Gains from Trade versus Gains from Migration: What Makes Them So Different?

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Latest revision: December 2004; minor corrections: January 2006.

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Abstract: Would unrestricted "economic" migration enhance the potential gains from free trade? With free migration, consumers' feasible sets become non-convex. Under standard assumptions, however, Walrasian equilibrium exists for a continuum of individuals with dispersed ability to afford each of a finite set of possible migration plans. Then familiar conditions ensuring potential Pareto gains from trade also ensure that free migration generates similar supplementary gains, relative to an arbitrary status quo. As with the gains from customs unions, however, wealth may have to be redistributed across international borders.

JEL Classification: F22, F13, D61, C62.

Keywords: Migration, gains from trade, general equilibrium, non-convexities.

Gains from Trade versus Gains from Migration

1 Introduction

1.1 Trade versus Migration

Among policy-minded economists, surely one of the most widely accepted claims must be that international free trade generally has desirable consequences. Propositions concerning the gains from trade are routinely taught. Moreover, it seems that economists have helped provide the intellectual impetus behind the drive toward liberalizing international trade which has been taking place under GATT and now the World Trade Organization. Economists also seem to be helping to promote the new free trade areas that are emerging in several different regions of the world.

Most economists also seem pre-disposed to applaud measures that encourage labour mobility within nations. They worry about rigidities in housing markets that make it harder for workers to move to better jobs. Nobody seems willing to defend the internal passport controls that used to operate in the former Soviet Union. There might be some concern about cities becoming too crowded, or about remote areas becoming depopulated. But these seem generally to be regarded as exceptions to the general idea that labour mobility has facilitated desirable economic growth, and that it is one of the most important mechanisms for interregional risk-sharing, especially within the U.S.A.[1]

[1] See, for instance, the papers by Barro and Sala-i-Martin (1991, 1992), as well as by Blanchard and Katz (1992).

On the other hand, except perhaps for a few specialists in international economics, there are not many in the profession who seem willing to speak out in favour of migration across national borders.[2] Generally, even many of the politicians who would never dream of advocating trade restrictions for economic reasons feel little need to hesitate in condemning "economic" migration as a threat to the employment and other prospects of their electorates. In this regard, Harris (1995, especially ch. 4) would seem to be more accurate in characterizing the threat that politicians really fear as being to the whole concept of the nation state, rather than to the economic interests of their electorates. Especially as those residents who seem most likely to be adversely affected by immigration — unskilled workers who are themselves recent immigrants — are quite likely to lack political power or even influence.

With this background in mind, the obvious question for an economic theorist is whether any model can possibly justify this stark contrast between the apparently widespread desire to promote trade on the one hand while restricting migration on the other. To the extent that moves toward free trade really are beneficial, is there anything fundamentally different about migration which prevents it conferring similar benefits? On the other hand, to the extent that international migration is likely to harm the economic

[2] In this connection, the "specialists" should definitely include Bhagwati (1983, 1984), as well as Brecher and Choudhri (1981), Grossman (1984), Hamilton and Whalley (1984), Kemp (1993), and also Razin and Sadka (1999). Most of the extensive literature on migration, however, discusses the impact of immigration (or occasionally emigration) on national or regional economies, especially labour markets. Where economic costs and benefits are assessed at all, the benefits to the migrants themselves and to their families are often disregarded. Certainly it is rare to pay attention to measures of world rather than national welfare. See Wong (1986b) and Quibria (1988), amongst others.

interests of some existing residents of a nation, why is it any different from free trade, which can also harm the interests of those holding significant stakes in industries destined to become uncompetitive?

1.2 Trade as a Substitute for Migration?

Faced with these questions, much of traditional trade theory seems of little help because it often considers only special models such as Heckscher–Ohlin in which free trade leads to international factor price equalization. This, of course, makes the free movement of either capital or labour entirely irrelevant. Just one recent example is Section 2 of Wellisch and Walz (1998). The same idea appears to underlie the claim of Layard *et al.* (1992, p. 3): "There is an overwhelming case for complete freedom of trade, including agricultural as well as industrial products. ... There is no special virtue in bringing Easterners to the West to produce labor-intensive goods, rather than enabling them to produce those goods at home and then sell them abroad."

But the special models traditionally used in orthodox trade theory often ignore land diversity and other economically relevant aspects of geography. Also, if history had been different, we suspect that international economics might instead have concentrated on other special models where the free movement of both capital and labour leads to international product price equalization, thus making the trade of goods irrelevant — see, for example, Mundell (1957) and Wong (1986a). In this vein, Hamilton and Whalley (1984) come up with huge estimates of efficiency and equity gains to the world as a whole from free migration, even in the absence of free trade. However, they consider only homogeneous labour, so their estimates can be taken only as rough indicators that the issue really does deserve economists' attention.

Our main conclusion will be that, in the first-best setting that is usually used to demonstrate the gains from trade, there is really no purely theoretical argument which can justify free trade without at the same time justifying free migration. Both trade and migration bring gains to some and losses to others. Moreover, except in a few special cases of little practical relevance, the policy measures needed to avoid any individual losses and to ensure that there is a Pareto improvement are much the same for both. To the extent that the situations we consider are unrestrictive, this leaves those who wish to defend one and not the other without any purely theoretical arguments. Indeed, our work shows that, as with trade restrictions, any economic justification for restricting migration must depend in an essential way on particular empirical facts rather than on any generally applicable theoretical analysis.

1.3 Theoretical Background

Our formal argument develops counterparts to the classical propositions on the gains from trade, as originally stated by Samuelson (1939, 1962) and by Kemp (1962). These early works, however, only showed that if trade were freed and if an equilibrium with free trade then came about, the resulting allocation would be Pareto non-inferior. It was not until 1972 that three articles by Chipman and Moore, by Grandmont and McFadden, and by Kemp and Wan, published virtually simultaneously, established when equilibrium would exist under appropriate conditions of free trade. This was a significant step because, without existence results of this kind, the earlier propositions would lack content. Accordingly, the technical contribution of this paper and its successor (Hammond and Sempere, 2005) is to demonstrate similar existence results, but only after overcoming some important obstacles. Specifically, we extend the approach of Grandmont and McFadden (1972), as well as Kemp and Wan (1972), by considering an appropriate "sagacious" wealth distribution rule. We then prove existence of a fixed point in a domain of price and excess demand vectors, which corresponds to a Pareto improving Walrasian equilibrium.[3]

In the absence of public goods, the main obstacle to proving existence of equilibrium with gains from migration arises because of the obvious difficulty a potential migrant faces in being in more than one place at a time. As Malinvaud (1972, pp. 22–3 and 165) argues in connection with consumption in the two cities of Paris and Lyon, such obstacles give rise to non-convexities in consumers' feasible sets. Specifically, an internationally mobile worker may be able to offer one day's labour today on either side of the Atlantic, but even a worker who manged to fly by Concorde would have found it difficult to supply half a day's labour in North America and another half later on the same day in Europe. Because of these non-convexities, the usual existence results do not apply generally even to economies with a continuum of agents. Accordingly it is not enough, following Grossman (1984), Tu (1991) or Kemp (1993), to treat labour services like any other commodity

[3]This contrasts with the approach of Chipman and Moore (1972), who construct a social welfare function in order that its maximum is reached at an allocation where all consumers gain relative to the status quo. They then argue that such an allocation can be decentralized through competitive markets with associated lump-sum transfers. This approach, however, yields a wealth distribution rule that may not be defined out of equilibrium. Moreover, attempts to extend its definition could allow the existence of other equilibria that may not be Pareto superior to the status quo.

in an Arrow–Debreu economy. Indeed, to overcome non-existence problems of the kind investigated by Dasgupta and Ray (1986) and also Coles and Hammond (1991), we follow Mas-Colell (1977) and Yamazaki (1978, 1981) in using dispersion assumptions to guarantee that the aggregate demand correspondence has a relatively closed graph, thus ensuring that a Walrasian equilibrium exists.

It might be thought that the limitations of realistic redistributive policies create another obstacle, as they appear to in Wellisch and Walz (1998), for instance.[4] Free trade and free migration do have different welfare effects in their model. Their results, however, depend on redistributive policies being constrained in ways that may negate gains from trade as well as gains from migration. Thus, there is no contradiction of our first-best results establishing gains from trade and gains from migration under similar circumstances when unlimited redistribution is possible.

1.4 Outline

In the remainder of the paper, Section 2 sets up a general equilibrium model of an international economy with a continuum of agents, a finite set of nations or localities, and complete markets for dated contingent commodities in each nation or location. The only departures from a standard model are those required to make migration plans explicit, and to recognize how the feasible set of net trades in other commodities depends on the migration plan.

[4]See also Wildasin (1994) and Razin and Sadka (1995), where income redistribution is a kind of local public good subject to congestion. This can indeed distort the choice of migration plans. In Hammond and Sempere (2005), however, we show it does not invalidate the gains from *appropriate* migration.

Thereafter, Section 3 sets out the definitions of wealth distribution rules and equilibrium. It also states a lemma claiming existence of a compensated equilibrium — the proof is given in the Appendix.

Next, Section 4 sets out our key dispersion assumption and demonstrates our main result, showing that there are potential Pareto gains from adding free migration to free trade.

Finally, Section 5 contains concluding remarks.

The longer proofs of two lemmas are given in the appendix.

2 Notation, Model and Basic Assumptions

2.1 Nations, Consumers and Commodities

Suppose the world consists of a finite set K of different countries — or, more generally, different physical locations — indexed by k. To allow time for migration as well as uncertainty, consider an intertemporal Arrow–Debreu economy in which D is the finite set of relevant date–event pairs.

Suppose there is a continuum of consumers I indexed by i. Following Aumann (1964) and Hildenbrand (1974), it has been traditional to take $I = [0, 1] \subset \mathbb{R}$. Then, however, Lusin's theorem implies that measurable functions on I have to be continuous except on sets I_ϵ of measure less than ϵ, for $\epsilon > 0$ arbitrarily small. An alternative less restrictive formulation has $I = [0, 1] \times \Theta$, where Θ is the topological space of consumer characteristics. In any case, let $\Im$ be the σ-field of Borel measurable subsets of I. Also, let ν be Lebesgue measure in case $I = [0, 1]$, or any measure on I whose marginal distribution on $[0, 1]$ is Lebesgue, in case $I = [0, 1] \times \Theta$. In both cases, $(I, \Im, \nu)$ is an atomless measure space of consumers.

Each individual consumer $i \in I$ is assumed to have a *migration plan* in the form of a mapping $k^{iD} : D \to K$. Thus, $k^i(d)$ indicates the nation in which consumer i plans to reside and function as an economic agent at each date–event pair $d \in D$. Obviously, the set of all possible migration plans is the (finite) Cartesian product set K^D. At the original date $d = 0$, history determines $k^i(0)$ as the nation which the consumer inhabits as the economy starts. For simplicity, we assume that the set of consumers is fixed.[5]

Assume that there is a finite set $G(d)$ of dated contingent commodities in each date–event $d \in D$. Suppose this set is partitioned into pairwise disjoint components $T(d)$ and $N_k(d)$ ($k \in K$), where $N_k(d)$ is the set of goods in date–event d specific to country k that are not traded internationally, and $T(d)$ is the set of internationally traded goods. Dependence on d allows new commodities, of course, but also allows non-tradeable commodities to become tradeable (or *vice versa*) as a result of trade policy or technical change. It is assumed that each set $N_k(d)$ includes all relevant kinds of labour, since labour is not traded directly across borders. Rather, migrants move across borders to supply labour in other nations. Then the relevant set of dated contingent commodities is $G := \cup_{d \in D} G(d)$ and the finite-dimensional commodity space is $\mathbb{R}^G$.

Let $G_k(d) := T(d) \cup N_k(d)$ denote the subset of goods that can be traded in nation k at date–event d. Also, let $G_k := \cup_{d \in D} G_k(d)$ denote the subset

[5] Of course, it would be more realistic to model consumers being born and raised where their parents choose to reside. But we are unaware of any sufficiently general equilibrium model which includes the results of demographic decisions like this. Moreover, though such a model could be formulated without undue difficulty, it would be hard to apply the Pareto criterion when some individual decisions affect whether other individuals ever come into existence.

of all goods that can be traded in nation k; these will be the goods which can appear as inputs and/or outputs in production activities within nation k. Finally, let $G(k^D) := \cup_{d \in D} G_{k(d)}(d)$ denote the subset that can be traded by a consumer with migration plan k^D.

The following notation will be used for vector inequalities, whenever $x \in \mathbb{R}^G$:

$$\begin{aligned}
&\text{(i)} \quad x \geqq 0 \quad &\Longleftrightarrow \quad &\forall g \in G: \ x_g \geq 0; \\
&\text{(ii)} \quad x > 0 \quad &\Longleftrightarrow \quad &[x \geqq 0 \text{ and } x \neq 0]; \\
&\text{(iii)} \quad x \gg 0 \quad &\Longleftrightarrow \quad &\forall g \in G: \ x_g > 0.
\end{aligned}$$

Also, let 1^G denote the vector $(1, 1, \ldots, 1) \in \mathbb{R}^G$.

2.2 Consumers' Characteristics

Different migration plans obviously incur different costs. For instance, staying in one place for an extended period requires many fewer airline tickets than living two years in Italy, then two years in California, then one year in Germany, and so on.[6] Thus, unless $k^i(d) = k^i(0)$ for all $d \in D$, the vector x^i must include at least some minimal net trades in particular commodities such as transport and shipping. It may also include foreign language instruction.

For this reason, we assume that each consumer i's net trade vector $x^i \in \mathbb{R}^G$ is restricted to a *conditional feasible set* $X^i(k^{iD})$ that is compatible with the chosen migration plan $k^{iD} \in K^D$. Note that $X^i(k^{iD})$ could be empty for some k^{iD} either because the migration plan k^{iD} is physically impossible, or because of legal restrictions that could be removed if freer migration is allowed. A special case is when all migration is prohibited, in which case

[6] These locations reflect one author's actual migration plan during 1989–94.

$X^i(k^{iD})$ is empty unless $k^i(d) = k^i(0)$ for all $d \in D$. Even in this case, our results imply the gains from freer trade.

Our first formal assumption is:

(A.1) For every migration plan $k^{iD} \in K^D$, each consumer $i \in I$ has a (possibly empty) closed conditional feasible set $X^i(k^{iD})$ satisfying $x^i_g = 0$ for all $g \notin G(k^{iD})$. The set $X^i(k^{iD})$ satisfies the *free disposal of commodities* condition requiring that, whenever $x^i \in X^i(k^{iD})$ and $\tilde{x}^i \geqq x^i$ with $\tilde{x}^i_g = 0$ for all $g \notin G(k^{iD})$, then $\tilde{x}^i \in X^i(k^{iD})$. In addition, each consumer $i \in I$ has a non-empty *overall feasible set* defined by

$$F^i := \{\, (x^i, k^{iD}) \in \mathbb{R}^G \times K^D \mid x^i \in X^i(k^{iD})\,\}$$

Note that each conditional feasible set $X^i(k^{iD})$ is not yet required to be convex. This allows us to prove a general existence lemma that is useful in later work discussing public goods subject to congestion — see Hammond and Sempere (2005).

Consumers will be allowed to have preferences over migration plans as well as net trade vectors. In our continuum economy, there is no reason to assume that preferences are convex. So our next assumption is:

(A.2) Each consumer i has a weak preference relation $\succsim^i$ defined on F^i that is reflexive, complete, transitive, continuous, as well as *weakly monotonic in commodities* in the sense that, whenever $x^i \in X^i(k^{iD})$ and $\tilde{x}^i \geqq x^i$ with $\tilde{x}^i_g = 0$ for all $g \notin G(k^{iD})$ and $\tilde{x}^i_g > x^i_g$ for all $g \in G(k^{iD})$, then $(\tilde{x}^i, k^{iD}) \succ^i (x^i, k^{iD})$.[7]

[7]Because $\succsim^i$ is continuous, (A.1) and (A.2) imply that, whenever $x^i, \tilde{x}^i \in X^i(k^{iD})$ with $\tilde{x}^i \geqq x^i$, then $(\tilde{x}^i, k^{iD}) \succsim^i (x^i, k^{iD})$.

Note that $(x^i, k^{iD}) \in F^i \iff (x^i, k^{iD}) \succsim^i (x^i, k^{iD})$ because $\succsim^i$ is reflexive and complete. So each consumer i's feasible set F^i and preference relation $\succsim^i$ are characterized completely by the closed graph of $\succsim^i$, given by

$$\Gamma^i := \{ (x^i, k^{iD}, \tilde{x}^i, \tilde{k}^{iD}) \in F^i \times F^i \mid (x^i, k^{iD}) \succsim^i (\tilde{x}^i, \tilde{k}^{iD}) \}$$

As has become standard since the work of Hildenbrand (1974), we assume:

(A.3) The *consumer characteristic space* Θ of feasible sets F and of preference relations $\succsim$, as represented by their closed graphs $\Gamma \subset \mathbb{R}^G \times K^D \times \mathbb{R}^G \times K^D$, is endowed with the topology of closed convergence and the associated Borel σ-field $\mathcal{B}$. Moreover, the mapping $i \mapsto \Gamma^i$ from I to $\mathbb{R}^G \times K^D \times \mathbb{R}^G \times K^D$ is measurable w.r.t. the respective σ-fields $\Im$ and $\mathcal{B}$.

A *continuum exchange economy*, as defined in Aumann (1964), is a measurable mapping $\mathcal{E} : I \to \Theta$ from the measure space of consumers into the space Θ of individual characteristics. When $I = [0, 1] \times \Theta$, the mapping should obviously satisfy $\mathcal{E}(i, \theta) = \theta$ for every $(i, \theta) \in I$. Then (A.3) is satisfied trivially.

2.3 Production

Next, suppose that there is a finite set of producers $j \in J$. We assume that, even though the owners of a firm can migrate and offer their labour and management services in other countries, they cannot transport any production activities with them. In fact, as Konishi (1996) has suggested for a different model, in our framework too a freely mobile firm or transnational corporation can be decomposed into several different firms, with no more than one in each separate nation. So one may usefully regard each j as a production unit in one location that does not straddle any national border.

Let J_k denote the set of firms based in nation k. Then the different sets J_k are assumed to be pairwise disjoint, with $J = \cup_{k \in K} J_k$. It is also assumed that each producer $j \in J_k$ based in nation k must have a zero net supply of every good except those in the set $G_k = N_k \cup T$ of goods that can be traded in nation k.

The rest of the paper will pay no attention to the individual producers $j \in J$ or to their net output vectors. Instead, all our analysis will involve the aggregate net output vector $y_k = \sum_{j \in J_k} y^j$ and aggregate production set $Y_k = \sum_{j \in J_k} Y^j$ of each nation $k \in K$. Thus:

(A.4) Each nation $k \in K$ has a closed and convex production set $Y_k \subset \mathbb{R}^G$ whose members are net output vectors with components that measure the net outputs per head of world population. In addition, $y_{kg} = 0$ whenever $g \notin G_k$ and $y_k \in Y_k$ — i.e., $Y_k \subset \mathbb{R}^{G_k} \times \{0\}$. Finally, there is *free disposal of commodities* in the sense that, if $y_k \in Y_k$ and $\tilde{y}_k \leqq y_k$ with $\tilde{y}_k \in \mathbb{R}^{G_k} \times \{0\}$, then $\tilde{y}_k \in Y_k$.

Note that the traditional assumption that $0 \in Y_k$ is not required. Indeed, in later work allowing for public goods, it is important not to impose this assumption.

The collection Y_k $(k \in K)$ of national production sets, whose product is $\mathbf{Y}^K := \prod_{k \in K} Y_k$, is also assumed to satisfy the requirement that:

(A.5) For each aggregate lower bound $\underline{y} \in \mathbb{R}^G$, the constrained set of international production allocations defined by

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

is bounded.

This means that bounded aggregate global inputs only allow bounded outputs in each separate country, as well as in the international economy as a whole.

2.4 Feasible Allocations and the Status Quo

An *allocation* is a collection $(\mathbf{x}^I, \mathbf{k}^{ID}, \mathbf{y}^K)$ of a jointly measurable function pair $i \mapsto (x^i, k^{iD}) \in \mathbb{R}^G \times K^D$ specifying the net trade vector and migration plan of each individual $i \in I$, together with a profile of net output vectors $\mathbf{y}^K = \langle y_k \rangle_{k \in K}$. The allocation is *feasible* if $(\mathbf{x}^I, \mathbf{k}^{ID}, \mathbf{y}^K)$ together satisfy:

(i) $(x^i, k^{iD}) \in F^i$ a.e. in I;

(ii) $y_k \in Y_k$ for all $k \in K$;

(iii) $\int_I x^i d\nu = \sum_{k \in K} y_k$.

Note that (iii) requires that the average net demand vector of consumers worldwide should equal the aggregate net output of producers per head of world population.

There will be combined gains from free trade and migration if the economy shifts to an equilibrium allocation that is Pareto superior to a prespecified status quo feasible allocation $(\bar{\mathbf{x}}^I, \bar{\mathbf{k}}^{ID}, \bar{\mathbf{y}}^K)$. Notice that if there is no migration at all in the status quo, then $\bar{k}^i(d) = k^i(0)$ for all $d \in D$ a.e. in I.

For each consumer i and $(\hat{x}^i, \hat{k}^{iD}) \in F^i$, define also the two upper preference sets

$$\begin{aligned} P^i(\hat{x}^i, \hat{k}^{iD}) &:= \{ (x^i, k^{iD}) \in F^i \mid (x^i, k^{iD}) \succ^i (\hat{x}^i, \hat{k}^{iD}) \} \\ \text{and} \quad R^i(\hat{x}^i, \hat{k}^{iD}) &:= \{ (x^i, k^{iD}) \in F^i \mid (x^i, k^{iD}) \succsim^i (\hat{x}^i, \hat{k}^{iD}) \} \end{aligned}$$

with projections onto $\mathbb{R}^G$ given by

$$\begin{aligned} P^i_G(\hat{x}^i, \hat{k}^{iD}) &:= \{\, x^i \in \mathbb{R}^G \mid \exists k^D \in K^D : (x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD}) \,\} \\ \text{and} \quad R^i_G(\hat{x}^i, \hat{k}^{iD}) &:= \{\, x^i \in \mathbb{R}^G \mid \exists k^D \in K^D : (x^i, k^{iD}) \in R^i(\hat{x}^i, \hat{k}^{iD}) \,\} \end{aligned}$$

Then assume that, relative to the status quo:

(A.6) Each upper preference set $R^i_G(\bar{x}^i, \bar{k}^{iD})$ has a lower bound $\underline{x}^i \in \mathbb{R}^G$ such that $x^i \in R^i_G(\bar{x}^i, \bar{k}^{iD})$ implies $x^i \geqq \underline{x}^i$; also, the mapping $i \mapsto \underline{x}^i$ (which is measurable because of (A.3)) has the property that the mean lower bound $\int_I \underline{x}^i d\nu$ is a finite vector in $\mathbb{R}^G$.

Assumption (A.3) ensures that the correspondence $i \mapsto\!\!\!\to R^i_G(\bar{x}^i, \bar{k}^{iD})$ has a measurable graph. So the integral $\int_I R^i_G(\bar{x}^i, \bar{k}^{iD}) d\nu$, which might be called the *aggregate gains from trade and migration* set, is well defined as the set of integrals of all integrable selections from this correspondence — see Hildenbrand (1974, pp. 53–4). Then assumption (A.6) ensures that it is bounded below. In combination with (A.5), (A.6) ensures that whenever $x = \int_I x^i \, d\nu$ for some feasible allocation $(\mathbf{x}^I, \mathbf{k}^{ID}, \mathbf{y}^K)$ with $x^i \in R^i_G(\bar{x}^i, \bar{k}^{iD})$ a.e. in I, then $\int_I \underline{x}^i \, d\nu \;\leqq\; x \;\leqq\; \sum_{k \in K} y_k$ where $\mathbf{y}^K = \langle y_k \rangle_{k \in K}$ belongs to the bounded set $\mathbf{Y}^K \left(\int_I \underline{x}^i \, d\nu \right)$. Hence, there is a bounded feasible subset F of pairs $(x, \mathbf{y}^K) \in \mathbb{R}^G \times \mathbf{Y}^K$ with $x \in \int_I R^i_G(\bar{x}^i, \bar{k}^{iD}) d\nu$.

Following a key idea of Arrow and Debreu (1954), from now on we embed this bounded set F in the interior of a compact Cartesian product set $\hat{X} \times \prod_{k \in K} \hat{Y}_k$, and then replace each Y_k by $\hat{Y}_k$. In equilibrium this loses no generality. It affects the wealth distribution rule out of equilibrium, but this is of no significance for our results.

2.5 Profit Maximization

Let $P := \mathbb{R}^G_+ \setminus \{0\}$ be the domain of possible (unnormalized) semi-positive price vectors.

Assume that producers maximize profits taking the price vector $p > 0$ as given. For each nation $k \in K$, define the net supply correspondence and profit function respectively on the domain P as

$$\left.\begin{array}{lll} \eta_k(p) & := & \arg \\ \pi_k(p) & := & \end{array}\right\} \max_{y_k} \{ p\, y_k \mid y_k \in Y_k \}$$

Because the construction in Section 2.4 makes the set Y_k compact, each correspondence η_k is non-empty valued and has a closed graph relative to $P \times \mathbb{R}^G$; each profit function π_k is continuous on P.

3 Wealth Distribution and Equilibrium

3.1 Wealth Distribution Rules

Define a *wealth distribution rule* $\mathbf{w}^I(p)$ as a mapping $w : I \times P \to \mathbb{R}$. This mapping specifies each consumer i's wealth level $w^i(p)$ as a function that depends on the price vector $p > 0$.

The rule $\mathbf{w}^I(p)$ is said to be *budget feasible* if, for each $p > 0$, the map $i \mapsto w^i(p)$ is measurable, with $\int_I w^i(p) d\nu = \sum_{k \in K} \pi_k(p)$. Thus, mean distributed wealth per head in the world is required to match aggregate profit per head. Nevertheless, international transfers of wealth are allowed, in general. Up to a point, these can take the form of dividend payments to different firms' foreign owners.

Because any equilibrium involves budget balance for each individual, the net wealth transfer per head to the residents of each country must equal the value of net imports at world prices. For this reason, international transfers create imbalances of trade in any resulting equilibrium. Section 3.3 below discusses the extent to which such international transfers can be avoided.

3.2 Sagacious Rules

Given any price vector $p > 0$, define

$$\bar{e}^i(p) := \inf_{x^i, k^{iD}} \{ p\, x^i \mid (x^i, k^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD}) \}$$

as the greatest lower bound on the wealth which consumer i needs to sustain the status quo standard of living. Note that the infimum will be attained as a minimum if $p \gg 0$, but may not be if $p_g = 0$ for some $g \in G$ — for example, if $X = \{(x_1, x_2) \in \mathbb{R}^2_+ \mid x_1\, x_2 \geq 1\}$. Nevertheless, even in this example, one has $\bar{e}^i(p) = 2\sqrt{p_1\, p_2}$ for all $p > 0$, which is a continuous function of the vector p. Generally, in fact:

LEMMA 1: Under assumptions (A.1)–(A.3) and (A.6), the function $(i, p) \mapsto \bar{e}^i(p)$ is integrable w.r.t. i, and continuous and homogeneous of degree one w.r.t. p.

PROOF: See appendix.

The budget feasible wealth distribution rule $\mathbf{w}^I(p)$ is said to be *sagacious* (cf. Grandmont and McFadden, 1972) if, for all $p > 0$, one has:

(i) $w^i(p) \geq \bar{e}^i(p)$ a.e. in I;

(ii) whenever $\int_I \bar{e}^i(p) d\nu < \sum_{k \in K} \pi_k(p)$, then $w^i(p) > \bar{e}^i(p)$ a.e. in I.

Note that expenditure minimization implies that $\bar{e}^i(p) \leq p\, \bar{x}^i$ a.e. in I, whereas profit maximization implies that $\pi_k(p) \geq p\, \bar{y}_k$ for all $k \in K$. Together with feasibility of the status quo allocation, we obtain

$$\int_I \bar{e}^i(p)d\nu \leq \int_I p\,\bar{x}^i\,d\nu = \sum_{k\in K} p\,\bar{y}_k \leq \sum_{k\in K} \pi_k(p)$$

for all $p > 0$.

It follows that (i) is always possible. So is (ii). Indeed, an obvious example of a sagacious distribution rule is

$$w^h(p) = \bar{e}^h(p) + \theta^h \left[\sum_{k\in K} \pi_k(p) - \int_I \bar{e}^i(p)d\nu\right] \quad (\text{all } h \in I,\, p > 0)$$

for any measurable function $i \mapsto \theta^i$ satisfying $\theta^i > 0$ a.e. in I and also $\int_I \theta^i d\nu = 1$.[8] So we assume that:

(A.7) The wealth distribution rule $\mathbf{w}^I(p)$ defined by $w : I \times P \to \mathbb{R}$ is integrable w.r.t. i, continuous and homogeneous of degree one w.r.t. p, and sagacious.

3.3 Can International Transfers Be Avoided?

As Section 3.1 suggests, it might seem desirable to show that free trade with or without free migration can lead to Pareto gains even without international transfers. Yet, the results of Ohyama (1972), Kemp and Wan (1976), Dixit and Norman (1980) and of Grinols (1981) illustrate how achieving Pareto gains from customs unions typically requires international transfers — see also Hammond and Sempere (1995). Treating the world as a whole as if it were one global customs union, these results imply that, starting from arbitrary distorted trade, the gains to free trade may well require international

[8] For an economy with a finite set of consumers $i \in \{1, 2, \ldots, n\}$, Kemp and Wan (1972) consider a similar rule, but with $\theta^i = 0$ for all $i > 1$. Clearly, this does not generalize easily to a continuum economy. Nor does it typically yield a strict Pareto improvement.

transfers. Countries whose terms of trade deteriorate as a result of free trade may need compensation from countries whose terms of trade improve. Of course, in the commonly studied case when the status quo is autarky, such transfers are unnecessary.

In the case of free migration, efficiency requires transfers to be independent of the migration decision. In general, if there are any transfers at all, such independence makes it impossible to achieve balanced transfers among the changing set of current residents of each nation. Instead, we will consider what happens when each nation may be compensated for shifts in its terms of trade, and each nation k's budget is distributed between individuals in the fixed set $I_k(0) := \{ i \in I \mid k^i(0) = k \}$ of those who reside in nation k at the initial date–event 0.

For each nation $k \in K$ and price vector $p > 0$, let $r_k(p) := \int_{I_k(0)} w^i(p) \, d\nu$ denote the wealth per head of world population allocated to the individuals in $I_k(0)$. Clearly, global budget balance implies that $\sum_{k \in K} r_k(p) = \sum_{k \in K} \pi_k(p)$. If there are no international transfers, including those when producers pay dividends to foreign owners, then $r_k(p) = \pi_k(p)$ for all $k \in K$.

However, in order for the wealth distribution rule to be sagacious, as required to ensure gains from trade and migration, the wealth distribution rule should also be *internationally sagacious* in the sense that for all $k \in K$ and $p > 0$ one has $r_k(p) \geq \bar{e}_k(p) := \int_{I_k(0)} \bar{e}^i(p) \, d\nu$, with strict inequality whenever $\sum_{k \in K} \pi_k(p) > \sum_{k \in K} \bar{e}_k(p) = \int_I \bar{e}^i(p) \, d\nu$. Thus each nation k needs its profits $\pi_k(p)$ supplemented by a net subsidy of at least $s_k(p) := \bar{e}_k(p) - \pi_k(p)$ in order that each consumer $i \in I_k(0)$ be left no worse off than in the *status quo*.

Let $\bar{x}_k := \int_{I_k(0)} \bar{x}^i \, d\nu$ denote the *status quo* mean net trade vector per head of world population for the set $I_k(0)$ of consumers. Note then that

$s_k(p) \leq p\,(\bar{x}_k - \bar{y}_k)$, so the net subsidy need not exceed the obvious compensation that nation k needs in order to afford its *status quo* net import vector $\bar{x}_k - \bar{y}_k$. Of course, when $\bar{e}_k(p) \leq \pi_k(p)$ for all $k \in K$ at the equilibrium price vector $p > 0$, international transfers are not needed in equilibrium. Note that this condition is automatically satisfied if the status quo involves autarky.

3.4 Budget Sets and Equilibrium Demands

Given the wealth distribution rule $\mathbf{w}^I(p)$ and price vector $p > 0$, consumer i's *budget set* is

$$B^i(p) := \{\, (x^i, k^{iD}) \in F^i \mid p\,x^i \leq w^i(p) \,\}$$

This set may be empty for some price vectors p on the boundary of $\mathbb{R}^G_+$. However, this creates no difficulties for our later existence proof.

Next, i's *Walrasian* or *uncompensated demand* set is

$$\gamma^i(p) := \{\, (\hat{x}^i, \hat{k}^{iD}) \in B^i(p) \mid (x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD}) \Longrightarrow p\,x^i > w^i(p) \,\}$$

By contrast, i's *compensated demand* set is

$$\gamma^i_C(p) := \{\, (\hat{x}^i, \hat{k}^{iD}) \in B^i(p) \mid (x^i, k^{iD}) \in R^i(\hat{x}^i, \hat{k}^{iD}) \Longrightarrow p\,x^i \geq w^i(p) \,\}$$

Let $\xi^i(p)$ and $\xi^i_C(p)$ be the corresponding projections of these two demand sets onto the commodity space $\mathbb{R}^G$.

Compensated demand is a useful tool in general equilibrium analysis because the graph of the correspondence $p \mapsto\!\!\!\to \gamma^i_C(p)$ is easily shown to be a relatively closed subset of $P \times (\mathbb{R}^G \times K^D)$ provided that F^i is closed, while the preference relation $\succsim^i$ and function $w^i(p)$ are both continuous. Without more restrictions, the same is not true of the uncompensated demand correspondence $p \mapsto\!\!\!\to \gamma^i(p)$, as is well known.

It is easy to show that, given any $p > 0$, assumptions (A.1) and (A.2) together imply that $\gamma^i(p) \subset \gamma^i_C(p)$ and also that $p\, x^i = w^i(p)$ for all $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i_C(p)$.

3.5 Walrasian and Compensated Equilibrium

A *Walrasian equilibrium* is a feasible allocation $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K)$, as defined in Section 2.4, together with a price vector $\hat{p} > 0$, such that:

$$\text{(i) } \hat{y}_k \in \eta_k(\hat{p}) \text{ for all } k \in K; \quad \text{(ii) } (\hat{x}^i, \hat{k}^{iD}) \in \gamma^i(\hat{p}) \text{ a.e. in } I.$$

A *compensated equilibrium* is like a Walrasian equilibrium in that it satisfies condition (i). But it satisfies only a weaker version of condition (ii), requiring that $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i_C(\hat{p})$ a.e. in I.

A *compensated equilibrium with free disposal* replaces the equality in (iii) of Section 2.4 with the inequality $\int_I \hat{x}^i d\nu \leqq \sum_{k\in K} \hat{y}_k$. Because $\hat{p}\, x^i = w^i(\hat{p})$ for a.e. $i \in I$, any such equilibrium has the property that

$$\int_I \hat{p}\hat{x}^i d\nu = \int_I w^i(\hat{p}) d\nu = \sum_{k\in K} \pi_k(\hat{p}) = \sum_{k\in K} \hat{p}\hat{y}_k$$

This implies the *rule of free goods*: if any good $g \in G$ is in excess supply in equilibrium — i.e., if $\int_I \hat{x}^i_g d\nu < \sum_{k\in K} \hat{y}_{kg}$ — then $\hat{p}_g = 0$ for that good.

3.6 Existence of Compensated Equilibrium

The following is our first existence result:

Lemma 2: Suppose that assumptions (A.1)–(A.7) are all satisfied. Then there exists a compensated equilibrium with free disposal $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ such that $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ a.e. in I.

Proof: See appendix.

The next Corollary shows that there also exists a compensated equilibrium without free disposal.

Corollary: Suppose that $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ is a compensated equilibrium with free disposal. Provided that (A.4) holds, there exists a compensated equilibrium $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \tilde{\mathbf{y}}^K, \hat{p})$ (without free disposal) satisfying $\tilde{y}_k \leqq \hat{y}_k$ for all $k \in K$.

Proof: Define $\hat{z} := \int_I \hat{x}^i d\nu - \sum_{k\in K} \hat{y}_k$. The definition of a compensated equilibrium with free disposal implies that $\hat{z} \leqq 0$. For each $k \in K$, define $z_k \in \mathbb{R}^{G_k} \times \{0\}$ as the vector whose non-zero components are given by

$$z_{kg} := \begin{cases} \hat{z}_g & \text{if } g \in N_k \\ \hat{z}_g/\#K & \text{if } g \in T \end{cases}$$

Obviously each $z_k \leqq 0$ and $\sum_{k\in K} z_k = \hat{z}$.

Next, define $\tilde{y}_k := \hat{y}_k + z_k$ for each $k \in K$. Then $\tilde{y}_k \leqq \hat{y}_k$ for each $k \in K$, and also $\tilde{y}_k \in Y_k$ because (A.4) includes free disposal of goods $g \in G_k$. Moreover

$$\int_I \hat{x}^i d\nu - \sum_{k\in K} \tilde{y}_k = \int_I \hat{x}^i d\nu - \sum_{k\in K} (\hat{y}_k + z_k) = \hat{z} - \sum_{k\in K} z_k = 0$$

so the allocation $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \tilde{\mathbf{y}}^K)$ is feasible without free disposal.

Finally, the rule of free goods implies that $\hat{p}_g\, \hat{z}_g = 0$ for all $g \in G$. Thus, given any $K \in K$, one has $\hat{p}_g\, z_{kg} = 0$ for all $g \in G_k$ and so $\hat{p}\, \hat{z}_k = 0$. This implies that $\tilde{y}_k \in \eta_k(\hat{p})$, and so completes the proof that $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \tilde{\mathbf{y}}^K, \hat{p})$ is a compensated equilibrium without free disposal. □

The above proof relies on the free disposal part of (A.4). Instead of free disposal in production, however, one could alternatively rely on the free disposal part of (A.1), together with the weak monotonicity of (A.2). Then a similar but more complicated argument can be used to demonstrate the conclusion of the corollary — i.e., the existence of a compensated equilibrium without free disposal.

4 Dispersion and the Gains from Migration

4.1 The Cheaper Point Lemma

Because assumptions (A.1) and (A.2) imply local non-satiation, a familiar argument shows that $\gamma^i(p) \subset \gamma^i_C(p)$ and so $\xi^i(p) \subset \xi^i_C(p)$. The converse, however, is not true in general. Indeed, it typically relies on the existence of a "cheaper point" combined with the following:

(A.8) For every migration plan $k^{iD} \in K^D$, each consumer $i \in I$ has a convex conditional feasible set $X^i(k^{iD})$.

This assumption allows us to apply the following extension of the well known "cheaper point lemma". Note that it is true even when $p_g = 0$ for some $g \in G$.

Lemma 3: Suppose that (A.1), (A.2) and (A.8) are satisfied. For any fixed pair $i \in I$ and $p > 0$, let $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i_C(p)$ be a compensated demand. Suppose too that, whenever $(x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD})$, the migration plan k^{iD} allows the existence of a "conditional cheaper point" $\tilde{x}^i \in X^i(k^{iD})$ satisfying $p\,\tilde{x}^i < w^i(p)$. Then $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i(p)$.

Proof: Suppose $(x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD})$. Because $X^i(k^{iD})$ is convex and preferences are continuous, the hypotheses imply that there exists some $x^i(\epsilon) := x^i + \epsilon\,(\tilde{x}^i - x^i) \in X^i(k^{iD})$, with $\epsilon \in (0, 1)$ sufficiently close to 0, such that $(x^i(\epsilon), k^{iD}) \in R^i(\hat{x}^i, \hat{k}^{iD})$. Because $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i_C(p)$, it follows that

$p\,x^i(\epsilon) \geq w^i(p)$. But $p\,\tilde{x}^i < w^i(p)$, and so

$$(1-\epsilon)\,p\,x^i + \epsilon\,w^i(p) > (1-\epsilon)\,p\,x^i + \epsilon\,p\,\tilde{x}^i = p\,x^i(\epsilon) \geq w^i(p)$$

Because $\epsilon < 1$, this evidently implies that $p\,x^i > w^i(p)$. This is true for every $(x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD})$, so $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i(p)$. □

4.2 Dispersion

By construction, a sagacious wealth distribution rule generates lump-sum transfers enabling each consumer to afford at least the status quo standard of living. And if $\int_I \bar{e}^i(p) d\nu < \sum_{k \in K} \pi_k(p)$, then almost every consumer i will have some cheaper point (x^i, k^{iD}) in the feasible set F^i that satisfies $p\,x^i < w^i(p)$. However, this may not be enough in our model to prevent a non-null set of individuals $i \in I$ from demanding some pair $(\hat{x}^i, \hat{k}^{iD})$ with a net trade vector $\hat{x}^i$ that is a cheapest point of the relevant *conditional* feasible set $X^i(\hat{k}^{iD})$ given the migration plan $\hat{k}^{iD}$. This creates a boundary problem which could prevent the existence of Walrasian equilibrium. The same phenomenon arises in the models of Dasgupta and Ray (1986) and of Coles and Hammond (1995), where its implications are further analysed.

To avoid this problem entirely, we invoke an additional "dispersion" assumption. This is motivated in part by the *dispersed needs* assumption of Coles and Hammond (1995). Somewhat similar are Mas-Colell's (1977) assumption that the distribution of individuals' endowment vectors is absolutely continuous w.r.t. Lebesgue measure, and especially Yamazaki's (1978, 1981) *dispersed endowments* assumption.

To state this extra assumption formally, first define

$$\bar{X}^i(k^D) := \{\, x^i \in X^i(k^D) \mid (x^i, k^D) \in R^i(\bar{x}^i, \bar{k}^D) \,\}$$

and then let

$$\underline{w}^i(p, k^D) := \min_{x^i} \{ p\, x^i \mid x^i \in \bar{X}^i(k^D) \}$$

be the minimum wealth needed by consumer i at prices $p > 0$ in order to sustain the migration plan k^D without being worse off than in the status quo. By (A.6), this is well defined unless $\bar{X}^i(k^D)$ is empty, or possibly if $p \in \operatorname{bd} \mathbb{R}^G_+$. When the minimum does not exist, there can be no boundary problem anyway, so nothing is lost by defining $\underline{w}^i(p, k^D) := +\infty$. By (A.3), for each fixed $p > 0$ and $k^D \in K^D$, the function $i \mapsto \underline{w}^i(p, k^D)$ is measurable.

Next, for each $p > 0$ and $k^D \in K^D$, define

$$I^*(p, k^D) := \{ i \in I \mid w^i(p) = \underline{w}^i(p, k^D) \}$$

This is the set of individuals whose associated wealth level $w^i(p)$ is *critical* in the sense of being just enough to afford the migration plan k^D without being worse off than in the status quo. Note that each set $I^*(p, k^D)$ is measurable because of (A.3). Then assume:

(A.9) (Dispersion) For every $p > 0$ and $k^D \in K^D$, one has $\nu(I^*(p, k^D)) = 0$.

Because the set K^D is finite, (A.9) implies that the set

$$I^*(p) := \cup_{k^D \in K^D} I^*(p, k^D)$$

satisfies $\nu(I^*(p)) = 0$. So, at any price vector $p > 0$, it is required that at most a null set of consumers have critical wealth levels.

For each $p > 0$ and $k^D \in K^D$, the measure ν on I and the measurable function $i \mapsto (\underline{w}^i(p, k^D), w^i(p)) \in \mathbb{R}^2$ together induce a joint measure $\sigma(p, k^D)$ defined on the Borel sets $B \subset \mathbb{R}^2$ by

$$\sigma(p, k^D)(B) := \nu(\{ i \in I \mid (\underline{w}^i(p, k^D), w^i(p)) \in B \})$$

This is the joint distribution of minimum wealth levels that just make migration plan k^D possible, together with individuals' actual wealth levels $w^i(p)$. Note then that $\nu(I^*(p,k^D)) = \sigma(p,k^D)(E)$, where $E := \{\,(u,v) \in \mathbb{R}^2 \mid u = v\,\}$ denotes the diagonal subset of $\mathbb{R}^2$. Because E has Lebesgue measure zero in $\mathbb{R}^2$, an unnecessarily strong but plausible sufficient condition for (A.9) to hold is that each measure $\sigma(p,k^D)$ should be absolutely continuous w.r.t. Lebesgue measure on $\mathbb{R}^2$ — cf. Mas-Colell (1977).

4.3 Dispersion and Sagacity

For each $p > 0$ and each $i \in I$, a particular critical wealth level is

$$\underline{w}^i(p) := \min_{k^D} \{\, \underline{w}^i(p,k^D) \mid k^D \in K^D \,\}$$

Then assumption (A.9) implies that $w^i(p) > \underline{w}^i(p)$ for a.e. $i \in I$. But (A.7) requires that $\sum_{k\in K} \pi_k(p) = \int_I w^i(p)d\nu$. So when $\sum_{k\in K} \pi_k(p) = \int_I \underline{w}^i(p)d\nu$ for some $p > 0$, it is impossible to satisfy (A.9) with any sagacious wealth distribution rule. Hence, together (A.7) and (A.9) implicitly rule out the possibility that $\sum_{k\in K} \pi_k(p) = \int_I \underline{w}^i(p)d\nu$. Evidently

$$\sum_{k\in K} \pi_k(p) \geq \sum_{k\in K} p\,\bar{y}_k = \int_I p\,\bar{x}^i \geq \int_I \underline{w}^i(p)d\nu$$

It follows that $\sum_{k\in K} \pi_k(p) = \int_I \underline{w}^i(p)d\nu$ only when the *status quo* aggregate net output vector $\sum_{k\in K} \bar{y}_k$ maximizes aggregate profits at prices p and also, for a.e. $i \in I$, the *status quo* net trade vector $\bar{x}^i$ is a cheapest point of $\cup_{k^D\in K^D} \bar{X}^i(k^D)$. So this possibility is a boundary case.

With this in mind, let

$$Z := \sum_{k\in K} Y_k - \int_I \bigcup_{k^{iD}\in K^D} \bar{X}^i(k^{iD})d\nu$$

denote the set of net export vectors in $\mathbb{R}^G$ that the world economy would be capable of producing in principle with an allocation Pareto non-inferior to the status quo, if trade outside the world economy became possible. Because the status quo is a feasible allocation, $0 \in Z$. A familiar assumption which rules out the boundary case is that 0 is an interior point of Z — i.e., $0 \in \operatorname{int} Z$. This interiority condition implies that, for every $p > 0$, there exists $z \in Z$ with $p\,z > 0$. Hence, there must exist $y_k \in Y_k$ for all $k \in K$, as well as $x^i \in \cup_{k^{iD} \in K^D} \bar{X}^i(k^{iD})$ for a.e. $i \in I$, such that $z = \sum_{k \in K} y_k - \int_I x^i d\nu$. But then

$$\sum_{k \in K} \pi_k(p) - \int_I \underline{w}^i(p) d\nu \geq \sum_{k \in K} p\,y_k - \int_I p\,x^i d\nu = p\,z > 0$$

So if $0 \in \operatorname{int} Z$, then the boundary case is impossible. For this reason, (A.7) and (A.9) are together consistent with a broad range of general equilibrium models.

4.4 Any Compensated Equilibrium is Walrasian

The following lemma is used twice in the proof of the main theorem:

Lemma 4: Suppose that (A.8) and (A.9) are satisfied. Let $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ be any compensated equilibrium relative to the wealth distribution rule $\mathbf{w}^I(p)$ such that $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ a.e. in I. Then this compensated equilibrium is Walrasian.

Proof: Consider any $i \notin I^*(\hat{p})$ such that $(\hat{x}^i, \hat{k}^{iD}) \in \gamma_C^i(\hat{p})$. Suppose that $(x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD})$. By definition of $I^*(\hat{p})$, it must be true that $w^i(\hat{p}) \neq \underline{w}^i(\hat{p}, k^{iD}) \leq \hat{p}\,x^i$. One case occurs when $w^i(\hat{p}) < \underline{w}^i(\hat{p}, k^{iD})$, and so $w^i(\hat{p}) < \hat{p}\,x^i$. The second case occurs when $w^i(\hat{p}) > \underline{w}^i(\hat{p}, k^{iD})$, and so there exists some $\tilde{x}^i \in X^i(k^{iD})$ with $\hat{p}\,\tilde{x}^i < w^i(\hat{p})$. But then (A.8) and Lemma 3 imply that $\hat{p}\,x^i > w^i(\hat{p})$.

So in either case one has $\hat{p}\, x^i > w^i(\hat{p})$ whenever $(x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD})$. Hence, it has been proved that $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i(\hat{p})$ whenever $i \notin I^*(\hat{p})$ and $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i_C(\hat{p})$. But in compensated equilibrium the latter is true a.e. in I. By (A.9), it follows that $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i(\hat{p})$ a.e. in I, so the compensated equilibrium is Walrasian. □

4.5 Main Theorem

Our main theorem on gains from trade and migration is as follows:

THEOREM: *Suppose that (A.1)–(A.9) are all satisfied. Then, relative to the wealth distribution rule* $\mathbf{w}^I(p)$ *which satisfies (A.7):*

1. *there exists a Walrasian equilibrium* $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$*;*

2. *every Walrasian equilibrium* $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ *must satisfy* $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ *a.e. in I, with* $(\hat{x}^i, \hat{k}^{iD}) \in P^i(\bar{x}^i, \bar{k}^{iD})$ *a.e. in I unless the status quo is already a Walrasian equilibrium with free migration at the same price vector* $\hat{p}$*.*

PROOF: (1) By the Corollary to Lemma 2, assumptions (A.1)–(A.7) jointly imply that there exists a compensated equilibrium $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ satisfying $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ a.e. in I. By Lemma 4, (A.8) and (A.9) imply that this must be a Walrasian equilibrium.

(2) Let $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ be any Walrasian equilibrium. Because (A.2) implies local non-satiation, a standard argument shows that $\hat{p}\, \hat{x}^i = w^i(\hat{p})$ a.e. in I. By (A.7), $w^i(\hat{p}) \geq \bar{e}^i(\hat{p})$ a.e. in I. Now one case occurs when $w^i(\hat{p}) > \bar{e}^i(\hat{p})$; then preference maximization implies that $(\hat{x}^i, \hat{k}^{iD}) \in P^i(\bar{x}^i, \bar{k}^{iD})$. Alternatively $\hat{p}\, \hat{x}^i = w^i(\hat{p}) = \bar{e}^i(\hat{p})$, in which case $\bar{e}^i(\hat{p})$ is the minimum of $\hat{p}\, x^i$ as (x^i, k^{iD}) range over the set $R^i(\bar{x}^i, \bar{k}^{iD})$; then preference maximization

implies that $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$. Either way, one must have $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ a.e. in I.

Next, note that

$$\int_I w^i(\hat{p})\, d\nu = \sum_{k \in K} \pi_k(\hat{p}) \geq \sum_{k \in K} \hat{p}\ \bar{y}_k = \int_I \hat{p}\, \bar{x}^i\, d\nu \geq \int_I \bar{e}^i(\hat{p})\, d\nu$$

Moreover (A.7) implies that $w^i(\hat{p}) > \bar{e}^i(\hat{p})$ and so $(\hat{x}^i, \hat{k}^{iD}) \in P^i(\bar{x}^i, \bar{k}^{iD})$ a.e. in I unless $\sum_{k \in K} \pi_k(\hat{p}) = \int_I \bar{e}^i(\hat{p}) d\nu$. In this exceptional case, however, because $\pi_k(\hat{p}) \geq \hat{p}\, \bar{y}_k$ for all $k \in K$, it follows that $\pi_k(\hat{p}) = \hat{p}\, \bar{y}_k$ for all $k \in K$. Furthermore, because both $w^i(\hat{p}) \geq \bar{e}^i(\hat{p})$ and $\hat{p}\, \bar{x}^i \geq \bar{e}^i(\hat{p})$ for a.e. $i \in I$, it follows that $w^i(\hat{p}) = \bar{e}^i(\hat{p}) = \hat{p}\, \bar{x}^i$ for a.e. $i \in I$. This shows that $(\bar{\mathbf{x}}^I, \bar{\mathbf{k}}^{ID}, \bar{\mathbf{y}}^K, \hat{p})$ is a compensated equilibrium in this exceptional case and so, by Lemma 4, a Walrasian equilibrium. □

Obviously, a special case is when the status quo results from free trade but restricted migration. Then Theorem 1 implies that there are potential Pareto gains from free migration which supplement those from free trade. Another special case is when no goods are internationally traded, so T is the empty set. Even then, there are potential Pareto gains from free migration. Moreover, as discussed in Section 3.3, these gains do not rely on transfers between sets of individuals $I_k(0)$ residing in different countries $k \in K$ at date 0. However, those who are expected to pay a lump-sum tax should not be able to avoid it by emigrating.

Finally, when migration is impossible for any $i \in I$ because $X^i(k^{iD})$ is empty unless $k^i(d) = k^i(0)$ for all $d \in D$, the theorem is both an extension and a slight strengthening of earlier results on the gains from trade, or on the gains from customs unions.

5 Concluding Remarks

Freeman (1993, p. 449) has put the issue in rather eloquent terms: "Given that the economic analyses of immigration and trade are similar, why do economists lead the charge for free trade but not for free immigration? Support free trade, and you are mainstream. Express doubts, and your friends wonder which industry/union pays your rent (or if you imbibed excessively of an increasing returns drug). But declare yourself for open-door immigration, and you are dismissed as an idealist, maybe even a card-carrying member of a human rights or amnesty group."

In fact, the classical gains from trade theorem shows the Pareto non-inferiority of free trade relative to autarky, without any need for international lump-sum transfers of wealth. If the status quo involves even limited trade, however, compensation for price changes and for losses of tariff revenue may require international transfers.

In our model, proving that there are gains from combining free trade with free migration involves essentially the same need to compensate potential losers. Moreover, proving that there are gains from free migration alone requires starting from a status quo involving free trade but restrictions on migration implying that it is not already a Walrasian equilibrium once individuals are given the opportunity to migrate freely.

Policy makers in real economies are incompletely informed. In Hammond and Sempere (1995), we argued in particular that workers' private information about their career plans would make the standard lump-sum compensation payments of first-best theory incentive incompatible. Thus, first-best gains from trade arguments generally lack practical content.

Following a suggestion of Dixit and Norman (1986), in our earlier work we were able to devise alternative second-best policies ensuring that all individuals would benefit from free trade and other forms of economic liberalization. However, these policies involved unrealistic freezes of consumer prices and after tax dividends. In future work, we intend to explore what similar second-best policies, if any, are able to ensure that free migration leads to a Pareto superior (or non-inferior) allocation. In particular, we shall examine whether, in a second-best economy with private information, there is any theoretical reason why free migration is less likely to be beneficial than free trade. Our conjecture is that any practical difficulties apply equally to labour and commodity market liberalization, so there is no a priori theoretical reason to favour free trade over free migration. In particular, there seems no good economic reason to distinguish international borders from those between different regions of a single nation.

A second apparent obstacle concerns public goods and externalities. Of course, the existing literature on gains from trade has largely neglected these. Indeed, it is precisely this neglect which leaves the door open for environmentalist pressure groups to argue that exceptions to free trade policies should be made when exporting industries in foreign countries face lenient or non-existent controls designed to protect the environment.

In the case of migration, the neglect of public goods and the need to finance them seems especially damaging. As shown in Hammond and Sempere (2005), however, public goods and externalities by themselves invalidate neither the gains from trade nor the gains from *appropriate* migration regulated with *appropriate* residence charges. The key to our argument is that nobody can possibly lose if both the provision of public goods and the congestion levels affecting the costs of producing them are both frozen.

Appendix: Proofs of Lemmas 1 and 2

Lemma 1: Under assumptions (A.1)–(A.3) and (A.6), the function $(i, p) \mapsto \bar{e}^i(p)$ is integrable w.r.t. i, and continuous and homogeneous of degree one w.r.t. p.

Proof: Homogeneity of degree one w.r.t. p is trivial.

To show integrability, for each $i \in I$ and for $n = 1, 2, \ldots$ define the set

$$R^i_n := \{ (x^i, k^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD}) \mid x^i \leqq \bar{x}^i + n\, 1^G \}$$

Obviously, $\bar{x}^i \in R^i_n$ for each i and n. Because preferences are continuous, the set $R^i(\bar{x}^i, \bar{k}^{iD})$ is closed, so by (A.1), each R^i_n is non-empty and compact. Hence, given any price vector $p > 0$, one can define

$$\bar{e}^i_n(p) := \min_{x^i, k^{iD}} \{ p\, x^i \mid (x^i, k^{iD}) \in R^i_n \}$$

which satisfies $\bar{e}^i_n(p) \leq p\, \bar{x}^i$. Standard arguments show that the mapping $i \mapsto \bar{e}^i_n(p)$ is measurable, whereas by (A.6), it is integrably bounded. This implies that the mapping is integrable, for each n. But for each fixed $i \in I$ and $p > 0$, the sequence $\bar{e}^i_n(p)$ is decreasing in n and converges to $\bar{e}^i(p)$ as $n \to \infty$. So the monotone convergence theorem establishes that the mapping $i \mapsto \bar{e}^i(p)$ is integrable for each $p > 0$.

It remains to prove that each $\bar{e}^i(p)$ is continuous w.r.t. p. When (A.1), (A.2) and (A.6) hold, this is an immediate implication of the following:

Claim: Let $X \subset \mathbb{R}^G$ be any non-empty closed set that is bounded below by $\underline{x}$. For each $p \in \mathbb{R}^G_+$, define $\bar{e}(p) := \inf_{x \in X} p\, x$. Then the mapping $p \mapsto \bar{e}(p)$ is continuous.

Proof of Claim: Suppose that $p_n \to p$, where $p_n \in \mathbb{R}^G_{++}$ for $n = 1, 2, \ldots$. Let $e_* := \liminf_{n\to\infty} \bar{e}(p_n)$ and $e^* := \limsup_{n\to\infty} \bar{e}(p_n)$. It is enough to prove that $e^* \leq \bar{e}(p) \leq e_*$.

(1) Given any $x \in X$, the definition of $\bar{e}$ implies that $\bar{e}(p_n) \leq p_n\, x$ for $n = 1, 2, \ldots$. Therefore $e^* \leq \limsup_{n\to\infty} p_n\, x = p\, x$. Since this is true for all $x \in X$, it follows that $e^* \leq \bar{e}(p)$.

(2) Let $H := \{\, g \in G \mid p_g > 0 \,\}$, so $p = (p^H, 0)$ where $p^H \gg 0$. (We use the same notation even if $p \gg 0$, so $H = G$ and $p = p^H$.) Given any $\epsilon > 0$, for each large n one has $\bar{e}(p_n) \leq e^* + \epsilon$. Moreover, there exists $x_n = (x_n^H, x_n^{G\setminus H}) \in X$ such that $p_n\, x_n \leq \bar{e}(p_n) + \epsilon$. Hence

$$p_n^H\, x_n^H \leq e^* + 2\epsilon - p_n^{G\setminus H}\, x_n^{G\setminus H} \leq e^* + 2\epsilon - p_n^{G\setminus H}\, \underline{x}^{G\setminus H}$$

for all large n. Because $p_n^H \to p^H \gg 0$, $p_n^{G\setminus H} \to 0$, and $x_n^H \geqq \underline{x}^H$, it follows that the sequence x_n^H is bounded. So for n large enough, $(p_n^H - p^H)\, x_n^H \geq -\epsilon$ and

$$\begin{aligned} \bar{e}(p_n) \;&\geq\; p_n^H\, x_n^H + p_n^{G\setminus H}\, x_n^{G\setminus H} - \epsilon \;\geq\; p^H\, x_n^H + p_n^{G\setminus H}\, \underline{x}^{G\setminus H} - 2\epsilon \\ &\geq\; p^H\, x_n^H - 3\epsilon \;=\; p\, x_n - 3\epsilon \;\geq\; \bar{e}(p) - 3\epsilon. \end{aligned}$$

This implies that $e_* \geq \bar{e}(p) - 3\epsilon$. Since this is true for all $\epsilon > 0$, we conclude that $e_* \geq \bar{e}(p)$. □

Lemma 2: Suppose that (A.1)–(A.7) are all satisfied. Then there exists a compensated equilibrium $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ with $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ a.e. in I.

Proof: (1) For each $p \gg 0$ and $i \in I$, define the *modified* budget set

$$\bar{B}^i(p) := \{\, (x^i, k^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD}) \mid p\, x^i \leq w^i(p) \,\}$$

Because the wealth distribution rule of (A.7) is sagacious and $p\,x^i$ attains a minimum over the set $R^i(\bar{x}^i, \bar{k}^{iD})$ when $p \gg 0$, it follows that $\bar{B}^i(p)$ is non-empty for a.e. $i \in I$ and all $p \gg 0$.

Next, define the *modified* compensated demand set

$$\begin{aligned} \bar{\gamma}^i_C(p) &:= \gamma^i_C(p) \cap R^i(\bar{x}^i, \bar{k}^{iD}) \\ &= \{ (\hat{x}^i, \hat{k}^{iD}) \in \bar{B}^i(p) \mid (x^i, k^{iD}) \in R^i(\hat{x}^i, \hat{k}^{iD}) \Longrightarrow p\,x^i \geq w^i(p) \} \end{aligned}$$

Also, let $\bar{\xi}^i_C(p)$ denote the projection of $\bar{\gamma}^i_C(p)$ onto $\mathbb{R}^G$. Because the sets $\bar{B}^i(p)$ and $R^i(\bar{x}^i, \bar{k}^{iD})$ are both non-empty and closed, it follows that both $\bar{\gamma}^i_C(p)$ and $\bar{\xi}^i_C(p)$ are non-empty for a.e. $i \in I$ and all $p \gg 0$.

Given the unit simplex Δ of $\mathbb{R}^G$, define the closed domain $\Delta_n := \{ p \in \Delta \mid p \geqq (1/n)1^G \}$ for each integer $n \geq \#G$. Routine arguments establish that, for each $i \in I$, the correspondence $\bar{\xi}^i_C : \Delta_n \twoheadrightarrow \mathbb{R}^G$ has a closed graph.

Because of (A.1)–(A.6), standard arguments show that, for each $p \gg 0$, the correspondence $i \mapsto\!\!\!\rightarrow \bar{\xi}^i_C(p)$ has a measurable graph in $I \times \mathbb{R}^G$. It follows that $\int_I \bar{\xi}^i_C(p) d\nu$, the mean of this correspondence, is well defined as a non-empty subset of $\mathbb{R}^G$. Consider the mean excess demand correspondence $\zeta_n : \Delta_n \twoheadrightarrow \mathbb{R}^G$ defined by $\zeta_n(p) := \int_I \bar{\xi}^i_C(p) d\nu - \sum_{k \in K} \eta_k(p)$. Note that each set Y_k is convex as well as compact when restricted as discussed in Section 2.4. Because the measure ν is non-atomic, standard arguments show that, for each integer $n \geq \#G$, the correspondence ζ_n has non-empty convex values and — because of (A.5) and (A.6) in particular — a compact graph.

Next, for each $n \geq \#G$, consider the domain Z_n equal to the convex hull of the compact set $\zeta_n(\Delta_n)$. Because $Z_n \subset \mathbb{R}^G$ and $\#G$ is finite, Z_n is also compact. Then define the correspondence $P_n(z) := \arg\max_p \{ p\,z \mid p \in \Delta_n \}$ for all $z \in Z_n$. Of course, $P_n(\cdot)$ also has non-empty convex values and a compact graph in $Z_n \times \Delta_n$.

It follows that for each $n \geq \#G$, the correspondence which is defined by $(p, z) \mapsto\!\!\!\to P_n(z) \times \zeta_n(p)$ maps the compact convex set $\Delta_n \times Z_n$ into itself. It also has non-empty convex values and a compact graph. By Kakutani's theorem, for each $n \geq \#G$, there exists a fixed point $(p_n, z_n) \in P_n(z_n) \times \zeta_n(p_n)$ with $p\, z_n \leq p_n\, z_n$ for all $p \in \Delta_n$. Because of (A.2) and (A.7), a standard argument confirms that $z_n \in \zeta_n(p_n)$ implies $p_n\, z_n = 0$, so $p\, z_n \leq 0$ for all $p \in \Delta_n$. In addition, there must exist sequences $(x_n^i, k_n^{iD}) \in \bar{\gamma}_C^i(p_n)$ for a.e. $i \in I$, as well as $y_{kn} \in \eta_k(p_n)$ for all $k \in K$, such that $z_n = \int_I x_n^i \, d\nu - \sum_{k \in K} y_{kn}$ for all $n \geq \#G$.

Now, (A.6) and (A.5) imply that the sequence z_n ($n \geq \#G$) is uniformly bounded below. Also, because Δ_n includes the vector $(1/\#G)\, 1^G$ whose components are all equal to $1/\#G$, and because $p_n \in P_n(z_n)$ with $p_n\, z_n = 0$, it follows that $\sum_{g \in G} z_{ng} \leq 0$ whenever $n \geq \#G$. Hence, the sequence (p_n, z_n) is restricted to a compact subset of $\Delta \times \mathbb{R}^G$. Let $(\hat{p}, \hat{z})$ be the limit of any convergent subsequence.

Because of (A.1) and (A.5), Fatou's Lemma in many dimensions can now be applied as in the (effectively identical) existence proofs to be found in Mas-Colell (1977, p. 451), Yamazaki (1981, pp. 648–52), Khan and Yamazaki (1981, pp. 223–4) or Coles and Hammond (1995, pp. 52–3). Here it guarantees the existence of a subsequence n_r ($r = 1, 2, \ldots$) of $n = \#G, \#G + 1, \#G + 2, \ldots$ together with measurable functions $\hat{x} : I \to \mathbb{R}^G$, $\hat{k}^D : I \to K^D$ and a profile of national net output vectors $\hat{\mathbf{y}}^K$ such that as $r \to \infty$, so $(x_{n_r}^i, k_{n_r}^{iD}) \to (\hat{x}^i, \hat{k}^{iD})$ a.e. in I, while $y_{kn_r} \to \hat{y}_{kn}$ for all $k \in K$ and also $\int_I \hat{x}^i \, d\nu - \sum_{k \in K} \hat{y}_k \leqq \hat{z}$.

Now, for $r = 1, 2, \ldots$ one has $(x_{n_r}^i, k_{n_r}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ for a.e. $i \in I$ and also $y_{kn_r} \in \eta_k(p_{kn_r})$. Because the sets $R^i(\bar{x}^i, \bar{k}^{iD})$ are all closed and each correspondence $\eta_k(\cdot)$ has a closed graph, it follows that the limits as $r \to \infty$

satisfy $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ for a.e. $i \in I$ and $\hat{y}_k \in \eta_k(\hat{p})$ for all $k \in K$. In particular, part (i) of the definition of compensated equilibrium is satisfied.

Next, for any positive integers q and r such that $n_r \geq q \geq \#G$, one has $p_q\, z_{n_r} \leq 0$ for all $p_q \in \Delta_q \subset \Delta_{n_r}$. Taking the limit as $r \to \infty$ gives $p_q\, \hat{z} \leq 0$ for all $p_q \in \Delta_q$. But any $p \in \Delta$ is the limit of a sequence $p_q \in \Delta_q$ $(q \geq \#G)$, so $p\, \hat{z} \leq 0$ for all $p \in \Delta$. Hence $\hat{z} \leqq 0$, implying that $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K)$ is a feasible allocation.

Finally, assumption (A.2) implies that preferences are continuous. So, whenever $(x^i, k^{iD}) \in P^i(\hat{x}^i, \hat{k}^{iD})$ and $(x^i_{n_r}, k^{iD}_{n_r}) \to (\hat{x}^i, \hat{k}^{iD})$ as $r \to \infty$, for all large r one must have $(x^i, k^{iD}) \succ^i (x^i_{n_r}, k^{iD}_{n_r})$. But then, for a.e. $i \in I$, because $(x^i_{n_r}, k^{iD}_{n_r}) \in \bar{\gamma}^i_C(p_{n_r})$, this implies that $p_{n_r}\, x^i \geq p_{n_r}\, x^i_{n_r} = w^i(p_{n_r})$. Taking limits as $r \to \infty$, one has $\hat{p}\, x^i \geq \hat{p}\, \hat{x}^i = w^i(\hat{p})$ a.e. in I. Because of assumptions (A.1)–(A.2), the same inequality $\hat{p}\, x^i \geq w^i(\hat{p})$ also holds whenever $(x^i, k^{iD}) \in R^i(\hat{x}^i, \hat{k}^{iD})$. Hence, $(\hat{x}^i, \hat{k}^{iD}) \in \gamma^i_C(\hat{p})$ for a.e. $i \in I$. This confirms that $(\hat{\mathbf{x}}^I, \hat{\mathbf{k}}^{ID}, \hat{\mathbf{y}}^K, \hat{p})$ is a compensated equilibrium. It was already proved that $(\hat{x}^i, \hat{k}^{iD}) \in R^i(\bar{x}^i, \bar{k}^{iD})$ for a.e. $i \in I$. □

Acknowledgements

The authors should disclose that they are themselves migrants, as natives and citizens of the U.K. and Spain respectively. In fact, for displaying great tolerance of ourselves as temporary or "permanent" immigrants, we are grateful to the citizens of Italy, where our collaboration began, and to those of the countries where we now work. In addition, Hammond owes similar gratitude to the citizens (and often the taxpayers) of Australia, Germany, Belgium, Israel, Japan, Austria, France, and Norway, who have supported his extended visits of at least one month to their respective countries.

Earlier versions of the paper were presented to the Latin American meeting of the Econometric Society in Rio de Janeiro, August 1996, to the 1st conference of the Latin American and Caribbean Economic Association (LACEA) in Mexico City, October 1996, to the European Workshop in General Equilibrium Theory at CORE in May 1997, to the meeting of the European Economic Association in Toulouse, August 1997, to the Conference of the Association for Public Economic Theory in Tuscaloosa, May 1998, to the Graz–Udine workshop in Economic Theory, June 1999, and to the Southern California Economic Theory conference in Santa Barbara, March 2000. For their comments and interest, our gratitude to the audiences there and in seminars at the Universities of Western Ontario, Rome (La Sapienza), California at Riverside, Graz, Oslo, Tokyo, Lausanne, Osaka, Kobe, and Alicante, as well as UCLA, El Colegio de México, ITAM, Keio and Stanford Universities and the National University of Singapore. Our special thanks to Douglas Nelson who, during a visit to Graz in 1996, drew Hammond's attention to much of the background literature in international economics, and also Shinsuke Nakamura of Keio University, for noticing some errors and prompting an improved formulation.

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