	0.256
	3	10.779	0.256	0.256	0	0.256	0.256
	4	10.779	0.256	0.256	0.256	0	0.256
	5	10.779	0.256	0.256	0.256	0.256	0
CU (1,2)	1	10.821	0	0	0.275	0.275	0.275
	2	10.821	0	0	0.275	0.275	0.275
	3	10.759	0.253	0.253	0	0.259	0.259
	4	10.759	0.253	0.253	0.259	0	0.259
	5	10.759	0.253	0.253	0.259	0.259	0
CU (1,2,3)	1	10.845	0	0	0	0.282	0.282
	2	10.845	0	0	0	0.282	0.282
	3	10.845	0	0	0	0.282	0.282
	4	10.728	0.252	0.252	0.252	0	0.265
	5	10.728	0.252	0.252	0.252	0.265	0
CU(1,2,3,4)	1	10.857	0	0	0	0	0.284
	2	10.857	0	0	0	0	0.284
	3	10.857	0	0	0	0	0.284
	4	10.857	0	0	0	0	0.284
	5	10.688	0.255	0.255	0.255	0.255	0
Grand customs union	1	10.859	0	0	0	0	0
	2	10.859	0	0	0	0	0
	3	10.859	0	0	0	0	0
	4	10.859	0	0	0	0	0
	5	10.859	0	0	0	0	0
CU(1,2) & CU(3,4,5)	1	10.772	0	0	0.273	0.273	0.273
	2	10.772	0	0	0.273	0.273	0.273
	3	10.826	0.279	0.279	0	0	0
	4	10.826	0.279	0.279	0	0	0
	5	10.826	0.279	0.279	0	0	0

From Table 5 (contrast this with Table 2), optimal tariff of a country/customs union depends not only on its relative size to the world but also the composition of coalition structures in the world. This is shown when we compare between the coalition structures of a world with only one customs union, CU(1,2) and a world with two customs unions of CU(1,2) and CU(3, 4,5). Tariffs set by members of CU(1,2) fall from 0.275 (when countries 3, 4 and 5 are separate countries) to 0.273 (when countries 3, 4 and 5 form a customs union).

Further, the interdependence of countries' optimal tariffs shows some interesting results. The formation of CU(1,2) raises the member's tariffs from a pre-CU level of 0.256 to post-CU level of 0.275. Non-members, i.e. country 3, 4 and 5 lower their tariffs on imports from CU members (from 0.256 to 0.253) while tariffs between themselves are increased (from 0.256 to 0.259). This pattern where country 3, 4 and 5 set higher tariffs on non-CU members than those on CU members can be explained by the 'import sourcing condition' of Sinclair & Vines (1995) in the following way: first, as a result of the formation of a CU between 1 and 2, consumption of home good of the CU, i.e. goods 1 and 2, increases due to the removal of intra-bloc tariffs and higher external tariffs set on non-CU goods. Increased consumption of goods 1 and 2 also means higher marginal cost of production (given upward sloping marginal cost now) and thus higher prices. With this switch of consumption toward CU goods from non-CU goods, there is a fall in the consumption of goods 3, 4 and 5, which also means a fall in the marginal cost of production and thus a fall in prices. All these bring the world prices of good 1 and 2 to be relatively higher than those of goods 3, 4 and 5. Since a country prefers a balanced consumption bundle to an unbalanced one given the love-of-variety preferences, these non-CU countries, say country 3, faced with two sources of imports, one from the CU, which is more expensive, and the other from the non-CU countries, which is less expensive, will therefore sets lower tariffs on CU goods and higher tariffs on non-CU goods. This pattern of non-CU countries setting higher tariffs on non-CU imports than tariffs on CU imports continues as the CU enlarges. Note that the average tariffs set by non-CU countries in all these trade scenarios stay around 0.255 – 0.256. But as the CU expands into CU (1, 2, 3, 4), country 5, which is now the only non-CU country in the world, sets higher tariffs on its imports (which are all sourced from CU countries) than the tariffs when the CU comprises countries 1, 2 and 3. This reason for this seemingly unusual tariff pattern is simply because now there is only one source of import, i.e. they are all sourced from the CU of 1,2,3,4 and hence the 'import-sourcing condition' explained above disappears. Note that country 5's optimal tariff of 0.255 is roughly the same as the average tariffs set by the non-CU countries stated earlier.

It is interesting to note that even though now the optimal tariff of a country is dependent on other countries'/customs union's tariff level, Yi's qualitative results that open regionalism is good continues to hold because of the quasilinear preferences assumption in the model. As long as quasilinear preferences are assumed in the model, there will be zero income effect on the consumption of non-numeraire good and hence even if we assume the model in Table 5 to have a larger country in the world, the larger country will behave exactly the same as a smaller country would behave, i.e. sets the same tariff. This means that even in the asymmetric country size world, a larger country will not be better off by staying out of a customs union and setting a Nash tariff. All countries will improve their own welfare levels by joining a customs union and a grand customs union will be a stable coalition structure.

3.2 Stage 2 - CES preferences

In this model, the assumption of Ricardian technology is retained but that of quasilinear preferences is replaced with constant elasticity of substitution (CES) preferences. The utility function has two levels. At the top level, a consumer allocates his budget between the consumption of the numeraire good, MM (which is a homogeneous good) and the consumption of an aggregate of the non-numeraire good, TG (which is a differentiated good). The lower level involves the distribution of consumption of the non-numeraire good among the individual varieties of the differentiated good, q. These two levels of utility functions can be combined into a single level if the elasticities of substitution of the two levels are the same. If this assumption is made, the numeraire good is then treated similarly as one of the varieties of the differentiated good. But we want to treat these two goods as different types of goods, which is similar to Yi's assumption, a two-level utility function is made instead of a single level, that is $\alpha \neq \theta$ (we assume that elasticity of substitution at the sub-level is higher than the one at the top level, $\theta > \alpha$). The top-level utility and sub-utility functions are as follow:

$$W_i = \left(b_i^{(1-\alpha)} TG_i^{\alpha} + (1-b_i)^{(1-\alpha)} MM_i^{\alpha}\right)^{1/\alpha}$$

$$TG_i = \left(\sum_j a_j^{i\,(1-\theta)} q_j^{i\,\theta}\right)^{1/\theta}$$

Given this love-of-variety type preferences and that $0 < \alpha < 1$, each good is consumed in every country which means that each country exports part of its own variety of differentiated good in exchange for some imports of all other varieties of the differentiated good.

With a CES utility function, the demand function for a differentiated product *j* is as follows:

$$q_j = \frac{I}{P} a_j^{\theta} \left(\frac{p_j}{P}\right)^{-\theta}$$

where I : Budget allocated for the consumption of differentiated good
P: Price index for good TG
p_j : price of good j

This demand function shows that demand for q_j is an increasing function of I, income, and decreasing for p_j, the price of own good[10].

We consider both Cournot and Bertrand cases. In the Cournot case, each firm maximises its profit by setting its output, assuming other firms' output levels are constant; in the Bertrand case, each firm sets its price to maximise profit, assuming other firms' prices are constant.

Table 6 shows simulation results of a model with two countries in the world. When countries are symmetric in size, i.e. equal endowment of the numeraire good, it is expected that both countries are better off under global free trade than in a world with restricted trade where all countries set Nash tariffs. But even when countries are

[10] With a CES demand function in this model, the demand curve can be steeper than its marginal revenue curve. Appendix 2 provides further explanations.

asymmetric in size where country 1 is two times larger than country 2 in its endowment of the numeraire good, the optimal tariff of country 1 is the same as the optimal tariff of country 2. Country 1, although being larger, does not have the capability to improve its terms of trade[11].

Table 6 Welfare and tariff levels under 'No Coalition' and 'Global Free Trade' (2 countries in the world)

Country's endowment	1 : 10 2 : 10				1: 20 2: 10			
Trade Scenario	Welfare		Tariff		Welfare		Tariff	
No coalition	Bertrand	Cournot	Bertrand	Cournot	Bertrand	Cournot	Bertrand	Cournot
	1: 9.618	9.567	0.031	0.032	18.848	18.740	0.031	0.032
	2: 9.618	9.567	0.031	0.032	10.006	9.962	0.031	0.032
Global free trade	1: 9.648	9.600	0	0	18.878	18.772	0	0
	2: 9.648	9.600	0	0	10.067	10.027	0	0

The reason that the larger country sets the same optimal tariff as the small country is the Ricardian technology assumption in the model. When marginal cost is constant, the ability of a large country to improve its terms of trade disappears because every country faces a flat foreign marginal cost in the import market, which is similar to a small country assumption.

Table 6 also shows that as the endowment of one country, country 1, increases, the welfare level of not only this country, but also the other country increases. As country 1's endowment of numeraire good rises, it increases its exports of numeraire good to country 2 at a price of one (as this is the numeraire good) and at the same time increases its imports of country 2's differentiated good at a price that exceeds one (because of a price mark-up). This exchange benefits country 2 and hence country 2 gains from a rise in country 1's endowment.

3.3 Stage 3 – Increasing marginal costs and CES preferences

Table 7 shows the model with increasing marginal costs and CES preferences for the case of 2 countries in the world. Three combinations of country sizes, including the case of symmetric country size are considered. When countries are

[11] We also observe that the Nash tariff levels of 0.031 under Bertrand competition and 0.032 under Cournot competition are notably lower compared with other studies reported in the literature that also use CES utility function (for example, Krugman (1991)). This outcome of low tariffs in our model is due to the presence of a negative tariff component in the overall optimal tariff. See explanation on the 'rent-extraction' type tariff in Appendix 3.

symmetric in size, all countries are better off under global free trade and a grand customs union can be a stable outcome. But when countries are asymmetric in size, a grand customs union may not be a stable outcome.

Table 7 Welfare and tariff levels under 'No Coalition' and 'Global free trade' (2 countries in the world) – CES utility and increasing marginal costs

Country's endowment	1 : 10 2 : 10				1: 20 2: 10			
Trade Scenario	Welfare		Tariff		Welfare		Tariff	
	Bertrand	Cournot	Bertrand	Cournot	Bertrand	Cournot	Bertrand	Cournot
No coalition	1: 9.135 2: 9.135	9.109 9.109	0.051 0.051	0.051 0.051	17.711 9.299	17.666 9.280	0.0855 0.0304	0.085 0.030
Global free trade	1: 9.159 2: 9.159	9.135 9.135	0 0	0 0	17.714 9.378	17.670 9.360	0 0	0 0

Note: SNOPT solver is used for all simulations.

Table 7 continued.

Country's endowment	1: 30 2: 10			
Trade Scenario	Welfare		Tariff	
	Bertrand	Cournot	Bertrand	Cournot
No coalition	26.149 9.452	26.089 9.439	0.114 0.017	0.113 0.017
Global free trade	26.132 9.596	26.075 9.583	0 0	0 0

When the larger country is three times larger than the smaller country, it prefers to avoid a global free trade since its welfare level is higher under 'No Coalition'. Qualitative results are the same for both Bertrand and Cournot competitions. This result is essentially the large country case for optimal tariff as demonstrated by Johnson (1954) that a country may gain by imposing a tariff even if other countries retaliate.

Table 8 reports the Bertrand case of a 5-country world model where country 1 is endowed with 60 units of numeraire good and countries 2 to 4 have 10 each. It shows that a grand customs union is unlikely to be the Nash equilibrium customs-union structure even if the open regionalism rule is adopted. This is because country 1's welfare level is higher when all countries set Nash tariffs than under global free trade[12].

[12] Results for the Cournot-type competition are similar to the Bertrand case.

Table 8 CES utility and identical increasing marginal costs (Bertrand Competition)

Trade Scenario	Country (Endowment)	Welfare	Tariffs on Good 1	2	3	4	5
No CU	1 (60)	51.6082	0	0.038	0.038	0.038	0.038
	2 (10)	9.387	-0.023	0	-0.010	-0.010	-0.010
	3 (10)	9.387	-0.023	-0.010	0	-0.010	-0.010
	4 (10)	9.387	-0.023	-0.010	-0.010	0	-0.010
	5 (10)	9.387	-0.023	-0.010	-0.010	-0.010	0
CU (1,2) only	1	52.610	0	0	0.069	0.069	0.069
	2	9.420	0	0	0.069	0.069	0.069
	3	9.358	-0.023	-0.011	0	-0.009	-0.009
	4	9.358	-0.023	-0.011	-0.009	0	-0.009
	5	9.358	-0.023	-0.011	-0.009	-0.009	0
CU (1,2,3) only	1	51.608	0	0	0	0.096	0.096
	2	9.418	0	0	0	0.096	0.096
	3	9.418	0	0	0	0.096	0.096
	4	9.321	-0.022	-0.010	-0.010	0	-0.007
	5	9.321	-0.022	-0.010	-0.010	-0.007	0
CU(1,2,3,4) only	1	51.606	0	0	0	0	0.120
	2	9.413	0	0	0	0	0.120
	3	9.413	0	0	0	0	0.120
	4	9.413	0	0	0	0	0.120
	5	9.277	-0.021	-0.009	-0.009	-0.009	0
CU(2,3) only	1	51.611	0	0.038	0.038	0.039	0.039
	2	9.386	-0.002	0	0	0.017	0.017
	3	9.386	-0.002	0	0	0.017	0.017
	4	9.380	-0.023	-0.010	-0.010	0	-0.010
	5	9.380	-0.023	-0.010	-0.010	-0.010	0
CU(2,3,4) only	1	51.611	0	0.038	0.038	0.038	0.040
	2	9.385	0.016	0	0	0	0.041
	3	9.385	0.016	0	0	0	0.041
	4	9.385	0.016	0	0	0	0.041
	5	9.366	-0.023	-0.009	-0.009	-0.009	0
CU(2,3,4,5) only	1	51.604	0	0.038	0.038	0.038	0.038
	2	9.383	0.029	0	0	0	0
	3	9.383	0.029	0	0	0	0
	4	9.383	0.029	0	0	0	0
	5	9.383	0.029	0	0	0	0
Grand customs	1	51.602	0	0	0	0	0
Union	2	9.403	0	0	0	0	0
	3	9.403	0	0	0	0	0
	4	9.403	0	0	0	0	0
	5	9.403	0	0	0	0	0

Note:
Marginal cost functions for all countries are identical and increasing with output: $c = 1 + 0.1\sum q$, where $\sum q$: total output of the individual variety of the differentiated good. θ =0.8.

For a small country such as country 2, the best outcome would be that it is the only country that forms a customs union with the large country, country 1 (trade scenario CU(1,2) in the table). But CU(1,2) cannot be a stable equilibrium structure under open regionalism where membership of a customs union is open to outsiders. Other small countries will join to increase their welfare levels. As more small countries join in, the large country, country 1 will find its position being worsened and hence has an incentive to leave the union.

Welfare levels in the table also suggest that there is no incentive for small countries to form customs union among themselves, as their welfare levels are higher when all countries set Nash tariffs than any customs union structures among the small countries. The reason for this is that all the small countries prefer to subsidise their imports, i.e. set negative tariffs under Nash equilibrium. But when some or all the small countries form customs union, they are constrained to set zero tariffs among members. This zero-tariff constraint changes the optimal tariffs on non-member countries (become positive tariffs) and is actually welfare reducing.

We note that some of the Nash tariffs set by small countries in both tables are negative with CES utility preferences. Negative Nash tariff is possible when a country is so small relative to the other country that the rationale for an import subsidy (due to the flatter marginal revenue curve than its demand) outweighs all other reasons for a positive tariff (see Appendix 3).

We also note that the welfare level of the large country, country 1, is better off when there is a CU of some of the small countries, i.e. CU(2,3) and CU(2,3,4) (but not when all small countries form a CU), than when there is no CU in the world where each sets Nash tariffs. This is because the formation of CU among some of the small countries forces the prices of the non-CU small countries to fall as a result of trade diversion. This enables the large country to increase its tariff on imports from non-CU small countries.

4. Effects of varying MC slope on relative size of large country

The previous section demonstrates that a large country, when sufficiently larger relative to others, prefers to stay out of a customs union, hence a grand customs union is not an equilibrium coalition structure. Tables 8 and 9 give an example of a large country that owns 60 per cent of the world's endowment, but different marginal cost parameters would imply different thresholds.

We examine the effects of changing the slope of marginal cost function, *b*, on the optimal tariff of a country. An increase in b, ceteris paribus, raises a country's optimal tariff due to a rise in the marginal-import-cost-type tariff. As a result, the minimum size of the larger country needed, *s*, in order for it to prefer staying out of a customs union and hence *not* having grand customs union as equilibrium, *falls* as the slope of the marginal cost function *increases*; Table 10 summarises the effect.

Table 10 Effects of varying *b* on *s*

b	*s* (as percentage of the world's endowment)
0.1	60
0.2	44
0.3	40
0.4	39
0.5	38
0.6	37
0.7	37
0.8	37
0.9	37
1.0	36

5. Concluding remarks

Quasilinear preferences and constant marginal cost are standard assumptions in the regionalism literature (examples of recent works include Chen and Joshi (2010), Mrazova (2010), Oladi and Beladi (2008), Ornelas (2005a, b)). As Ornelas (2005a) noted, this standard treatment may pose some important restrictions (e.g. on the external tariffs of FTA). This paper shows what may happen when this standard treatment is removed.

This paper has explained in details and systematically why open regionalism rule works in Yi's model and in what conditions that the rule does not work. This paper demonstrates that Yi's conclusion that open regionalism rule is good is confined to his unique pair of assumptions, i.e. constant marginal cost and quasi-linear preferences. His claim collapses once these assumptions are replaced with a concave production possibility frontier and CES preferences in a world with asymmetric country sizes. The present paper examines the customs union case. Yi (1998) shows that if we move to the case of FTA, the open regionalism story falls apart.

The construction and assumptions of this model where all goods are tradable and one of them (the numeraire good) is traded freely, i.e. tariff is zero on this good, plus the love-of-variety preferences, inherently suppress the optimal tariff levels on the non-numeraire goods. As a result, a country in such model will have less incentive to stay out of a CU and hence a grand customs union is more likely to occur. Nevertheless, this paper demonstrates that even under such circumstances, a grand customs union may still not be the equilibrium coalition. A model with a non-tradable sector or all goods that are subject to tariffs will yield higher optimal tariffs, thereby leading to stronger incentives for countries to stay out of a CU and thus less likely to have a grand customs union.

In the real world that comprises countries that are asymmetric in economic sizes, production technologies that are better represented by a concave production possibility curves, and many non-tradable goods, Yi's result on open regionalism rule is perhaps too optimistic. We demonstrate in this paper that open regionalism rule does not ensure trade blocs will be stepping stones toward global free trade.

Appendices

Appendix 1
Sensitivity test on the maximum number of countries in the world where a grand customs union is a stable outcome without open regionalism rule when MC slope increases

In Yi's model, whether open regionalism rule matters in ensuring a stable outcome of a grand customs union depends on the substitution parameter, γ, and the number of countries in the world, N. Let N* be the maximum number of countries that the world can contain and still have a stable outcome of a grand customs union without open regionalism rule. Yi has shown that N* is small for all values of γ. Sensitivity analysis is made on N* for Model 1 (i.e. stage 1 - replaces the Ricardian technology with increasing marginal cost). We recalibrate the model to the same initial free trade quantities each time when the slope of the marginal cost function, b increases. This is done by allowing the intercept, x, to adjust so as to obtain the same free trade quantities.

Let $c = x + b(\sum_i q_{ij})$

where c: marginal cost
x: intercept of the marginal cost function
b: slope
$\sum_i q_{ij}$: total output of the differentiated good

Three values of b, i.e. 0, 0.1 and 0.9 are chosen. b = 0 is Yi's case while b =0.1 and 0.9 are for the case of increasing marginal cost. More values of b could have been tested but showing these three values is sufficient to show the effects of b on N*. Interpreting these slope values in terms of cost elasticity (i.e. percentage change in marginal cost given 1 per cent change in total output of the differentiated good) depends on the number of countries in the world and γ values[13]. For a 5-country world with γ = 0.5, b = 0.1 gives a cost elasticity of 0.099 and b = 0.9 gives an elasticity of 0.347. The figures differ slightly when the number of countries in the world and the value of γ change. For example, for a 7-country world with γ = 0.5, b = 0.1 gives an elasticity of 0.109; for a 5-country world with γ = 0.3, b = 0.1 gives an elasticity of 0.119.

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[13] The formula for the cost elasticity is $e_c = b \times \frac{\sum_i q_{ij}}{c}$.

Table A1 N*, maximum number of countries in the world where a grand customs union is a stable outcome even without open regionalism rule

b	γ =1	γ =0.5	γ =0.3
0 (from Yi)	4	6	8
0.1	4	5	6
0.9	3	3	3

Results in Table A1 show that as the slope of the marginal cost increases, N* falls for all values of γ and the value of N* becomes less sensitive to the value of γ as the slope of marginal cost curve increases.

The intuition behind this result is as follows. For an existing member of a customs union, if it accepts a new member into the CU, it gains by being able to buy the variety of the differentiated good from the new member at lower cost (since there is zero tariff now). But if it rejects a new member and continues to set Nash tariffs, it benefits from foreign rent extraction through optimal tariffs. So, whether the existing member would welcome a new member depends on these two effects. If the benefits from freer trade outweigh the gain from foreign rent extraction, a new member is welcome. But if it is the other way round, a new member is not welcome. Given γ and b, as the number of countries in the world, N, increases, the size of a customs union of N-1 members is getting larger than the left-out country and therefore the gain from foreign rent extraction increases while the benefits from freer trade falls. There is a critical value of N where the benefits from freer trade outweigh the gain from foreign rent extraction and hence a new member is welcome, which means there is a strong incentive for countries to form a grand customs union.

As the value of the substitution parameter, γ falls, goods between countries become less substitutable. Since consumers value varieties in their consumption, the benefits from freer trade increases as γ falls and hence existing members are more willing to accept new members. This also means it is more likely to achieve a grand customs union in the absence of the open regionalism rule. The critical value, N* therefore increases as γ increases.

The reason why N* falls as the slope of MC, b, rises is that when MC is horizontal, the cost of one extra unit of imported good and the cost of one extra unit of domestic good are the same. But when MC slopes upward, the marginal cost of acquiring one extra unit of imported good is higher than the marginal cost of acquiring one extra unit of domestic good. The benefits from foreign rent extraction increases as the slope of MC increases. The critical value, N* therefore falls as b increases.

Note that here we assume the slopes of MC curves are the same across all countries. The value of N* changes if asymmetry in MC slopes between countries is introduced.

Appendix 2 Deriving marginal revenue function of a CES demand

We show here that with a CES utility function, the demand curve can be steeper than its marginal revenue curve.

A CES demand function for good 1 has the following form:

$q_1 = a_1^{\sigma}. (p_1/ P)^{-\sigma} . M/P$

where q_1: quantity demanded for good 1
a_1: CES share parameter for good 1
p_1: price of good 1
σ : elasticity of substitution, $1< \sigma \leq \infty$
M : Income

and $P = \left(\sum_{k=1}^{n} a_k^{\sigma} . p_k^{1-\sigma} \right)^{1/1-\sigma}$

Total revenue of selling q_1,

$$R_1 = p_1 . q_1$$

$$= a_1^{\omega} \left(\frac{p_1^{1-\sigma}}{P^{\sigma}} \right) . \frac{M}{P}$$

$$= a_1^{\sigma} \left(\frac{p_1}{P} \right)^{1-\sigma} .M$$

$$= a_1^{\sigma} . p_1^{1-\sigma} . P^{\sigma-1} .M$$

$$= a_1^{\sigma} . p_1^{1-\sigma} . \left(\sum_{k=1}^{n} a_k^{\sigma} p_k^{1-\sigma} \right)^{\frac{\sigma-1}{1-\sigma}} .M$$

$$= a_1^{\sigma} . p_1^{1-\sigma} . \left(\sum_{k=1}^{n} a_k^{\sigma} p_k^{1-\sigma} \right)^{\frac{-(1-\sigma)}{1-\sigma}} .M$$

$$= a_1^{\sigma} . p_1^{1-\sigma} . \left(\sum_{k=1}^{n} a_k^{\sigma} p_k^{1-\sigma} \right)^{-1} .M$$

dR1/dp1

$$= a_1^{\sigma}.(1-\sigma).p_1^{-\sigma}.M.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1} + a_1^{\sigma}.p_1^{1-\sigma}.M.(-1).\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-2}.a_1^{\sigma}.(1-\sigma).p_1^{-\sigma}$$

$$= a_1^{\sigma}.(1-\sigma).p_1^{-\sigma}.M.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1}.\left[1 - a_1^{\sigma}.p_1^{1-\sigma}.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1}\right]$$

$$q_1 = a_1^{\sigma}.p_1^{-\sigma}.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1}.M$$

dq1/dp1

$$= a^{\sigma}{}_1.(-\sigma).p_1^{-\sigma-1}.M.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1} + a_1^{\sigma}.p_1^{-\sigma}.M.(-1).\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-2}.a_1^{\sigma}.(1-\sigma).p_1^{-\sigma}$$

$$= a_1^{\sigma}.p_1^{-\sigma}.M.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1}.\left[(-\sigma).p_1^{-1} - a_1^{\sigma}.(1-\sigma).p_1^{-\sigma}.\left(\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right)^{-1}\right]$$

Marginal revenue, $MR_1 = dR_1/dq_1 = dR_1/dp_1 \,.\, dp_1/dq_1 = dR_1/dp_1 \,.\, (dq_1/dp_1)^{-1}$

$$= \frac{(1-\sigma)\left(1 - a_1^{\sigma}.p_1^{1-\sigma}\left[\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right]^{-1}\right)}{\left((-\sigma)\,p_1^{-1} - a_1^{\sigma}.(1-\sigma).p_1^{-\sigma}.\left[\sum_{k=1}^{n} a_k^{\sigma}.p_k^{1-\sigma}\right]^{-1}\right)}$$

The slope of MR_1, $dMR_1/dq_1 = dMR_1/dp_1 \cdot dp_1/dq_1$

dp_1/dq_1 is the slope of demand.

If $0 < dMR_1/dp_1 < 1$, then $dMR_1/dq_1 < dp_1/dq_1$ (marginal revenue is flatter than demand)

If $dMR_1/dp_1 > 1$, then $dMR_1/dq_1 > dp_1/dq_1$ (marginal revenue is steeper than demand)

If $dMR_1/dp_1 < 0$, then $dMR_1/dq_1 > 0$ (marginal revenue slopes upward)

To see how dMR_1/dp_1 changes with p_1, simulations are made on a range of p_1, given $p_2=1$, $a_1=0.5$, $a_2=0.5$, $M=10$, $\sigma=5$, assuming there are two goods. The values chosen for a_1, a_2, M and σ are based on the parameters in our main model. The results are shown in Table A2.

Table A2 Examining how dMR_1/dp_1 changes with p_1

p_1	dMR_1/dp_1	dp_1/dq_1	dMR_1/dq_1
0.991	0.237	-0.065	-0.015
0.992	0.242	-0.065	-0.016
0.993	0.246	-0.065	-0.016
0.994	0.251	-0.066	-0.016
0.995	0.256	-0.066	-0.017
0.996	0.260	-0.066	-0.017
0.997	0.265	-0.066	-0.017
0.998	0.269	-0.066	-0.018
0.999	0.273	-0.066	-0.018
1.000	0.278	-0.067	-0.019
1.001	0.282	-0.067	-0.019
1.002	0.286	-0.067	-0.019
1.003	0.291	-0.067	-0.020
1.004	0.295	-0.067	-0.020
1.005	0.299	-0.068	-0.020
1.006	0.303	-0.068	-0.021
1.007	0.308	-0.068	-0.021
1.008	0.312	-0.068	-0.021
1.009	0.316	-0.068	-0.022
1.010	0.320	-0.068	-0.022
1.011	0.324	-0.069	-0.022
1.012	0.328	-0.069	-0.023
1.013	0.332	-0.069	-0.023
1.685	0.841	-0.564	-0.475
1.900	0.831	-1.074	-0.892

The values for dMR_1/dp_1 are positive but less than 1. This means that given the parameters of p_2=1, a_1=0.5, a_2 =0.5, M=10, σ=5, marginal revenue is flatter than its demand curve for the price range shown above.

The value of dMR_1/dp_1 is independent of M but is sensitive to the value of p_2, a_1 and σ. For example, if $p_2 > 1$ dMR_1/dp_1 are negative for some price range. dMR_1/dp_1 also turns to negative values for some price range when a_1 and σ are increased. When dMR_1/dp_1 is negative, this means that dMR_1/dq_1 is positive (since dp_1/dq_1 is negative). When this happens, marginal revenue slopes upwards.

Appendix 3

Components of optimal tariffs in the CES model with market power

The overall tariff set by a country in our model can be decomposed into 4 components as follows. Note that (i), (iii), (iv) are positive tariffs but (ii) is a negative tariff (i.e. import subsidy). The presence of component (ii) in the model hence yields overall relatively low optimal tariffs in our simulation results.

(i) Gros-type tariff

Given this model where firms set mark-up prices in all goods markets, a tariff is desired with the reason as explained by Gros (1987): when price exceeds marginal cost in the home good market, consumers see the price as the cost of home good but the true cost to the country is actually measured by the marginal cost. A positive tariff is desired in order to increase the domestic price of imports so as to bring the price ratio between home and import goods closer to the true social cost ratio between the two goods.

(ii) Rent-extraction-type tariff (to extract rent from foreign firm with market power)

An import subsidy is desired as explained by Helpman and Krugman (1989) – With a CES demand function in this model, the demand curve is steeper than its marginal revenue curve (see Appendix 2 for derivation of CES demand and its marginal revenue). This means that marginal revenue declines slower than price and it is therefore welfare improving to have an import subsidy as the gain by the consumers due to fall in prices outweighs the cost of import subsidy which is determined by the slope of marginal revenue curve.

(iii) Marginal-import-cost-type tariff

This is the standard optimal tariff. It arises when the marginal cost rises when output rises explained by Helpman and Krugman (1989, Ch4: p52).

(iv) Export-tax-equivalent-type tariff

There are two reasons for this type of tariff: (a) to extract monopoly profit in the export market, and (b) to correct the wrong perceived demand function.

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