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Abstract

Classical welfare economics demonstrates potential Pareto improvements from "supply-side" policy changes that increase the efficiency of aggregate production. Special cases reviewed here concern market integration in customs unions and the gains from international trade. These classical results rely on incentive incompatible lump-sum compensation of losers. Some extensions to second-best welfare economics are presented. They require that governments freeze most of the parameters of each consumer's budget set, leaving flexible producer prices to clear markets, and uniform poll subsidies to generate actual Pareto improvements. Generally, supply-side reforms are only beneficial when combined with other suitable policies to compensate deserving losers.

1. Introduction

Standard neoclassical welfare economics not only displays the logical connections between perfectly competitive and Pareto efficient allocations of resources. It goes on to claim that there are gains to free international trade and other forms of market liberalizing "supply side" policies. These move the economy out toward its Pareto frontier. It is true that liberalization may harm some unfortunate individuals, but there is anyway a potential Pareto improvement. This would become an actual Pareto improvement if the gainers were made to compensate the losers, which they can more than afford to do. Moreover, the Scitovsky (1941) reversal test is passed; if the market liberalizing policy were to be reversed, there is no way in which any gainers from this reverse could compensate all the losers.

The practical limitations of the standard neoclassical argument have now become all too apparent. For that argument requires the gainers to compensate the losers by means of lump-sum transfers, bearing no relation at all to individuals' transactions in the liberalized economy. Such transfers are impractical because, in order that the losers do all get fully compensated, they must depend on what each individual's pattern of trade would have been in the absence of the liberalizing reform. Yet this is rarely known with any certainty and so, as Feenstra (1990) has recently emphasized, individuals themselves would have every incentive to make excessive claims concerning the damage that they have suffered because of liberalization. Indeed, even those who really do gain from liberalization have an incentive to claim that they too have suffered damage. Many "potential" Pareto improvements are therefore illusory, since there is really no possibility of arranging the lump-sum transfers necessary to convert them into actual Pareto improvements.

Even without assuming that lump-sum compensation is possible, Diamond and Mirrlees (1971) gave alternative sufficient conditions for efficient production still to be generally desirable. In order to convert a move toward the production frontier into a Pareto improvement, their argument would require any losers to be compensated by adjustments to commodity taxes and subsidies, including those on different kinds of labour, and also to taxes on dividends. Actually, Diamond and Mirrlees assume in most of their work that the government would always set taxes on each separate commodity differentially in order to maximize some Paretian Bergson social welfare function. Certainly their assumptions imply that the government has available a wide enough range of tax instruments to ensure that consumer prices can be held fixed while producer prices are varied in order to balance supply and demand for each good. We shall assume that firms' after tax dividend payments to their shareholders can be held fixed as well. Then no consumer need become worse off as a result of an induced price change or a reduction in dividend income, so it no longer matters that lump-sum compensation is impossible. Indeed, a price, wage and dividend freeze, together with increased production efficiency, creates a surplus for the government. This can be used to pay a poll subsidy, or to make some other tax change which benefits all consumers.

This paper will both synthesize these results and examine carefully the conditions for their validity. In fact, four related propositions will be considered. After Section 2 has presented the basic model and assumptions, Sections 3 to 6 consider our main results concerning the gains from creating a customs union. Whether the formation of a customs union is welfare increasing was for long a rather difficult question to answer. After all, when several nations free trade barriers among them and establish a common external tariff, there is the efficiency enhancing effect of trade creation. This is generally welfare increasing in first best economies. But there may also be an offsetting efficiency decreasing effect of trade diversion, because imposing a common external tariff may divert production toward higher cost producers — see, for instance, Viner (1931, 1950), Meade (1956), Scitovsky (1958), Lipsey (1960, 1970), Krauss (1972), Miller and Spencer (1977), and many other papers cited therein.

Despite the complication of trade diversion, Sections 3 to 6 consider different variations of a more recent result showing how such unions can be formed in a way which not only benefits the countries forming the union, but even does no damage to countries which are excluded from it. The key idea for this result emanates from Kemp (1964), which was then reformulated by Kemp and Wan (1976), and finally extended by Grinols (1981). The result shows how, when a customs union is formed, there will exist both a vector of common external tariffs and a system of lump-sum transfers between consumers in the nations belonging to the union, such that nobody in the world, either inside or outside the union, is worse off with the customs union than without it. The argument relies on the union being able to maintain an external tariff so that border prices are frozen, as is the total amount of trade in each commodity which the union as a whole carries out with the rest of the world. In particular, there is none of the trade diversion which plays such a prominent role in the older literature on customs unions. Within the union, however, there are no tariffs and so there will be a common producer price vector.

To establish this result, Section 3 first considers the special case when each nation has a lone representative consumer. Next, Section 4 raises the issue of how to distribute the potential gains, in order to convert a potential Pareto improvement into an actual one. Thereafter Section 5 presents the classical result, which is when lump-sum transfers can be used to achieve such a Pareto improvement. Finally, Section 6 demonstrates how to combine price, wage and dividend freezes with uniform national poll subsidies in all the nations of the union in order to generate a Pareto improvement.

The rest of the paper shows how a number of other standard propositions are really straightforward corollaries of this key result for customs unions. Section 7 begins with the first of the two classical results on the gains from trade due to Samuelson (1939, 1962), Kemp (1962), Grandmont and McFadden (1972), Dixit and Norman (1980, 1986), with discussion by Kemp and Wan (1986), etc. It states that worldwide free trade is superior to autarky. Such free trade is a special case of a customs union which extends over the whole world after starting with no trade between any of its member nations. Next, Section 8 is about the general desirability of improving aggregate production efficiency in a closed economy, which is the special case of a customs union with one nation only and no external trade.

Thereafter, Section 9 considers the other of the two classical theorems concerning the gains from trade. This states that a small country with no influence over its terms of trade is better off with free trade than with any kind of managed trade. It is the special case of a closed economy with an additional foreign trade sector that functions like an additional producer. A major implication arises in connection with the theory of project evaluation and the standard but contentious claim that, under certain conditions, border prices should be used as shadow prices for traded goods, and producer prices for non-traded goods — for extensive discussion of this claim see Little and Mirrlees (1974), Dasgupta and Stiglitz (1974), Blitzer, Dasgupta and Stiglitz (1981), Bell and Devarajan (1983), Diewert (1983), Dixit (1985), Hammond (1986), Mookherjee (1986), Drèze and Stern (1987), etc. Section 10 considers project evaluation in general, and shows that this claim is valid under somewhat weaker conditions than has usually been recognized.

Finally, Section 11 discusses practical limitations to the validity of all these results. The main conclusion which emerges is that the benefits of market oriented supply side policies may not be anything like as robust or universal as many economists seem to believe, judging from their generally favourable attitude to almost indiscriminate market liberalization, especially on the supply side of the economy.

An appendix presents the main proof of the existence of an equilibrium in the model of Section 6 with frozen consumer prices and dividends, but with flexible producer prices and a uniform poll subsidy specific to each nation of the union.

2. Notation, Model and Assumptions

The customs union is assumed to come together from a finite set K of nations which are indexed by k. Suppose that there is a finite set G of physical commodities, so that the commodity space is the Euclidean space $\Re^G$. Assume too that $G = \cup_{k \in K} N_k \cup T$ can be partitioned into the disjoint sets N_k of non-traded goods specific to each nation $k \in K$, together with the set T of traded goods.

Nation k's economy consists of a finite set I_k of consumers and a finite set J_k of firms. Internationally owned firms are excluded, as is the migration of consumers and workers. The set of all consumers in the union is $I := \cup_{k \in K} I_k$ and the set of all producers is $J := \cup_{k \in K} J_k$. When public production has to be considered, any publicly owned firms in each country k will simply be included in the set J_k. That also allows us to discuss the evaluation of public sector projects.

For each consumer $i \in I$, let X^i denote i's set of feasible net trade vectors, whose typical member is x^i. Assume that each set X^i is a closed and convex subset of $\Re^G$ satisfying $0 \in X^i$. The latter condition says that autarky is feasible for each consumer, but it does *not* imply that each consumer can actually survive without trade. Suppose also that each set X^i has some lower bound $\underline{x}^i$ for which $x^i \in X^i$ implies $x^i \geqq \underline{x}^i$. Finally, if $g \notin N_k \cup T$, so that good g is neither internationally traded nor a non-traded good specific to nation k, then it is assumed that $x^i_g = 0$ whenever $i \in I_k$ and $x^i \in X^i$ because no individual in nation k can trade the good.

In addition, each consumer i is assumed to have an ordinal utility function $U^i : X^i \to \Re$ which is continuous, quasi-concave, and *locally non-satiated* in the sense that, if $x^i \in X^i$ and N is any open set in $\Re^G$ for which $x^i \in N$, then there exists $\tilde{x}^i \in X^i \cap N$ with $U^i(\tilde{x}^i) > U^i(x^i)$. This is a fairly standard assumption in general equilibrium theory. Notice that it is a significant weakening of the more customary monotonicity assumption, which we avoid because it would be inconsistent with consumers in each nation being unable to trade the non-traded goods that are specific to other nations.

For each consumer $i \in I$, let m^i denote i's total unearned (net) income from dividends paid by firms and from government transfers. Also, for each m^i and consumer price vector $q \neq 0$, let $B^i(q, m^i) := \{ x^i \in X^i \mid q\, x^i \leq m^i \}$ denote i's budget set. Then the above assumptions imply that each $i \in I$ has a utility maximizing demand correspondence $\xi^i(q, m^i) := \arg\max_{x^i} \{ U^i(x^i) \mid x^i \in B^i(q, m^i) \}$ which: (a) has a non-empty convex value for every consumer price vector $q \gg 0$ and every income level m^i large enough to ensure that $B^i(q, m^i)$ is non-empty; (b) is upper hemi-continuous (in particular, it has a closed graph) whenever there is a *cheaper point* $\tilde{x}^i \in X^i$ with $q\, \tilde{x}^i < m^i$; and (c) satisfies the *budget exhaustion* condition that $q\, x^i = m^i$ for all $x^i \in \xi^i(q, m^i)$. In fact, of course, (b) and (c) are true whenever $q \neq 0$, whether or not $q \gg 0$.

Each producer $j \in J$ is assumed to have a production set $Y^j \subset \Re^G$ of feasible net output vectors, whose typical member is y^j, and which satisfies $0 \in Y^j$. The aggregate production sets $Y_k := \sum_{j \in J_k} Y^j$ of the nations $k \in K$ are assumed to be closed and convex. They are also assumed to satisfy the property that, for each aggregate lower bound $\underline{y} \in \Re^G$ on union-wide net outputs, and so for each upper bound $-\underline{y}$ on net inputs, the constrained set of international production distributions

$$Y^K(\underline{y}) := \{ y^K \in Y^K := \prod_{k \in K} Y_k \mid \sum_{k \in K} y_k \geqq \underline{y} \}$$

within the union is bounded. In other words, bounded inputs in the union as a whole allow only bounded aggregate inputs and outputs in each separate nation of the union. Finally, if $g \notin N_k \cup T$, then it is assumed that $y^j_g = 0$ whenever $j \in J_k$ and $y^j \in Y^j$, so that no firm in nation k can have a non-zero net supply of good g.

The paper is about potential Pareto improvements to a given initial allocation $(\bar{\mathbf{x}}^{\mathbf{I}}, \bar{\mathbf{y}}^{\mathbf{J}})$ in the customs union, where

$$\bar{\mathbf{x}}^{\mathbf{I}} := \langle \bar{x}^i \rangle_{i \in I}; \quad \bar{\mathbf{y}}^{\mathbf{J}} := \langle \bar{y}^j \rangle_{j \in J}$$

are the lists of all consumers' initial net trade vectors and of all producers' initial net output vectors, respectively. The associated net import vector in each country $k \in K$ will be denoted by

$$\bar{z}_k := \sum_{i \in I_k} \bar{x}^i - \sum_{j \in J_k} \bar{y}^j$$

which must also be the aggregate excess demand vector. Let w denote the world price vector at which countries outside the union trade with those inside. It is assumed that each nation k of the union must observe some balance of trade constraint of the form $w \, \bar{z}_k = \bar{b}_k$, where $\bar{z}_k$ denotes the net import vector and $\bar{b}_k$ denotes the maximum allowable trade deficit — which may well be zero, or even negative for nations with past debts that need servicing.

No producer prices will be specified for the initial allocation because it will typically be assumed that there is not necessarily even any nation in which production is efficient before the reform. For some results, however, it will be assumed that there are initial consumer prices $\bar{q}^k$ in each nation k, with associated unearned incomes $\bar{m}^i := \bar{q}^k \, \bar{x}^i$ for each consumer $i \in I_k$, such that $\bar{x}^i \in \xi^i(\bar{q}^k, \bar{m}^i)$.

After the customs union has been formed, it is assumed that both the world price vector w and the aggregate net import vector $\bar{z} := \sum_{k \in K} \bar{z}_k$ of the customs union as a whole are left unchanged. Furthermore, all internal tariffs are assumed to be abolished, leading to free international trade within the customs union. After the change, therefore, there will be a common producer price vector p which applies to each firm throughout the union. This price vector will be different from w because of the vector $p - w$ of common external tariffs on each traded commodity. We assume that tariffs $p - w$ and producer prices p all adjust to clear markets within the customs union while external prices w and aggregate net imports $\bar{z}$ remain fixed. Thus both external tariffs and internal producer prices are endogenous. Finally, let q^k denote the price vector facing all consumers in country k. It will differ from the producer price vector p because of commodity or linear income taxes whose magnitudes in nation k must be the appropriate components of $q^k - p$.

We consider a supply side policy change which induces each producer $j \in J$ to maximize profit, whatever the producer price vector $p \neq 0$ may be. So, let

$$\left.\begin{array}{rcl} \eta^j(p) & := & \arg \\ \pi^j(p) & := & \end{array}\right\} \max_{y^j} \{\, p\, y^j \mid y^j \in Y^j \,\}$$

denote firm j's profit-maximizing net supply vectors and maximized profits at the price vector p. Note that $\pi^j(p) \geq 0$ because of our assumption that $0 \in Y^j$. Of course, it is possible that $\eta^j(p) = \emptyset$ and $\pi^j(p) = +\infty$. Nevertheless, for each nation $k \in K$ and producer price vector $p \in P$, let

$$\left.\begin{array}{rcl} \eta_k(p) & := \sum_{j \in J_k} \eta^j(p) = & \arg \\ \pi_k(p) & := \sum_{j \in J_k} \pi^j(p) = & \end{array}\right\} \max_{y_k} \{\, p\, y_k \mid y_k \in Y_k \,\}$$

denote respectively the profit maximizing aggregate net supply correspondence and the maximum possible aggregate profit.

Our final assumption is that forming the customs union really does improve overall production efficiency within the union, and also within each separate nation $k \in K$. Specifically, suppose that the original aggregate net output vector $\bar{y} := \sum_{j \in J} \bar{y}^j$ is not on the frontier of aggregate production set $Y := \sum_{j \in J} Y^j$, but in the interior. It is assumed, moreover, that if $\hat{y} = \sum_{j \in J} \hat{y}^j$ is on the frontier of Y, then $\sum_{j \in J_k} \hat{y}^j \neq \sum_{j \in J_k} \bar{y}^j$ for each $k \in K$. In other words, it is impossible to re-organize production efficiently within the union as a whole without changing the aggregate net output in each nation of the union. Of course, when these assumptions are met, there cannot be any price vector $p \neq 0$ at which $\bar{y}$ maximizes profits over Y, and so it must be true that $\sum_{j \in J} \pi^j(p) > p\,\bar{y}$ for all $p \neq 0$. Moreover, since each nation must move from $\bar{y}_k$ in order that the union's aggregate net output vector should reach the boundary of Y, it must be true that $\pi_k(p) > p\,\bar{y}_k$ for every $p \neq 0$. Note that this does *not* require firms to make more profit from the reform. But it does require the producers in each country $k \in K$ to earn more aggregate profit after the reform than they would have made, at the same producer price vector, by remaining at the initial allocation.

3. The Representative Consumer Case

As is to be expected, the argument is clearest when each nation joining the union has just one representative consumer, who is also the sole owner of all the nation's firms. The subscript i to denote an individual can therefore be dropped. Because of the free internal market, all goods will be bought and sold by both the representative consumer of each member nation and by all producers within the union at a common market clearing price vector p, provided that such a price vector exists.

Without at least one further policy measure, it may not be true that forming a customs union will by itself make even representative consumers in each of its member states better off. The reason is that, because of changing patterns of international trade within the union, some of its nations may lose too much tariff revenue when they move to an internal common market and a common external tariff. So we shall follow the gains from customs unions literature cited in the introduction, as well as Ohyama (1972), and postulate inter-governmental transfers which compensate for the loss of tariff revenue. Specifically, when the flexible internal market producer price vector is p, while the common external tariff maintains the union's border price vector fixed at w, we assume that each country $k \in K$ will still receive an amount $R_k(p) := (p - w)\,\bar{z}_k$ in revenue, even if its net import vector shifts away from $\bar{z}_k$. Since the aggregate net import vector of the whole community remains unchanged at $\bar{z}$, however, it follows that the total revenue from the common external tariff is $R(p) := (p - w)\,\bar{z} = \sum_{k \in K} R_k(p)$. This revenue therefore gets divided up between countries in a way which reflects the original rather than the new pattern of imports and exports within the union. After including allowable net borrowing $\bar{b}_k$, the resulting total unearned income of the representative consumer of country k is then

$$m_k(p) := (p - w)\,\bar{z}_k + \bar{b}_k + \pi_k(p) = p\,\bar{z}_k + \pi_k(p).$$

The earlier assumption of improved efficiency within each nation $k \in K$ implies, however, that $\pi_k(p) > p\,\bar{y}_k$ for every $p \neq 0$, while $\bar{z}_k = \bar{x}_k - \bar{y}_k$. From this it follows that

$$m_k(p) = p\,\bar{z}_k + \pi_k(p) > p\,\bar{z}_k + p\,\bar{y}_k = p\,\bar{x}_k,$$

so that the representative consumer in each nation $k \in K$ always has more than sufficient income to purchase $\bar{x}_k$, no matter what price vector $p \neq 0$ may occur in any new equilibrium. In particular, after the union has been formed, no country's representative consumer can be forced down to a cheapest point of the feasible set X_k, so avoiding the kind of "exceptional case" first noticed by Arrow (1951). Given all our other assumptions, this will therefore be sufficient to ensure that, after the customs union has been created, a union-wide competitive or Walrasian equilibrium $(\hat{\mathbf{x}}, \hat{\mathbf{y}}, p)$ really does exist. Such an equilibrium must satisfy the properties that:

(i) for all firms $j \in J$, the net output vector $\hat{y}^j$ satisfies $\hat{y}^j \in \eta^j(p)$, and so maximizes profits at producer prices p;

(ii) the representative consumer of each nation $k \in K$ has a net trade vector $\hat{x}_k$ maximizing utility $U_k(x_k)$ subject to the feasibility constraint $x_k \in X_k$ and the budget constraint $p\,x_k \leq m_k(p)$;

(iii) the market clearing condition $\bar{z} := \sum_{k \in K} \bar{z}_k = \sum_{k \in K} \hat{x}_k - \sum_{j \in J} \hat{y}^j$ is satisfied.

Moreover, the strict inequality $m_k(p) > p\,\bar{x}_k$ (all $k \in K$) clearly implies that each country's representative consumer is strictly better off as a result of free trade.

As for the rest of the world, it can remain completely unaffected by the formation of the union. Its pattern of trade with the union as a whole is exactly the same as it was before, without any change in prices or quantities, even though it may be doing more trade with some members of the union which is compensated by doing less with others. Since neither the prices at which it trades with the union nor the aggregate quantities of imports from and exports to the union are affected, there is no reason for the rest of the world to depart in any way from the allocation it experienced before the union was formed.

It is noteworthy that this classical result on the benefit of forming a customs union involves passing Scitovsky's reversal test. The reason is that the final allocation is Pareto efficient in the union's economy when the aggregate net import vector is $\bar{z} = \sum_{k \in K} \bar{z}_k$. Because $m_k(p) > p\,\bar{x}_k$ (all $k \in K$), the original allocation cannot possibly be Pareto superior or even Pareto indifferent to the post-reform allocation, so Scitovsky's reversal test is indeed passed.

4. Distributing the Potential Gains

In general each member state of the customs union has more than just a lone representative consumer. Then, obviously, simply increasing the aggregate real income of all consumers in each nation does not guarantee a Pareto improvement. Consumers who supply specialized labour skills to industries which are uncompetitive at the new equilibrium prices will usually find themselves significantly worse off because they have lost the main source of their livelihood. So may some of those who own the firms in such industries. To demonstrate that an increase in the total real income of each nation is truly a potential Pareto improvement therefore involves finding some redistribution scheme which could actually compensate these losers. Thus are the aggregate gains to all consumers from freer trade arranged in a way that allows each individual consumer to benefit.

In our model there will be a government in each nation of the union with the power to use two different kinds of redistributive instrument. The first is direct lump-sum redistribution between all the different consumers in the economy. Using an argument similar to Grandmont and McFadden's (1972), Section 5 below will exhibit a feasible transfer scheme ensuring that each consumer's net trade vector is no worse than in the original unreformed allocation. This transfer mechanism depends on private information, however, and so will disappear from the policymaker's true feasible set once informational constraints are taken into account. The second possibility, which is somewhat less unrealistic, is that each government has the power to impose upon transactions between national producers and consumers whatever commodity taxes and subsidies seem appropriate, as in Diamond and Mirrlees' (1971) model of optimal commodity taxation. Section 6 therefore considers how to combine a consumer price, wage and dividend freeze with a uniform poll subsidy, in order to distribute profits in a way which is incentive compatible.

As in the case of a single representative consumer, in any new competitive equilibrium there will be a single price vector p faced by all producers in the union simultaneously. Dividend payments and lump-sum taxes and subsidies then together redistribute the total profits $\pi_k(p)$ of all producers in each nation $k \in K$, as well as the external tariff revenue $R_k(p) = (p - w)\,\bar{z}_k$ and the allowable level of external borrowing $\bar{b}_k$, between the different consumers of that nation. Since the sum of these net transfers must depend on p, so in general must all the transfers themselves. So let $m^i(p)$ denote the function determining the unearned income of each consumer $i \in I$. Obviously, it will be assumed that, for each nation $k \in K$, the aggregate budget constraint

$$\sum\nolimits_{i \in I_k} m^i(p) \equiv (p - w)\,\bar{z}_k + \bar{b}_k + \pi_k(p) = p\,\bar{z}_k + \pi_k(p)$$

is always satisfied; this implies that each country simply redistributes its own national wealth, and that there are no international transfers other than the appropriate distribution of common external tariff revenue which was used in the representative consumer case discussed above. Commodity taxation also serves to determine how the consumer price vector q^k in each nation $k \in K$ depends upon the producer price vector p. Let $q^k(p)$ represent this functional dependence. Finally, it is also assumed that, for all $k \in K$, the functions $m^i(p)$ $(i \in I_k)$ and $q^k(p)$ are all continuous and homogeneous of degree one in producer prices p.

Now, converting the potential gains from a customs union to actual gains requires finding some equilibrium producer price vector p for the union as a whole, together with net transfers $m^i(p)$ to each consumer $i \in I_k$, and national commodity tax systems giving rise to consumer prices $q^k(p)$ for each nation $k \in K$. Such an equilibrium will also involve net output vectors $\hat{y}^j \in \eta^j(p)$ (all $j \in J_k$) and equilibrium net demand vectors $\hat{x}^i \in \xi^i(q^k(p), m^i(p))$ (all $i \in I_k$) for which:

(i) all consumers are better off because $U^i(\hat{x}^i) > U^i(\bar{x}^i)$ for all $i \in I$;

(ii) the union's aggregate resource balance constraint $\sum_{i \in I} \hat{x}^i - \sum_{j \in J} \hat{y}^j = \bar{z}$ is satisfied.

Section 3 found such an improvement for the special case of a representative consumer in each nation.

5. The Classical Theorem

In the classical case, the government is allowed to redistribute income by means of lump-sum transfers. Then an appropriate compensation scheme is that constructed by Grinols (1981), based in turn upon that devised earlier by Grandmont and McFadden (1972) for the special case discussed in Section 7 below where free trade is compared with autarky. Each individual will be assured more income than is needed to allow the original consumption bundle to be purchased at the new post-union equilibrium prices.

Specifically, after the union has been formed, the consumer price in each nation $k \in K$ of the union is taken to be $q^k(p) \equiv p$ because throughout the union no commodity taxes are imposed. As in Section 2 above, we assume that the supply side policy change really does improve production efficiency within each nation $k \in K$, in the sense that $\pi_k(p) > \sum_{j \in J_k} p\bar{y}^j$ for every $p \neq 0$. Finally, in order to ensure that all consumers in any nation k really do benefit from the customs union, arrange the transfers $m^i(p)$ to satisfy $m^i(p) > p\,\bar{x}^i$ (all $i \in I$) for every $p \neq 0$. An obvious example is when the transfer functions in each nation $k \in K$ take the linear form

$$m^i(p) = p\,\bar{x}^i + \theta^i_k \left[\pi_k(p) - \sum\nolimits_{j \in J_k} p\bar{y}^j\right]$$

for any set of positive "distributive" weights θ^i_k $(i \in I_k)$ satisfying $\sum_{i \in I_k} \theta^i_k = 1$. Then $\sum_{i \in I_k} m^i(p) = p\,\bar{x}_k + \pi_k(p) - p\,\bar{y}_k = p\,\bar{z}_k + \pi_k(p)$ Moreover, no consumer i can be forced down to a cheapest point of the feasible set X^i. Therefore our assumptions imply the existence of a competitive equilibrium allocation $(\hat{\mathbf{x}}^{\mathbf{I}}, \hat{\mathbf{y}}^{\mathbf{J}})$

and price vector p, and also imply that every consumer is strictly better off as a result of the policy reform.

Notice that the transfer system considered in this section must depend upon the net trade vector $\bar{x}^i$ which each consumer would have had in the allocation without reform. Usually the national governments do not know this. If some kind of revelation mechanism were instituted to discover it, asking consumers to report what transactions each would have made if the economy had remained unreformed, then there would always be an incentive for them to cheat by claiming more compensation than they really need — and by claiming to need compensation when they are actually better off even without it. So the classical transfer mechanism used in this section depends on private information in a way that makes it disappear from the policymaker's true feasible set once informational constraints are taken into account. The next section considers how to combine a price, wage and dividend freeze with a uniform poll subsidy, in order to distribute the gains from forming the customs union in a way which is incentive compatible.

Once again Scitovsky's reversal test is passed in this classical result on the benefit of increased production efficiency. Again, this is because the final allocation is Pareto efficient in the union economy. Because of our assumption that $\sum_{j \in J} p(\hat{y}^j - \bar{y}^j) > 0$, there is no way that the original allocation can be Pareto superior or even Pareto indifferent to the post-reform allocation, so Scitovsky's reversal test is indeed passed.

6. Poll Subsidies with Frozen Prices, Wages, and Dividends

As is surely more realistic, suppose that the government has too little information about consumers' characteristics to use lump-sum compensation for those who would otherwise lose from the policy reform. Instead we only allow combinations of commodity taxes (or subsidies) with uniform poll subsidies (or taxes). Note that poll subsidies are equivalent to universal tax credits. Such taxes and subsidies depend only on the entire distribution of characteristics in the population. As argued in Hammond (1979, 1987), it follows that in any large or continuum economy no individual consumer has the power to affect these taxes, and so no incentive to manipulate.

In order to prove that potential Pareto improvements exist even without lump-sum transfers, we shall allow ourselves some extra assumptions compared with the previous classical case. First, we require that the original allocation $\bar{\mathbf{x}}_K$ to consumers in each nation $k \in K$ be supported by a national consumer price vector $\bar{q}^k$ and by incomes $\bar{m}^i$, in the sense that all consumers $i \in I_k$ maximize U^i subject to the budget constraint $\bar{q}^k x^i \leq \bar{m}^i$. The production sector, however, may not be maximizing profits at any prices at all. Second, suppose that each consumer $i \in I$ has a single-valued vector demand set $\xi^i(\bar{q}^k, \bar{m}^i) = \{\bar{x}^i\}$ when faced with the initial budget constraint $\bar{q}^k x^i \leq \bar{m}^i$. These two assumptions will play an important rôle in ensuring that benefits can be passed on to all consumers by means of a uniform poll subsidy. Note that the second requirement is an automatic implication of the first when each consumer's utility function is *strictly* quasi-concave. Indeed, such strict quasi-concavity implies that each consumer's demand function be single-valued everywhere; here, however, it is enough to have it be single-valued for the initial budget constraint.

In this framework, Dixit and Norman (1980, pp. 79–80 and 191–3) considered the implications of either replacing autarky by free trade, or forming a customs union incorporating Ohyama's (1972) rule of compensation for tariff revenue. They show how such reforms, when combined with a consumer price freeze, can generate a (non-negative) surplus for the government(s) without making any consumer worse off. Later, Dixit and Norman (1986) discuss how appropriate tax changes can make this surplus take the form of an excess supply of each commodity. Then, provided that surplus commodities can be thrown away, such tax changes allow either a small increase in the consumer price of any good such as labour which everybody sells, or a small reduction in the consumer price of any good which everybody buys. Their argument is therefore similar to that given by Diamond and Mirrlees (1971) to support their claim that aggregate production should be efficient — see also Weymark (1979), who shows how small tax changes on groups of commodities may suffice to generate Pareto improvements. By contrast, we shall show that a Pareto superior equilibrium exists without any excess supplies of commodities that need to be disposed of. In addition, we allow firms to make profits, though we shall require dividend payments to be frozen. Finally, the later tax adjustments used by Dixit and Norman, etc., to guarantee an eventual Pareto improvement depend on knowing of at least one good which is either bought by everybody or else sold by everybody, and whose tax or subsidy rate can be varied independently of those on all other commodities. Instead, like Dixit (1985), we only rely on a uniform poll subsidy (or tax credit).

In order to have a robust procedure ensuring that no consumer can possibly be hurt by any price or dividend change, we therefore assume that each nation $k \in K$ has its consumer price vector q^k frozen at its original level $\bar{q}^k$. Since the producer price vector p must be the same everywhere within the customs union, this implies that each nation is arranging its own commodity taxes in order to freeze its own consumer prices. In particular, there must be no moves toward harmonizing different nations' commodity tax rates within the union. We also assume that all consumers in each nation $k \in K$ first have any dividends and other transfers which make up their unearned income m^i frozen at the values $\bar{m}^i$ which would apply in the absence of any reform, but that they then receive income supplements in the form of a nationwide uniform poll subsidy s^k. The overall result will be that each consumer $i \in I_k$ faces the budget constraint $\bar{q}^k x^i \leq \bar{m}^i + s^k$. So each consumer throughout the union really will benefit if $s^k > 0$ for all $k \in K$, and if integrated markets clear. As in Sections 3 and 5, nobody outside the union is forced to become worse off either because the union's aggregate net imports from outside remain unchanged at $\bar{z}$ and the price vector at which they are traded remains at w.

There is now one fairly easy special case. This is when it is possible to have a union wide uniform poll subsidy s, with $s^k = s$ for all $k \in K$, and when two additional assumptions are satisfied:

(i) $\bar{q}^k \gg 0$ for all $k \in K$ (or, since consumers in country k can only trade commodities in the set $N_k \cup T$, prices of other commodities are irrelevant, so it is enough to assume that $\bar{q}^k_{N_k \cup T} \gg 0$);

(ii) $\xi^i(\bar{q}^k, \bar{m}^i + s)$ is a single-valued demand function $x^i(s)$, for all $k \in K$ and all $i \in I_k$.

Then the new aggregate net demand in the union is given by the continuous function $x(s) := \sum_{k \in K} \sum_{i \in I_k} x^i(s)$. After subtracting the net import vector $\bar{z}$, the vector of net demands which needs to be met by production within the union is $x(s) - \bar{z}$. It will be enough to find a uniform positive level of s with the property that $x(s) - \bar{z}$ intersects the boundary of the (convex) aggregate production set $Y := \sum_{j \in J} Y^j$. For then there will be a price vector $p \neq 0$ which supports Y at a point $x(s) - \bar{z}$. If this price vector emerges as the producer price vector, then producers in the union will be willing to choose a profile $\mathbf{y}^\mathbf{J}$ of net output vectors which satisfies $\sum_{j \in J} y^j = x(s) - \bar{z}$. So all markets will clear and this will be an equilibrium of the required form. Profits in excess of the frozen dividends will be taxed away and used in helping to finance the uniform poll subsidy. Budgets will balance overall.

So now we need to show that there is a positive s for which $x(s) - \bar{z}$ lies on the boundary of Y. First, since $x^i(0) = \bar{x}^i$ for all $i \in I$, it follows that

$$x(0) - \bar{z} = \bar{x} - \bar{z} = \bar{y} \in \text{ int } Y$$

because of the assumption that initial production gives an aggregate net output vector $\bar{y}$ not on the frontier of the union's aggregate production set Y.

Now recall that $\underline{x}^i$ denotes a lower bound to consumer i's feasible set X^i. Recall also how it was assumed that, when $\underline{x}$ is used to denote $\sum_{i \in I} \underline{x}^i$, the truncated set $Y^K(\underline{x})$ of international production profiles satisfying $\sum_{k \in K} y_k \geqq \underline{x}$ is bounded, because bounded inputs can produce only bounded outputs. From this it follows that the truncated aggregate production set $Y(\underline{x}) := \{ y \in Y \mid y \geqq \underline{x} \}$

is also bounded. Now, for all $k \in K$ and $i \in I_k$, local non-satiation implies that $\bar{q}^k [x^i(s) - \underline{x}^i] = \bar{m}^i + s - \bar{q}^k \underline{x}^i$, because of budget exhaustion. The right hand side evidently tends to infinity as $s \to +\infty$. Thus the Euclidean norm of the non-negative vector $x^i(s) - \underline{x}^i$ also tends to infinity as $s \to +\infty$. So therefore does the Euclidean norm of the sum $x(s) - \underline{x} \equiv \sum_{i \in I} [x^i(s) - \underline{x}^i]$. Hence $x(s) - \bar{z}$ must lie outside the bounded set $Y(\underline{x})$ for large enough s. Since $x(s) \geqq \underline{x}$, this implies that $x(s) - \bar{z} \notin Y$ for large enough s. The set of s for which $x(s) - \bar{z} \in Y$ must therefore have a least upper bound which we denote by $\hat{s}$. Because $x(s)$ is continuous and Y is closed, it must be true that $x(\hat{s}) - \bar{z}$ lies on the boundary of Y. Because $x(0) - \bar{z} = \bar{y} \in \text{ int } Y$, it follows that $\hat{s} > 0$, as required.

This relatively simple argument is not really good enough, however. There are unnecessary extra assumptions, but more serious is the fact that financing a union wide uniform poll subsidy will usually require international redistribution. It is therefore more interesting to show that, even with uniform poll subsidies s^k ($k \in K$) that are *specific to each nation* which are entirely financed by national taxation and each nation's appropriate share of the external tariff revenue, there still exists a competitive equilibrium when consumer prices are frozen, but producer prices are free to adjust because of commodity taxes, and when any additional (or reduced) profits that result from the policy reform are fully taxed away (or compensated) by the governments. The existence proof we provide uses a somewhat involved fixed point argument, which is therefore left for the appendix.

In Sections 3 and 5 above we explained why the classical result on the benefit of forming a customs union involves passing Scitovsky's reversal test. In the "distorted" economy with commodity taxation, however, the earlier argument is invalid. It is virtually certain, after all, that the post-reform allocation will not even be constrained Pareto efficient. It is therefore just possible, though somewhat unlikely, that undoing the supply-side reform, going back to the original allocation, and then introducing some other reform that affects only the demand side of the union's economy, could produce in the end a new allocation that is Pareto superior to what emerges from the policy reform being considered in this section. If this were the case, then Scitovsky's reversal test would fail.

7. Free Trade is Superior to Autarky

Free international trade amounts to having a customs union embracing the whole world. Starting with autarky implies that, in effect, $\bar{z}_k = 0$ (all $k \in K$) because there are no initial net imports. It follows that the level of tariff revenue compensation satisfies $R_k(p) = 0$ for all $k \in K$ and all possible producer prices p. This explains the classical result concerning the gains from free trade compared to autarky, even in the absence of any international lump-sum transfers. It bears repeating, however, that this result depends on the possibility of paying national lump-sum compensation and/or of freezing consumer prices, wages, and dividends in the same way as in Sections 3 to 6.

8. The Potential Gains from Increased Production Efficiency

When the supply side of the (world) economy becomes more efficient as a whole, there is a sense in which this case subsumes all the others considered here. Examples of such increased efficiency that either have been considered already or will be considered later on include moves away from managed trade or autarky toward free trade (Sections 7 and 9), as well as the formation of a customs union, as discussed in Sections 3 to 6. Customs unions were dealt with first only because their analysis is rather more complicated, and so the argument needs to be set out in greater detail. All the other results are easy corollaries of those which apply to customs unions. In a single closed economy, of course, there is no rest of the world, nor is there any international trade or compensation for lost tariff revenue to worry about. That greatly simplifies the discussion without changing the fundamental nature of the earlier results.

Other important applications of the same result are to competition policy and other general measures which enhance the general efficiency of industry. Space does not permit a serious discussion here of monopoly power and imperfect competition, or of the measures for alleviating their adverse efficiency and welfare effects. This is left for later work.

9. The Potential Gains from Trade in a Small Country

Consider now just one small trading nation. As in Section 2, assume that the set of goods G can be partitioned into the two disjoint sets T of traded goods and N of non-traded goods. A typical vector $x \in \Re^G$ will be written in the partitioned form $(x_T, x_N) \in \Re^T \times \Re^N = \Re^G$. Assume too that the nation faces a constant border price vector $\bar{p}_T$ for traded goods which is independent of its trade pattern. The nation must then observe some balance of trade constraint of the form

$$\sum_{i \in I} \bar{p}_T \, x_T^i - \sum_{j \in J} \bar{p}_T \, y_T^j \leq \bar{b},$$

where $\bar{b}$ denotes the maximum allowable deficit. This implies that we can represent the possibilities for foreign trade by including in the set J an extra firm f with a production set of the form

$$Y^f := \{ (y_T^f, y_N^f) \in \Re^T \times \Re^N \mid y_N^f = 0;\ \bar{p}_T \, y_T^f \leq \bar{b} \}.$$

Because of arbitrage possibilities, it will then be enough to consider only producer price vectors of the form $(\bar{p}_T, p_N)$ for some non-traded good price vector $p_N \in \Re^N$.

Now we can proceed as in Sections 3 to 6 in order to compare free with managed trade. Indeed, there are very few changes needed in the analysis of that section. The only real difference is that the different resource balance constraints for traded goods need replacing by the above single balance of trade constraint. However, since the traded goods price vector $\bar{p}_T$ is invariable, one can treat all traded goods together as if they were a single Hicksian composite commodity, for which the balance of trade constraint is the appropriate resource balance constraint.

10. Project Evaluation

Another important example is of a project whose net output vector z has positive value at the relevant shadow prices. In fact, in order to ensure that the aggregate production set is convex even after allowing for the choice of whether to adopt the project or not, it will be assumed that the scale of the project can be made arbitrarily small. Thus, the project is assumed to have the effect of replacing a null initial production set $\bar{Y}^P := \{0\}$ by the new production set $Y^P := [0, z]$, where

$$[0, z] := \text{co}\{0, z\} = \{ y^P \mid \exists \lambda \in [0,1] : y^P = \lambda z \}$$

denotes the line interval of points that are convex combinations of the two end-points 0 and z. The corresponding profit function for the project is

$$\pi^P(p) := \max_{y^P} \{ p y^P \mid y^P \in [0, z] \} = \max_{\lambda} \{ \lambda p z \mid \lambda \in [0,1] \} = \max\{ p z, 0 \}.$$

Our test of increasing maximum total profit at all possible producer prices can be expressed as $p \bar{y} < \pi(p) + \pi^P(p)$ for all $p \neq 0$. An uninteresting special case occurs when $\bar{y} \in \text{ int } Y$, because then this test is already passed, and so a potential Pareto gain is possible, without any need to adopt the project even on a small scale. Accordingly we assume that $\bar{y}$ is on the boundary of Y. Then, since Y is assumed to be a convex set, there is a non-empty set

$$P(\bar{y}) := \{ \bar{p} \neq 0 \mid \forall y \in Y : \bar{p} y \leq \bar{p} \bar{y} \} = \{ \bar{p} \neq 0 \mid \pi(\bar{p}) = \bar{p} \bar{y} \}$$

of corresponding support or producer price vectors at which aggregate profits are maximized when the aggregate net output vector is $\bar{y}$. When the boundary of Y is smooth at $\bar{y}$, then $P(\bar{y})$ will consist of non-negative multiples of the normal to Y at $\bar{y}$, in which case it is enough to consider just one price vector in the tests set out below. When Y has a corner at $\bar{y}$, however, there will be a non-trivial convex cone of possible supporting price vectors to consider.

With this extra assumption, the test $p \bar{y} < \pi(p) + \pi^P(p)$ for all $p \neq 0$ is evidently satisfied only if $\bar{p} \bar{y} < \pi(\bar{p}) + \pi^P(\bar{p}) = \bar{p} \bar{y} + \pi^P(\bar{p})$ for all $\bar{p} \in P(\bar{y})$. This evidently implies that $\pi^P(\bar{p}) > 0$ and so $\bar{p} z > 0$ for all $\bar{p} \in P(\bar{y})$.

Conversely, suppose that $p\bar{y} = \pi(p) + \pi^P(p)$ for some price vector $p \neq 0$. Because $p\bar{y} \leq \pi(p)$ and $0 \leq \pi^P(p)$ for all $p \neq 0$, this is only possible if $p\bar{y} = \pi(p)$ and $0 = \pi^P(p)$. But then $p \in P(\bar{y})$ and yet $pz \leq 0$. The condition $\bar{p}z > 0$ for all $\bar{p} \in P(\bar{y})$ is therefore sufficient to ensure that $p\bar{y} < \pi(p) + \pi^P(p)$ for every price vector $p \neq 0$.

So the cost-benefit test $\bar{p}z > 0$ for all $\bar{p} \in P(\bar{y})$ represents a necessary and sufficient condition for the project, when adopted on a suitable scale, to give rise to a production efficiency gain of the kind we have been considering. The test involves valuing the net outputs of the project at ***all possible*** producer prices which could apply ***before*** the project has been put into effect. In the special case considered in Section 9 of a small country exchanging traded goods at the border price vector $\bar{p}_T$, it follows that these border prices are appropriate for valuing traded goods in our cost-benefit test for a supply side efficiency gain.

Note that, even though the cost-benefit test $\bar{p}z > 0$ for all $\bar{p} \in P(\bar{y})$ may be passed, this does not imply that $\hat{p}z > 0$ at the new equilibrium producer price vector $\hat{p}$. Of course, profit maximization implies that $\hat{p}z \geq 0$ in the new equilibrium. Nevertheless, this equilibrium could still have $\hat{p}z = 0$. Also, in this case a Pareto improvement might require the project to be adopted at less than full scale, with $\hat{y}^P = \lambda z$ for some λ satisfying $0 < \lambda < 1$. If $\hat{p}z > 0$ in the new equilibrium, however, then profit maximization implies that $\hat{y}^P$ must equal z, with the project adopted at full scale.

11. Practical Limitations

Supply side policies by themselves do not necessarily produce improved allocations from the point of view of consumers. There are, of course, increased efficiency gains for producers as a whole, in the sense that total profits are higher than they would be if producers did not react to the price changes. But those consumers who have been relying on protected or uncompetitive industries for their livelihoods, directly or indirectly, are obviously vulnerable. The classical theory of the gains from trade, from forming customs unions, or from other supply side policies, requires potential losers to receive lump-sum compensation. These must compensate individual consumers for any loss of earnings they will suffer after the firms which they own, manage, or work for are closed down because they are inefficient. The level of damage needing to be compensated, however, depends on several factors such as how long the employee would have remained with the firm, which is often not known. Thus adequate lump-sum compensation schemes will too often tempt employees and other suppliers to overstate the true extent of their losses.

We have presented an alternative second best case for using supply side policy to enhance production efficiency and increase profits. This rests on a different kind of compensation that may be a little easier to put into practice. As the supply side policy reform comes into effect, it is initially required that all consumer prices, including hourly wage rates net of tax, should be frozen. Then markets must be cleared by adjusting only producer prices, along with the tax wedges between these and the fixed consumer prices. In addition, all after-tax dividend payments to individuals should also be frozen by adjusting the corporate tax system. With such a freeze on prices, wages and dividends after tax, the supplies of labour and the demands for final goods in the consumption sector of the economy should all remain fixed. But production has become more profitable, so that there must be some extra tax revenue for the government. This can then be used to make everybody better off by means of some uniform poll subsidy or other tax change which benefits everybody, provided consumer prices, wages and profits remain frozen so that nobody is made worse off as a result of some price change induced by a change in demand caused by making somebody else better off. We showed how this could often be done even though paying a poll subsidy would itself affect the market clearing vector of producer prices.

A price, wage and dividend freeze on the demand side of the economy may appear to be a theoretical possibility, but it poses many practical problems. For example, the theory requires that wages should be cut for workers who supply a less productive quality of labour, but enforcing this is bound to create problems in practice. Relying on adjusting consumer tax rates (including tax rates for labour income) in order to clear markets is also likely to create many bureaucratic problems and to involve large administrative costs. Within the European Community, for instance, such fine tuning of tax rates would also violate many of the present rules against those specific subsidies to particular firms, industries, or regions of a country which the theory requires. Tax harmonization will make appropriate compensation even harder. Finally, this theory requires that the time paths of prices, wages and dividends be fixed at the levels they would assume in the absence of market integration. For most such prices, however, there is very little information from future markets or elsewhere which can be used to decide what these time paths would be more than a few months ahead. So the information needed to implement the freeze properly is simply lacking.

It is probably better, therefore, to seek something less ambitious than a Pareto improvement from market integration and other supply side policies. Then, however, the case for these policies becomes much weaker. If those who lose are particularly deserving, their losses will be more important than the gains of others, and one cannot favour such policies without some form of compensation. If the compensation is less than perfect, however, the same remains true — some individuals lose overall, while others gain, and there is no way to avoid comparing different individuals' gains and losses. All one can say is that, if better schemes of compensation are introduced for those who lose the most and whose losses are of most social concern, then it is more likely that the gains from supply side policies will outweigh the losses. It is important, however, to ask what compensation will be arranged, and to examine all its effects, before stating that these policies are definitely beneficial.

Appendix: Proof of Existence

As before, suppose that there is an initial allocation $(\bar{\mathbf{x}}^{\mathbf{I}}, \bar{\mathbf{y}}^{\mathbf{J}}) \in \prod_{i \in I} X^i \times \prod_{j \in J} Y^j$ for which $\sum_{i \in I} \bar{x}^i = \sum_{j \in J} \bar{y}^j + \bar{z}$, while for each $i \in I$ the initial net demand vector $\bar{x}^i$ maximizes $U^i(x^i)$ subject to $x^i \in X^i$ and $\bar{q}^k x^i \leq \bar{m}^i$. Now, for each $k \in K$, $i \in I_k$ and $s \geq 0$, let $B^i(s)$ and $\xi^i(s)$ denote respectively the budget set $\{ x^i \in X^i \mid \bar{q}^k x^i \leq \bar{m}^i + s \}$ and the corresponding demand set $\arg\max_{x^i} \{ U^i(x^i) \mid x^i \in B^i(s) \}$ that consumer i in nation k faces when consumer prices are fixed at $\bar{q}^k$ and unearned income is fixed at $\bar{m}^i$, but there is a poll subsidy of s. Of course it must be true that $\bar{x}^i \in \xi^i(0)$ for all $i \in I$.

Write $\underline{x} := \sum_{i \in I} \underline{x}^i$ and $Y_k := \sum_{j \in J_k} Y^j$. Then it was also assumed that the set of possible restricted union wide international production plans

$$Y^K(\underline{x} - \bar{z}) := \{ y^K \in \prod_{k \in K} Y_k \mid \sum_{k \in K} y_k \geqq \underline{x} - \bar{z} \}$$

is a bounded subset of $\Re^{GK}$.

Define the unit ball $B := \{ p \in \Re^G \mid \|p\| \leq 1 \}$ in $\Re^G$, where $\|p\| := \left[\sum_{g \in G} (p_g)^2 \right]^{\frac{1}{2}}$ denotes the usual Euclidean norm of p. For each firm $j \in J$ and producer price vector $p \in B$, let

$$\left. \begin{array}{lcl} \eta^j(p) & := & \arg \\ \pi^j(p) & := & \end{array} \right\} \max_{y^j} \{ p\, y^j \mid y^j \in Y^j \}$$

denote firm j's profit-maximizing net supply vectors and maximized profits at that price vector. Note that $\pi^j(p) \geq 0$. Of course, it is possible that $\eta^j(p) = \emptyset$ and $\pi^j(p) = +\infty$. Nevertheless, for each nation $k \in K$ and producer price vector $p \in B$, let

$$\left. \begin{array}{lcl} \eta_k(p) := \sum_{j \in J_k} \eta^j(p) & = & \arg \\ \pi_k(p) := \sum_{j \in J_k} \pi^j(p) & = & \end{array} \right\} \max_{y_k} \{ p\, y_k \mid y_k \in Y_k \}$$

denote respectively the profit maximizing aggregate net supply correspondence and the maximum possible aggregate profit. Assume (as in the main part of the paper) that $\pi_k(p) > \sum_{j \in J_k} p\, \bar{y}^j$ is always true.

Following Guesnerie (1979), a *tight semi-market equilibrium* in this world economy with frozen consumer prices and dividends but variable producer prices and poll subsidies specific to each nation in the customs union is defined as a producer price vector $\hat{p} \in B$, a collection $\hat{s}^k$ of poll subsidies (all $k \in K$), together with an (equilibrium) allocation $(\bar{\mathbf{x}}^{\mathbf{I}}, \bar{\mathbf{y}}^{\mathbf{J}}) \in \prod_{k \in K} \prod_{i \in I_k} \xi^i(s^k) \times \prod_{j \in J} \eta^j(p)$ for which $\sum_{i \in I} \hat{x}^i = \sum_{j \in J} \hat{y}^j + \bar{z}$.

EXISTENCE THEOREM. *Suppose that, in addition to the assumptions set out above, the initial allocation* $(\bar{\mathbf{x}}^{\mathbf{I}}, \bar{\mathbf{y}}^{\mathbf{J}})$ *satisfies* $\{\bar{x}^i\} = \xi^i(0)$ *for all* $i \in I$*. Then there exists a tight semi-market equilibrium, as defined above, with the additional properties that, for each* $k \in K$*, both* $s^k > 0$ *and the national budget constraint*

$$\#I_k \, \hat{s}^k = \hat{p}\,(\bar{z}_k + \hat{y}_k) + (\bar{q}_k - \hat{p})\,\hat{x}_k - \bar{m}_k$$

is satisfied, where $\bar{m}_k := \sum_{i \in I_k} \bar{m}^i$ *and* $\hat{x}_k := \sum_{i \in I_k} \hat{x}^i$.

PROOF: By hypothesis, the restricted set $Y^K(\underline{x} - \bar{z})$ of possible international production allocations within the customs union is bounded. So there are upper bounds y_k^* and lower bounds $\underline{y}_k$ such that $y^K \in Y^K(\underline{x} - \bar{z})$ only if $\underline{y}_k \leqq y_k \leqq y_k^*$ (all $k \in K$). Define $y^* := \sum_{k \in K} y_k^*$. Note that any feasible allocation $(\mathbf{x}^{\mathbf{I}}, \mathbf{y}^{\mathbf{J}})$ must satisfy the inequalities

$$\underline{x}^i \leqq x^i \leqq y^* + \bar{z} - \sum\nolimits_{h \neq i} \underline{x}^h \text{ (all } i \in I); \quad \underline{y}_k \leqq y_k \leqq y_k^* \text{ (all } k \in K).$$

Now, let $e \in \Re^G_{++}$ be any strictly positive G-vector, and define the compact sets

$$\tilde{X}^i := \{\, x^i \in X^i \mid x^i \leqq y^* + \bar{z} - \sum\nolimits_{h \neq i} \underline{x}^h + e \,\} \text{ (all } i \in I);$$

$$\tilde{Y}_k := \{\, y_k \in Y_k \mid \underline{y}_k - e \leqq y_k \leqq y_k^* + e \,\} \text{ (all } k \in K).$$

Also define the restricted budget, demand and national aggregate supply correspondences by:

$$\tilde{B}^i(s) := \{\, x^i \in \tilde{X}^i \mid \bar{q}^k x^i \leq \bar{m}^i + s \,\} \text{ (all } i \in I);$$

$$\tilde{\xi}^i(s) := \arg\max_{x^i} \{\, U^i(x^i) \mid x^i \in \tilde{B}^i(s) \,\} \text{ (all } i \in I);$$

$$\tilde{\eta}_k(p) := \arg\max_{y_k} \{\, p\, y_k \mid y_k \in \tilde{Y}_k \,\} \text{ (all } k \in K).$$

Note that, when $s \geq 0$, the sets $\tilde{X}^i$ ($i \in I$), $\tilde{Y}_k$ ($k \in K$), and so $\tilde{B}^i(s)$ are all compact and also non-empty. Moreover, since variations in s affect only consumers' wealth levels and not the prices they face, it is easy to adapt standard arguments showing that the correspondences $\tilde{\xi}^i(s)$ ($i \in I$) and $\tilde{\eta}_k(p)$ ($k \in K$) must have non-empty, convex and compact values, as well as closed graphs. Later on we shall make use of the following two product correspondences:

$$\tilde{\xi}^I(s^K) := \prod_{k \in K} \prod_{i \in I_k} \tilde{\xi}^i(s^k); \quad \tilde{\eta}^K(p) := \prod_{k \in K} \tilde{\eta}_k(p).$$

As in Debreu (1959), it is enough to prove existence of an equilibrium relative to these restricted correspondences. For:

LEMMA. *Suppose that $\hat{p} \in B$, that $\hat{s}^k \geq 0$ (all $k \in K$), and that the allocation $(\hat{\mathbf{x}}^\mathbf{I}, \hat{y}^K) \in \tilde{\xi}^I(\hat{s}^K) \times \tilde{\eta}^K(\hat{p})$ satisfies $\sum_{i \in I} \hat{x}^i = \sum_{k \in K} \hat{y}_k + \bar{z}$. Then there is an entire allocation $(\hat{\mathbf{x}}^\mathbf{I}, \hat{\mathbf{y}}^\mathbf{J}) \in \prod_{k \in K} \prod_{i \in I_k} \xi^i(\hat{s}^k) \times \prod_{j \in J} \eta^j(\hat{p})$ satisfying $\sum_{i \in I} \hat{x}^i = \sum_{j \in J} \hat{y}^j + \bar{z}$, as required for equilibrium. Moreover $\bar{q}^k \hat{x}^i = \bar{m}^i + \hat{s}^k$ for all $i \in I_k$ and all $k \in K$.*

PROOF: Under the hypotheses of the Lemma, the allocation $(\hat{\mathbf{x}}^\mathbf{I}, \hat{y}^K)$ is feasible, implying that $\underline{y}_k \leqq \hat{y}_k \leqq y_k^*$ (all $k \in K$) and that $\hat{x}^i \leqq y^* + \bar{z} - \sum_{h \neq i} \underline{x}^h$ (all $i \in I$).

For any $k \in K$, suppose that y_k is any net output vector satisfying $y_k \in Y_k$. Since Y_k is convex, for all $\lambda \in [0,1]$ the convex combination $y_k(\lambda) := \hat{y}_k + \lambda(y_k - \hat{y}_k) \in Y_k$. Moreover, if $\lambda > 0$ is small enough, then $\underline{y}_k - e \leqq y_k(\lambda) \leqq y_k^* + e$, implying that $y_k(\lambda) \in \tilde{Y}_k$. Because $\hat{y}_k \in \tilde{\eta}_k(\hat{p})$, it follows that

$$\hat{p}\, \hat{y}_k \geq \hat{p}\, y_k(\lambda) = \hat{p}\, \hat{y}_k + \lambda\, \hat{p}\, (y_k - \hat{y}_k)$$

and so $\hat{p}\, \hat{y}_k \geq \hat{p}\, y_k$. Since this is true for all $y_k \in Y_k$, one has $\hat{y}_k \in \eta_k(\hat{p}) \equiv \sum_{j \in J_k} \eta^j(p)$, and so $\hat{y}^j \in \eta^j(p)$ for all $j \in J_k$.

For any $k \in K$ and $i \in I_k$, suppose that $x^i \in X^i$ is any net trade vector satisfying $x^i \leqq y^* + \bar{z} - \sum_{h \neq i} \underline{x}^h$ and $\bar{q}^k x^i < \bar{m}^i + \hat{s}^k$. Then there exists $\tilde{x}^i \in \tilde{X}^i$ near x^i with $U^i(\tilde{x}^i) > U^i(x^i)$ and $\bar{q}^k \tilde{x}^i < \bar{m}^i + \hat{s}^k$. So any such $x^i \notin \tilde{\xi}^i(s^k)$. Since $\hat{x}^i \in \tilde{\xi}^i(s^k)$, while $\hat{x}^i \in X^i$ and $\hat{x}^i \leqq y^* + \bar{z} - \sum_{h \neq i} \underline{x}^h$, it follows that $\bar{q}^k \hat{x}^i = \bar{m}^i + \hat{s}^k$.

Now suppose that $\hat{s}^k > 0$ and $i \in I_k$. Suppose too that $x^i \in X^i$ is any net trade vector with $U^i(x^i) > U^i(\hat{x}^i)$. Since X^i is convex, for all small $\epsilon > 0$ and $\lambda > 0$ the two net demand vectors $\tilde{x}^i := x^i + \epsilon(\bar{x}^i - x^i)$ and $x^i(\lambda) :=$

$\hat{x}^i + \lambda(\tilde{x}^i - \hat{x}^i)$ are members of X^i. Since U^i is continuous and quasi-concave, both $U^i(\tilde{x}^i) \geq U^i(\hat{x}^i)$ and $U^i(x^i(\lambda)) \geq U^i(\hat{x}^i)$ for all sufficiently small ϵ and λ, while $x^i(\lambda) \ll y^* + \bar{z} - \sum_{h \neq i} \underline{x}^h + e$ also. Now, because i's preferences are locally non-satiated at $x^i(\lambda)$, there is an infinite sequence of points $x^i_n \in \tilde{X}^i$ satisfying $U^i(x^i_n) > U^i(x^i(\lambda)) \geq U^i(\hat{x}^i)$ $(n = 1, 2, \ldots)$ that converges to $x^i(\lambda)$. Since $\hat{x}^i \in \tilde{\xi}^i(\hat{s}^k)$, it follows that $x^i_n \notin B^i(\hat{s}^k)$ and so $\bar{q}^k x^i_n > \bar{m}^i + \hat{s}^k$ $(n = 1, 2, \ldots)$. Taking the limit as $n \to \infty$ gives $\bar{q}^k x^i(\lambda) \geq \bar{m}^i + \hat{s}^k$, and so

$$\bar{q}^k x^i(\lambda) = \bar{q}^k \hat{x}^i + \lambda \bar{q}^k (\tilde{x}^i - \hat{x}^i) \geq \bar{m}^i + \hat{s}^k = \bar{q}^k \hat{x}^i.$$

Since $\lambda > 0$, this implies that $\bar{q}^k \tilde{x}^i \geq \bar{q}^k \hat{x}^i = \bar{m}^i + \hat{s}^k$. But $\bar{q}^k \bar{x}^i = \bar{m}^i < \bar{m}^i + \hat{s}^k$ and so

$$\bar{m}^i + \hat{s}^k = \bar{q}^k \hat{x}^i \leq \bar{q}^k \tilde{x}^i = \bar{q}^k x^i + \epsilon \bar{q}^k (\bar{x}^i - x^i) < (1 - \epsilon) \bar{q}^k x^i + \epsilon (\bar{m}^i + \hat{s}^k).$$

Therefore $\bar{q}^k x^i > \bar{m}^i + \hat{s}^k$. This proves that $\hat{x}^i \in \xi^i(\hat{s}^k)$ in case $\hat{s}^k > 0$. On the other hand, if $\hat{s}^k = 0$, then $\hat{x}^i \in \tilde{\xi}^i(0) = \xi^i(0) = \{\bar{x}^i\}$ because $\bar{x}^i \in \tilde{X}^i$ and so $\bar{x}^i \in \xi^i(0)$. In either case, therefore, $\hat{x}^i \in \xi^i(\hat{s}^k)$ (all $i \in I_k$) for all $\hat{s}^k \geq 0$. ∎

The existence proof will now be completed by applying Kakutani's fixed point theorem to the Cartesian product of four suitably defined correspondences. Of these, the first two are the consumers' demand correspondence $\tilde{\xi}^I(s^K)$ and the nations' aggregate supply correspondence $\tilde{\eta}^K(p)$ defined above.

Third, the producer price vector p will be adjusted to z, the value of the aggregate excess demand vector $\sum_{i \in I} x^i - \sum_{j \in J} y^j - \bar{z}$. Thus, we define the price adjustment correspondence $P : \Re^G \twoheadrightarrow B$ by

$$P(z) = \begin{cases} \{ z/\|z\| \} & \text{if } z \neq 0; \\ B & \text{if } z = 0. \end{cases}$$

Its value therefore includes the single point $z/\|z\|$ on the boundary of B unless $z = 0$, in which case it consists of the whole of B. The correspondence P has non-empty, convex values and a closed graph. Its domain is bounded and convex.

Fourth and last, for each nation $k \in K$ let

$$\sigma^k(x_k, y_k, p) := \max \left\{ 0, \frac{p(\bar{z}_k + y_k - x_k) + \bar{q}^k x_k - \bar{m}_k + 1 - \|p\|}{\# I_k} \right\}$$

be the function indicating how much non-negative poll subsidy is to be paid out in that nation. The idea of including the term $1 - \|p\|$ is due to Bergstrom (1976).

Each function σ^k is continuous throughout the compact convex domain $D^k := \sum_{i \in I_k} \tilde{X}^i \times \tilde{Y}_k \times B$, and so the range $S^k := \sigma^k(D^k) \subset \Re_+$ is compact. In fact S^k is also a connected interval of the real line, so a convex set.

Notice that because of the definition of S^k, the restricted demand $\tilde{\xi}^i(s)$ will be non-empty for every $i \in I_k$ and $s \in S^k$. Even at the lower bound of S^k one has $\tilde{\xi}^i(0) = \xi^i(0) = \{\bar{x}^i\}$ because $\bar{x}^i \in \tilde{X}^i$ and because of the hypothesis that each individual's demand set is single-valued in the initial situation.

Let D be the Cartesian product domain $\prod_{i \in I} \tilde{X}^i \times \prod_{k \in K} \tilde{Y}_k \times B \times \prod_{k \in K} S^k$ and then define the correspondence $F : D \twoheadrightarrow D$ so that

$$F(\mathbf{x}, y^K, p, s^K) := \tilde{\xi}^I(s^K) \times \tilde{\eta}^K(p) \times P(\sum_{i \in I} x^i - \sum_{k \in K} y_k - \bar{z}) \times \prod_{k \in K} \{\sigma^k(\sum_{i \in I_k} x^i, y_k, p)\}.$$

Note that D is compact and convex, while F has non-empty, convex values and a closed graph. By Kakutani's theorem, F has a fixed point which we denote by $(\hat{\mathbf{x}}^{\mathbf{I}}, \hat{y}^K, \hat{p}, \hat{s}^K)$. To economize on notation, let

$$\hat{x}_k := \sum_{i \in I_k} \hat{x}^i \quad (\text{all } k \in K); \quad \hat{x} := \sum_{k \in K} \hat{x}_k = \sum_{i \in I} \hat{x}^i; \quad \hat{y} := \sum_{k \in K} \hat{y}_k.$$

To demonstrate that this does give the required strict semi-market equilibrium, we will show that $\|\hat{p}\| = 1$, that $\hat{x} = \hat{y} + \bar{z}$, and finally that $\hat{s}^k > 0$ (all $k \in K$).

For all $k \in K$, note that $\hat{x}^i \in \tilde{\xi}^i(\hat{s}^k)$ (all $i \in I_k$). The budget constraint therefore implies that $\bar{q}^k \hat{x}^i \leq \bar{m}^i + \hat{s}^k$. Moreover, the earlier Lemma assures us that this is an equality when $\hat{x} = \hat{y} + \bar{z}$. Therefore

$$\bar{q}^k \hat{x}_k \leq \sum_{i \in I_k} (\bar{m}^i + \hat{s}^k) = \bar{m}_k + \# I_k \, \hat{s}^k \tag{1}$$

with equality when $\hat{x} = \hat{y} + \bar{z}$. Because $\hat{s}^k = \sigma^k(\hat{x}_k, \hat{y}_k, \hat{p})$, it follows that

$$\# I_k \, \hat{s}^k \leq \max\{0, \hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k) + \# I_k \, \hat{s}^k + 1 - \|\hat{p}\|\} \tag{2}$$

with equality when $\hat{x} = \hat{y} + \bar{z}$. So

$$0 \leq \max\{-\# I_k \, \hat{s}^k, \hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k) + 1 - \|\hat{p}\|\} \tag{3}$$

with equality when $\hat{x} = \hat{y} + \bar{z}$.

Since $\hat{p} \in P(\hat{x} - \hat{y} - \bar{z})$, note that $\hat{x} \neq \hat{y} + \bar{z}$ would imply that $\hat{p}(\hat{x} - \hat{y} - \bar{z}) = \|\hat{x} - \hat{y} - \bar{z}\| > 0$ and $\|\hat{p}\| = 1$. Suppose that $\|\hat{p}\| < 1$ were true. Then one would also have $\hat{x} = \hat{y} + \bar{z}$, and so (3) would imply that

$$\hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k) + 1 - \|\hat{p}\| \leq 0.$$

But then summing over k gives

$$\hat{p}(\bar{z} + \hat{y} - \hat{x}) + \#K(1 - \|\hat{p}\|) \leq 0$$

which is impossible if $\|\hat{p}\| < 1$, since that implies $\hat{x} = \hat{y} + \bar{z}$. Therefore $\|\hat{p}\| = 1$ after all.

Thus (3) reduces to

$$0 \leq \max\left\{-\#I_k\,\hat{s}^k,\, \hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k)\right\}$$

which is only possible if $0 \leq \hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k)$ or $\hat{s}^k = 0$ (or both) for each k. But, since $\hat{x}_k \in \tilde{\xi}_k(\hat{s}^k)$ and also $\tilde{\xi}_k(0) = \{\bar{x}_k\}$, it follows that $\hat{s}^k = 0$ implies $\hat{x}_k = \bar{x}_k$. Then, however, our hypothesis that $p\,\hat{y}_k > p\,\bar{y}_k$ for all $p \neq 0$ implies that $\hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k) > \hat{p}(\bar{z}_k + \bar{y}_k - \bar{x}_k) = 0$ whenever $\hat{s}^k = 0$. Therefore, for each k one has $0 \leq \hat{p}(\bar{z}_k + \hat{y}_k - \hat{x}_k)$ with strict inequality if $\hat{s}^k = 0$. Summing over k then gives $0 \leq \hat{p}(\bar{z} + \hat{y} - \hat{x})$ with strict inequality if any $\hat{s}^k = 0$. Yet, as remarked earlier, $\hat{x} \neq \hat{y} + \bar{z}$ would imply that $\hat{p}(\hat{x} - \hat{y} - \bar{z}) > 0$ — a contradiction. Therefore $\hat{x} = \hat{y} + \bar{z}$. Since this implies that $0 = \hat{p}(\bar{z} + \hat{y} - \hat{x})$, one must also have $\hat{s}^k \neq 0$ and so $\hat{s}^k > 0$ (all $k \in K$). ▮

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