International Trade and Consumption Network Externalities

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Abstract: This paper studies the effects of trade liberalization in the presence of consumption network externalities. The framework is applicable to the choice of network products and sheds light on the debate on globalization and culture. In an extended Ricardian model of international trade the paper shows that (i) trade is not Pareto inferior to autarky if the free trade equilibrium is unique, (ii) trade is not Pareto superior to autarky if both countries are diverse (network competition) under free trade, but can be if each country is homogenous (network monopoly), (iii) and when multiple free trade equilibria exist everybody in a country can lose from free trade if that country is homogenous under autarky. Consumers of imported network goods tend to gain, while consumers of exported network goods tend to lose from trade liberalization.

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1 Introduction

The gains from trade theorem is one of the most fundamental results in international trade theory, and perhaps in economics more generally. Of course, trade involves distributional effects, but the gain in a country's aggregate output can often be used to make all individuals better off. Despite, or perhaps because of the relatively few exceptions, most economists believe in the benefits from trade liberalization and globalization. In the present paper I shed new light on the benefits from free trade by revisiting the argument in the context of consumption externatilities. This is an important exercise not only because very little has been done so far (which given the significance of the theorem seems surprising), but also because consumption externalities are likely to be relevant in many debates over the benefits of trade liberalization. Consumers often face the choice between differentiated products which are characterized by network externalities, for example, the choice of a computer operating system and other technology-related products such as video systems and television broadcasting standards. Similarly, in the context of cultural goods people may have an additional benefit from consuming a certain good when others do the same. Watching a movie (or tasting the same wine etc.) when others see it as well allows movie goers to share their experience.[1]

Trade liberalization matters in those contexts because it changes the relative price of goods and thus society's pattern of consumption. This paper addresses therefore the following questions: Is trade Pareto better than autarky? Does the answer depend on the distribution of tastes in society (i.e., the benefits from consuming one good over the other without network considerations), and if so how? And, does the conformity of society's consumption behavior before and after trade liberalization matter? The latter is a nontrivial question because the welfare effects of conforming and nonconforming behavior are tricky when consumers are heterogeneous and network externalities exist. When not all consume the same network good, there is some loss of utility because the network size is not maximal. However, diverse consumption behavior indicates that preferences must be sufficiently heterogeneous. When free trade eliminates diversity in behavior, the welfare effects are not clear *a priori.*

[1]Language adoption may serve as yet another example where in countries with multiple languages individuals must decide which and how many languages they should learn. Lazear (1999) analyzes adoption of language and culture in the context of immigration. A common language facilitates trade, but the incentive to learn is inversely related to the size of the minority in a country.

The following analysis is also useful for understanding the debate about the cultural effects of trade liberalization, a topic that has gained much consideration among economists recently (see section 2). For economists globalization and trade liberalization are good because physical output increases as the result of international specialization, which in turn enlarges the consumption set and makes individuals better off. By contrast, many critics are not so much concerned about the quantities of physical goods being consumed, but the pattern and origin of goods consumed. From that standpoint, the increase in physical consumption of mass produced goods of western origin like McDonald hamburgers, Hollywood movies, and pop music, is seen as negative because it crowds out self-produced or locally manufactured goods. Traditional life-styles vanish.[2] This argument is popular both in many developing countries and in industrialized countries like France, although it is challenged by Cowen (2002) on the basis of anecdotal evidence. Disdier, Head and Mayer (2006) provide econometric evidence that exposure to foreign media influences the name giving to babies in France. In addition, the relevance of the topic is underscored by the UNESCO Universal Declaration on Cultural Diversity, which emphasizes the role of cultural goods as "vectors of identity" and is concerned about current trade imbalances in related sectors.

The key innovation of the paper is to incorporate consumption externalities in the form of two domestic networks into a three-good, two-country Ricardian model of international trade. Besides consuming a composite good individuals must choose between consuming either one of two network goods.[3] When all individuals within a country consume the same network good, this is called *homogeneity* or *network monopoly*. Yet people differ in their taste for network goods and thus in equilibrium both network goods may be consumed (which leads to *diversity* or *network competition*). The terms network competition and network monopoly refer not to the number of firms (there are constant returns to scale and perfect competition in all markets), but rather to how many network goods are traded in the market. The degree of non-conforming behavior depends on the difference in prices of the network goods as well as the utility loss relative to the maximal network size when networks coexist. Trade liberalization changes the relative price of network goods, which in turn drives social consumption behavior and therefore indirectly also the utility losses and gains of being

[2] For a sociology perspective on this see Castells (1997). For an economics analysis of globalization critic Naomi Klein see a recent paper by Paul Segerstrom (2003).

[3] The literature on networks originated in industrial organization with the seminal work by Katz and Shapiro (1985).

in a particular network.

Incorporating the above network structure in a model of international trade based on technological differences allows me to analyze when and why the argument for open borders is strong. Recall that in a standard Ricardian model free trade is always (weakly) Pareto superior relative to autarky as countries specialize according to their comparative advantage. Consistent with this framework all results are derived under the assumptions of perfect competition, constant returns to scale, and identical factor endowments. Of course, many network goods are characterized by increasing returns to scale at the production level. The current model abstracts from this aspect, not because it is unimportant, but in order to focus on consumption externalities.

The first main result proves that in the presence of consumption externalities trade is not Pareto inferior to autarky if the free trade equilibrium is unique. While changes in a society's pattern of consumption due to trade liberalization have the potential to make an individual worse off, there are some individuals who are better off either from the traditional gains from trade due to efficient specialization, or from a favorable shift in consumption pattern, or from both. This is true regardless of whether the country is homogenous or diverse before and after opening borders, as long as there are not multiple equilibria (more on this below), which is a relatively weak requirement. For this reason the traditional gains from trade argument by economists is not completely swamped by network externalities.

The second main result shows whether and when trade liberalization is Pareto improving: When both countries are diverse under free trade, trade is not Pareto superior to autarky. Globalization critics have a point in that even under classical assumptions (constant returns to scale, perfect competition, symmetric country size, one factor of production) some people may lose. Intuitively, network diversity is a double-edged sword. On the one hand it indicates that the distribution of tastes for different network goods is sufficiently wide relative to the price difference. On the other hand, the diversity in consumption choices implies a utility loss. Under free trade the loss becomes more prominent for some individuals who continue to consume the same network good after borders open up. Yet, trade can be Pareto superior to autarky for some parameter values. This happens when both countries are homogenous in the same network good under free trade, thereby eliminating the losses from network competition. This result is in contrast to globalization critics because lack of diversity in consumption patterns is here the cause for Pareto superiority. Homogeneity under free trade is not always Pareto superior to autarky, however, because homogeneity comes at a price. Individuals with strong taste preference for one network good may find it advantageous to give up the consumption of their favored good if the rest of society prefers the other, but would have been better off under autarky when more individuals conform with their choice.

The last main result focuses on the welfare effects in a single country: For certain parameter values everybody in a country loses from free trade when the country is homogenous under autarky. Since the other country is by assumption more efficient in producing the second network good, free trade is consistent with homogeneity in either of the two network goods for some parameter values. When the two equilibria can be ranked in terms of individual welfare for one country, it is possible that the economy moves from the unique, superior and homogenous equilibrium under autarky to the worse homogenous equilibrium under free trade. This can occur only if the support of the distribution of underlying tastes for network goods (which are independent of the network externality) is small relative to the loss when network size is not maximal. The above case also opens up the possibility that trade is Pareto inferior to autarky, which happens if the other country is homogenous in the same good before and after trade liberalization (and hence those individuals are indifferent between closed and open borders).

Together the results highlight the importance of consumer choices. Economists have known for a long time that trade liberalization has distributional effects. In a simple Heckscher-Ohlin model a country's scarce factor loses from trade liberalization, while the abundant factor gains. By contrast, in the present context the gainers are those individuals who before *and* after trade liberalization consume the network good that is imported under free trade because of the favorable shift in society's consumption pattern and the traditional gains from trade. The individuals who consume the exported network good under free trade lose when the society's consumption pattern changes in favor of the imported network good.

The rest of the paper is organized as follows. The next section discusses related literature followed by section 3 that introduces the model and derives some preliminary results. Section 4 provides a characterization of the equilibria under both situations, which is followed in section 5 by the welfare analysis. Section 6 extends the model to other country asymmetries, non-unitary demands for network goods, and international consumption links. The final section concludes.

2 The Literature on Trade, Culture and Consumption Externalities

This paper is part of an emerging literature that attempts to model and understand the role of culture in the context of trade liberalization. In many cases culture is modelled as consumption externality, and for that reason I will survey the literature from this joint perspective. Pandey and Whalley's work (2004) is close in spirit to the present paper by analyzing the role of social networks in the context of trade liberalization. An individual's decision to switch sectors depends not only on the wage differential but also on the benefits from participating in a location specific network. Sector-specific benefits for workers on top of wages are also considered in Suranovic and Winthrop.

A key modelling aspect is the role of heterogeneity among consumers of cultural goods, both within and across countries. For example, Kubota (1999) examines trade negotiations in the presence of network externalities. Unlike the present paper, consumers within a country are identical and hence only one of two network good is consumed. This choice seems appropriate in order to focus on regional vs. multilateral trade liberalization, but at the same time it ignores the interesting case of network competition. Another contribution working with a representative agent approach for the most part is Rauch and Trindade (2005), who focus on consumption externalities within and across countries. This paper is discussed further below.

Other authors make agent heterogeneity within countries a key ingredient of the model. Francois and van Ypersele (2002) argue that protection of cultural goods can be Pareto improving. Using trade in movie pictures as an example, consumers have identical valuations for Hollywood produced movies, but differ in their valuations of local, non-Hollywood movies. Since individuals are interested only in the local movies produced in their own country and there are increasing returns to scale in producing movies, local non-Hollywood movies may be driven out of the market. A tariff on Hollywood movies can be Pareto improving because it makes local movies viable in both markets. Durbin (2002) extends the model by allowing consumers to value the other country's specific good. In that case trade means access to foreign varieties, which makes some consumers better off, but some are possibly worse off. The present paper also assumes heterogenous agents within countries. Unlike Francois and van Ypersele, however, the focus is on network externalities on the consumer side, and economies of scale in production do not play any role.

The literature can also be differentiated by the role of intertemporal links. Rauch and Trindade (2005) consider consumption externalities, both at the national, international and intertemporal level, as cultural diversity in the current period influences the marginal benefit of consumption tomorrow. In contrast to the present paper there are no competing networks and a representative consumer, thereby ignoring the conflict of interest among heterogenous consumers. Bala and Van Long (2005) analyze the effects of trade on cultural diversity. Using replicator dynamics they assume that the number of individuals preferring one type of good over another depends on the fraction of people having the same preference in the previous period as well as the relative price of the two goods. Trade may lead to the extinction of one preference type, depending on endowments and country size. In contrast, the present paper derives the interaction of individual behavior more directly, and consumer behavior is driven by differences in technology. I also provide a complete welfare analysis.

Finally, some papers are dealing mostly with the role of policy intervention in specific markets. Bekkali and Beghin (2005) and Richardson (2006) evaluate cultural content quotas in the context of commercial broadcasting, which is modelled as a public good financed by advertising. The latter author finds that a quota may raise consumer welfare, while the former allows consumers to substitute away from radio listening to leisure, thereby lowering welfare. Neither of the papers though models directly the external effects arising from local content consumption, but simply postulates such benefits. Grossman and Shapiro (1988) examine government policies in the context of counterfeiting of status goods, where the latter offers some additional benefit that buyers of counterfeits wish to acquire as well.

The present work is conceptually related to the theory of conformity developed by Bernheim (1994) and the concept of identity featured in Akerlof and Kranton (2000), papers that otherwise do not address trade liberalization. Bernheim's approach is more general than mine in the sense that individual status depends on the public perception of predispositions, which themselves are unobservable but are signaled through actions. Akerlof and Kranton emphasize the idea of identity as it originates in psychology and sociology, develop a simple two person model to illustrate the concept, and then discuss various applications.

3 The Model

3.1 Model Description

In this section a simple two-country Ricardian model of international trade is set up. In contrast to a standard Ricardian model I assume that individuals care about other individuals' choices, which gives rise to a consumption externality. This is explained in more detail below. I abstract from increasing returns to scale and from country asymmetries other than differences in technology. Each country produces three goods x, y, and z, using a linear technology with labor as the only input. The three-good model goes back to Lewis (1969). The production functions for Home and Foreign are

$$\begin{aligned} X &= \frac{L_x}{a_x}, \quad Y = \frac{L_y}{a_y}, \quad Z = \frac{L_z}{a_z} \\ X^* &= \frac{L_x^*}{a_x^*}, \quad Y^* = \frac{L_y^*}{a_y^*}, \quad Z^* = \frac{L_z^*}{a_z^*}, \end{aligned} \tag{1}$$

where $L_i, i = x, y, z$, is the quantity of labor used in each industry and a_i is the unit labor requirement coefficient in Home, and similar for Foreign. An asterisk denotes foreign country variables. All markets are perfectly competitive.

In each country there is a continuum of consumers of size one. Each individual supplies one unit of labor inelastically. In what follows I focus on the description of Home. Each consumer may purchase good z (a composite good) and one unit of either good x or y (the network goods).[4] One way to think about this setup is to see goods x and y as differentiated products in an industry (say different operating systems), and each person consumes only one of the two. The unit purchase restriction, which is realistic in the case of operating systems, simplifies the analysis of externalities in a general equilibrium trade model. The

[4] Assumptions introduced later will guarantee that consumption of good z only or the network good only will be dominated by consumption of both types of goods. In this sense consumption of a network good is essential and affordable.

assumption is discussed in section 6. Good z is a composite consumption good, comprising all other goods in the economy.

Assume that individual preferences are given by

$$U(b) = c_z + \begin{cases} b + \widetilde{I} - (1-\lambda)I & \text{if individual consumes good } x \\ \\ \widetilde{I} - \lambda I & \text{if individual consumes good } y \end{cases} \tag{2}$$

where c_z is the amount of good z consumed. b is a preference parameter that is uniformly distributed on $[-\overline{b}, \overline{b}]$ for $\overline{b} > 0$, and reflects the taste heterogeneity among consumers independent of network effects (i.e., a positive value of b indicates that the person prefers good x, and by how much, ignoring network effects). The parameter $\widetilde{I}$ is the base utility that each individual obtains when belonging to a network. I assume that $\widetilde{I}$ is sufficiently large so that consumption of a network good dominates consumption of good z only. If this holds, $\widetilde{I}$ plays no further role, as it becomes a constant in the utility function. The base utility from being in a network is reduced by an amount that depends on the pattern of consumption in society. Let $\lambda \in [0, 1]$ be the number and thus fraction of society that consumes good x. λ is therefore a national parameter (an assumption that is discussed in section 6). Utility of an individual who consumes good x is reduced in the amount of $I > 0$ for each individual that consumes good y. Each x consumer's reduction in utility is therefore $(1-\lambda)I$. Clearly, when all individuals consume x, there is no reduction. By analogy, if a person consumes good y, then the individual incurs a loss λI, that is larger the more individuals consume good x.

Let the price of good i be p_i, an individual's budget constraint reads

$$w = p_z c_z + \begin{cases} p_x & \text{if person buys good } x \\ p_y & \text{if person buys good } y \end{cases} \tag{3}$$

where w is the wage rate and thus income, given the assumption that each person inelastically supplies one unit of labor.

Before I analyze optimal consumption choices, I introduce the following assumption. The productivity in the production of network goods is sufficiently high in both countries such that a single country could serve world demand if the world population consumes the same network good. Since world population is two, this amounts to assuming $(a_x, a_y, a_x^*, a_y^*) < 1/2$. In equilibrium therefore each country must produce positive levels of good z, an assumption similar to the one made by Lewis (1969). In addition, the technology assumption ensures that consumption of z must be nonnegative as well everywhere. To see this, note from budget constraint (3) that for $i = x, y$

$$c_z = \frac{w - p_i}{p_z} \geq \frac{w(1 - a_i)}{p_z} > 0,$$

because the price of a good p_i can never exceed Home's production cost in equilibrium (wa_i). This completes the description of the model, which is identical to a standard Ricardian model except for the interdependent consumption behavior.

3.2 Preliminary Results

The equilibrium notion is straightforward. An *autarky equilibrium* is a vector of industry labor inputs and outputs $\{L_{i=x,y,z}, X, Y, Z\}$, a consumption tuple for each individual, consisting of c_z and the variety of the network good consumed (x or y), a price vector $\{p_i, w\}_{i=x,y,z}$, and a critical value $\widehat{\lambda}$ such that (i) all national goods markets and the national labor market clear given prices and $\widehat{\lambda}$, (ii) firms' input-output choices are feasible and maximize profits given the price vector, and (iii) individual consumption choices are feasible and maximize utility taking $\widehat{\lambda}$ and prices as exogenous. In addition, the following must be true: (iv) the number of individuals who prefer buying x based on (iii) must equal $\widehat{\lambda}$. The last condition is the only true novel aspect compared to a standard Ricardian trade model, and amounts together with (iii) to a fixed point requirement.

A *free trade equilibrium* has the same qualitative structure as the autarky equilibrium, with the difference that goods markets are integrated, that is, (i') national labor markets clear and the international markets for all goods are balanced. Each country has its own critical value, $\widehat{\lambda}$ and $\widehat{\lambda}^*$ (see section 6 for the possibility of international consumption links). It is natural but not necessary that the two will coincide, as shown later. In the remainder of this section I derive properties that both autarky and free trade equilibria must satisfy, namely conditions (ii) to (iv).

Before solving for the equilibrium, it is useful to introduce a new terminology.

Definition. A country is called *diverse* (network competition) if $\widehat{\lambda} \in (0, 1)$, and *homogenous* (network monopoly) *in good* $x(y)$ if $\widehat{\lambda} = 1$ ($\widehat{\lambda} = 0$).

I start solving the model with condition (ii). Perfect competition and profit maximization imply

$$p_i \leq wa_i, \quad i = x, y, z, \tag{4}$$

where the equality holds when the output in industry i is strictly positive.

Next consider condition (iii) regarding utility maximization. Recall that consumption of only z is never optimal and $c_z \geq 0$. The decision which network good to consume depends on the price difference of x and y, as well as the preference parameter b. I use the following definition $p \equiv \frac{p_y - p_x}{p_z}$ to denote the price difference in terms of good z. Using (2) and (3), a person buys x if

$$b \geq I(1 - 2\lambda) - p \equiv \widehat{b}(\lambda, p). \tag{5}$$

Condition (5) shows that the decision depends on the magnitude of the taste parameter b relative to I, λ and price difference p. The critical value $\widehat{b}$, which may be below $-\overline{b}$ or above $\overline{b}$, indicates the individual who is indifferent between consuming good x or y, given an arbitrary consumption pattern in society λ and price p. An individual consumes good y when $b < \widehat{b}$. Note that when $\widehat{b}(\lambda, p) \in (-\overline{b}, \overline{b})$, the critical value is strictly decreasing in λ and p. A crucial role below plays the sign of the difference $\overline{b} - I$. Note that when $\overline{b} > I$ the highest valuation individual for good x buys good x even if no one else does, as long as the price of x is less than the price of y.

The individual consumption choice is illustrated in *Figure 1* for an individual with preference parameter b under the assumptions $p > \max\{0, -b\}$. The two lines plot the utility as function of society's consumption pattern λ, given that the consumer either buys x or y. Obviously, $u(x, b)$ is increasing in λ, while $u(y)$ is decreasing. The intersection point gives the critical level of consumption behavior in society which makes the consumer indifferent between the two network goods. Values below (above) the critical value lead to strict preference for good $y(x)$.

An increase in the preference parameter b shifts only the $u(x, b)$ line upwards, thus lowers the threshold level and the set of $\lambda-$values that make the individual prefer good y. For sufficiently large values of b no intersection may exist, and hence the individual prefers good x regardless of what society does (and vice versa for sufficiently low values of b). Another parameter influencing individual decision making is the loss parameter I. An increase in I

rotates both utility curves downward around the maximum utility point. The base utility level $\widetilde{I}$ has no influence.

Turning to equilibrium condition (iv), aggregate demand for good x given an arbitrary consumption pattern in society λ equals the sum of all unit demands from those individuals for which condition (5) holds. Denote aggregate demand by $X^d(\lambda, p)$. A fixed point now requires

$$X^d(\lambda, p) = \int_{\min\{\overline{b}, \max\{-\overline{b}, \widehat{b}\}\}}^{\overline{b}} f(b)db = \frac{\overline{b} - \min\{\overline{b}, \max\{-\overline{b}, \widehat{b}\}\}}{2\overline{b}} = \lambda, \tag{6}$$

where I use for notational convenience $\widehat{b}$ as shortcut for $\widehat{b}(\lambda, p)$. For the moment I treat price p as a parameter. The *min* and *max* requirements stem from the fact that demand can neither exceed one nor become negative. The aggregate demand function can take only a certain number of shapes, as is illustrated in *Figure 2* (and which will be discussed in more detail below). To see this, properties of the aggregate demand function for good x are derived. When $-\overline{b} \leq \widehat{b}(\lambda, p) \leq \overline{b}$, X^d is increasing in λ as $\partial X^d / \partial \lambda = I/\overline{b} > 0$. Otherwise, aggregate demand is independent of λ. Since $\widehat{b}(\lambda, p)$ is monotone in λ, aggregate demand is piecewise linear with at most three segments. If there are three segments, the middle one is increasing in λ, and the other two are independent of λ. In addition, it is useful to have the properties of aggregate demand for good x at $\lambda = 0$ and $\lambda = 1$,

$$X^d(\lambda = 0, p) = \begin{cases} 0 & \text{if} \quad \overline{b} < I - p \\ \frac{\overline{b} - I + p}{2\overline{b}} & \text{if} \quad -\overline{b} \leq I - p \leq \overline{b} \\ 1 & \text{if} \quad I - p < -\overline{b} \end{cases} \tag{7}$$

and

$$X^d(\lambda = 1, p) = \begin{cases} 0 & \text{if} \quad I + p < -\overline{b} \\ \frac{\overline{b} + I + p}{2\overline{b}} & \text{if} \quad -\overline{b} \leq I + p \leq \overline{b} \\ 1 & \text{if} \quad \overline{b} < I + p. \end{cases} \tag{8}$$

I now prove the following preliminary result.

Lemma 1. For given price p :

- If $\overline{b} - I > \max\{p, -p\}$, there exists a unique stable fixed point

$$\widehat{\lambda} = \frac{1}{2}\left(1 + \frac{p}{\overline{b} - I}\right) \in (0, 1). \tag{9}$$

- If $\min\{p,-p\} \le \overline{b} - I \le \max\{p,-p\}$, there exists a unique stable fixed point where

$$\widehat{\lambda} = \begin{cases} 0 & \text{if } p < 0 \\ 1 & \text{if } p > 0. \end{cases}$$

- If $\overline{b} - I < \min\{p,-p\}$, there exist two stable fixed points, $\widehat{\lambda} = 0$ and $\widehat{\lambda} = 1$. An interior fixed point exists but is unstable.

Proof: Consider an interior fixed point, which must be a solution $\lambda \in (0,1)$ to equation (6) or $\overline{b} - \widehat{b}(\lambda) = 2\overline{b}\lambda$. Solving for λ gives (9), which is interior if and only if $-1 < \frac{p}{\overline{b}-I} < 1$, or

$$\overline{b} - I > \max\{p,-p\}.$$

The interior fixed point is stable[5] if

$$\frac{\partial X^d}{\partial \lambda} < 1. \tag{10}$$

Since the slope of aggregate demand is either 0 or $I/\overline{b}$, the interior equilibrium is stable whenever aggregate demand is independent of λ at the fixed point, or when $\overline{b} > I$ in the increasing portion of the aggregate demand curve. The former case, $\partial X^d/\partial\lambda = 0$, can never happen for an interior fixed point. To see this, note that it requires either $0 < X^d(\lambda = 0) < 1$, or $0 < X^d(\lambda = 1) < 1$, or both. Since X^d has at most three segments, these conditions are contradictory because X^d cannot both be dependent on λ at $\lambda = 0$ or $\lambda = 1$, and be independent of λ in order to have the zero slope (see (7) and (8)).

Next consider corner solutions. From (6), $\widehat{\lambda} = 0$ requires that $\min\{\max\{-\overline{b},\widehat{b}\},\overline{b}\} = \overline{b}$, which in turn requires $\widehat{b} \ge \overline{b}$ or $\overline{b} - I \le -p$. Similarly, for $\widehat{\lambda} = 1$ to be a fixed point, $\min\{\max\{-\overline{b},\widehat{b}\},\overline{b}\} = -\overline{b}$ is needed, which necessitates $\overline{b} - I \le p$. This means also that when both $\widehat{\lambda} = 0$ and $\widehat{\lambda} = 1$ are fixed points, the interior fixed point cannot be stable as

[5] Let $r(\lambda, p; b) \in \{x, y\}$ be the optimal choice of the network good of an individual of type b when society's consumption pattern is λ and price is p. Stability is then defined here as follows: An equilibrium pattern of consumption $\widehat{\lambda}$ is called stable if in the neighborhood of the equilibrium the difference between the aggregate number of individuals who consume x and the value of λ diminishes, that is, for all $r(\lambda, p; b) = x$

$$\int_{\underline{b}}^{\overline{b}} r(\lambda, p; b) f(b) db - \lambda \lesseqgtr 0$$

when $\lambda \gtreqless \widehat{\lambda}$. Since the integral is equivalent to aggregate demand for good x, the stability condition follows from differentiation with respect to λ.

$\bar{b} - I < \min\{p, -p\} < 0$ violates the stability condition (10) because $\partial X^d/\partial\lambda = I/\bar{b}$. The corner fixed points are stable by definition because $\partial X^d/\partial\lambda = 0$ at these points. ■

The aggregate demand curve and fixed points are shown in *Figure 2*. Panel 2a shows the unique interior fixed point, which is stable because aggregate demand cuts the 45 degree line from above. Panel 2b refers to the multiple fixed point case, where only the corner points are stable. An example for the unique corner case is shown in panel 2c. Panel 2d depicts an impossible configuration as aggregate demand cannot be dependent on λ at 0 and 1, and at the same time have a zero slope locally.

Lemma 1 is useful in a number of ways. While multiple fixed points can exist given p, there are at most two and they are corner solutions. Any interior fixed point is unique.

4 Equilibrium

4.1 The Closed Economy

I now solve for the autarky equilibrium, which requires to pin down the autarky price p^A. Once this price is found, the rest follows from Lemma 1. To this end - and parallel to the price term definition p - the definition $a \equiv \frac{a_y - a_x}{a_z}$ is used, which describes the productivity difference in producing the two network goods relative to the composite good's unit labor requirement. Obviously, $p^A = \frac{p_y - p_x}{p_z} = \frac{wa_y - wa_x}{wa_z} = a$ if all goods are produced. The sign of a, like the sign of p, is not determined *a priori*. Lemma 1 establishes for any given price p at most two fixed points. This leaves open the possibility that multiple equilibria in p with different consumption pattern could exist, that is, fixed points $\lambda' \neq \lambda''$ exist corresponding to two price terms $p' \neq p''$. In addition, if one network good is not produced, price p is not uniquely determined, as (4) does not have to hold with equality. As it turns out, however, all these concerns about multiplicity and indeterminacy are not justified. Nothing is lost by assuming that the autarky price always equals a. If for this price two corner equilibria exist according to Lemma 1, a different price leads to fixed points that must also be corner equilibria in terms of λ. Moreover, if for such a price a unique interior fixed point exist, then there cannot exist another price such that a corner equilibrium emerges as fixed point.

Lemma 2. Suppose there exists an autarky equilibrium which is unique given equilibrium price p. Then there does not exist another equilibrium price $p' \neq p$ which has a unique fixed point and a different consumption pattern.

Proof: First, there cannot be two different interior equilibria because an interior equilibrium requires $p = a$. Consider next a corner equilibrium, say $\lambda = 0$, which - using (7) and (8) or Lemma 1 - requires $a \leq p \leq \bar{b} - I \leq -p \leq -a$, where the two inequalities in the middle follow from the assumption that the fixed point is unique. The outside inequalities come from using $p_x \leq wa_x$. A second, interior equilibrium under price p' requires $p' = a$ and $\bar{b} - I > \max\{p', -p'\}$. These requirements are inconsistent with the corner equilibrium: When $a > 0$, the corner equilibrium implies $\bar{b} - I < 0$, while the interior equilibrium calls for $\bar{b} - I > 0$. Similarly, when $a < 0$ the interior equilibrium requires $\bar{b} - I \geq -p' = -a > 0$, a contradiction.

The last step is to consider the other corner equilibrium, $\lambda = 1$, as a second equilibrium besides $\lambda = 0$. Lemma 1 implies $-a \leq -p' \leq \bar{b} - I \leq p' \leq a$, if it is to be unique given p'. This contradicts the assumption that $\lambda = 0$ is an equilibrium however. ■

Lemmas 1 and 2 now give immediately the first main result by setting $p^A = a$.

Proposition 1. An autarky equilibrium exists for $p^A = a$ and has the following properties:

(a) If $\bar{b} - I > \max\{a, -a\}$, the equilibrium is unique, stable, and Home is diverse (network competition), where $\widehat{\lambda}^A = \left(1 + \frac{a}{\bar{b}-I}\right)/2$.

(b) If $\bar{b} - I \leq \max\{a, -a\}$, the equilibrium is stable and Home is homogenous (network monopoly).

  (b1) The equilibrium is unique if $\min\{a, -a\} \leq \bar{b} - I \leq \max\{a, -a\}$. Home is homogenous in x ($\widehat{\lambda}^A = 1$) if $a > 0$, and homogenous in y ($\widehat{\lambda}^A = 0$) if $a < 0$.

  (b2) There exist two equilibria, in which Home is homogenous in x or y if $\bar{b} - I < \min\{a, -a\}$.

Proposition 1 is illustrated in *Figure 3* for the case where $a > 0$, that is good y is more costly to produce than x. Depending on the value of $\bar{b} - I$ relative to a, the autarky equilibrium is unique or not, and is either diverse or homogenous. Diversity is more likely the larger the difference between the preference parameter for the person with the highest taste for good x ($\overline{b}$) and the value of the loss parameter (I), holding technology constant. An increase in $\overline{b}$ means *ceteris paribus* that preferences are more heterogeneous and the incentive to choose either x or y increases for those at the end of the taste distribution. A similar figure applies when $a < 0$. In this case the only difference is that the middle segment of *Figure* 3 is replaced by a unique equilibrium in which the country is homogenous in good y, that is, $\widehat{\lambda} = 0$. The comparative statics of $\widehat{\lambda}^A$ with respect to $\overline{b}$ and I depend on the sign of a, whose sign is determined by the absolute difference in unit labor coefficients of x and y.

For later comparison it is useful to write down equilibrium autarky utility levels conditional on the type of network good consumed,

$$\begin{aligned} u^A(x,b) &= \frac{1-a_x}{a_z} + b + \widetilde{I} - (1-\widehat{\lambda}^A)I \\ u^A(y) &= \frac{1-a_y}{a_z} + \widetilde{I} - \widehat{\lambda}^A I, \end{aligned} \tag{11}$$

where A denotes autarky values, and $\widehat{\lambda}^A$ follows from Proposition 1. Note that $u^A(y)$ is independent of b.

4.2 Free Trade

Recall that Foreign is identical to Home except for technology parameters. Thus $I = I^*, \overline{b} = \overline{b}^*$, and countries have the same population. To make trade potentially different from autarky, I assume

$$\frac{a_x}{a_x^*} < \frac{a_z}{a_z^*} < \frac{a_y}{a_y^*}. \tag{12}$$

This assumption narrows down the trading structure, without fixing it entirely. Condition (12) implies that under free trade Home produces and exports good x, while Foreign produces and exports good y, if all goods are consumed (recall that both countries must produce good z). Any other ordering of labor coefficients than (12) would open up the possibility that a country exports both x and y, something that appears less interesting for the present purpose. The assumption is also consistent with a situation in which each network good can be produced only in one country (which seems reasonable in the case of cultural goods, say French wine in France or Hollywood movies in the U.S., which can be formalized by assuming that a_y and a_x^* go toward infinity).

Condition (12) implies $a > a^*$ because from (12) I obtain $\frac{a_x}{a_z} < \frac{a_x^*}{a_z^*}$ and $\frac{a_y^*}{a_z^*} < \frac{a_y}{a_z}$, which in turn leads to $\frac{a_y}{a_z} - \frac{a_y^*}{a_z^*} > 0 > \frac{a_x}{a_z} - \frac{a_x^*}{a_z^*}$, and thus $a = \frac{a_y - a_x}{a_z} > \frac{a_y^* - a_x^*}{a_z^*} = a^*$. Foreign's autarky equilibrium has the same qualitative structure as the one given in Proposition 1. Depending on the sign of a^*, however, the range of values for $\overline{b} - I$ under which the foreign economy is diverse, can be larger or smaller. For example, if $a > a^* > 0$, Foreign is diverse for a larger set of values of $\overline{b} - I$. The reverse is true, however, if $-a^* > a > 0$.

The definition of a free trade equilibrium follows now the one under autarky with the difference that goods markets are integrated (while labor markets stay national) and consumers in both countries maximize utility given their national parameter λ and λ^* respectively. The critical value $\widehat{\lambda}$ has the same structure as in (9), assuming an interior solution, although now relating to the free trade price p^T. In the following I use superscript T to indicate free trade values (as opposed to A for autarky). Also I normalize the price of the composite good to one, $p_z^T = 1$.

Some preliminary insights are straightforward. With the price normalization, the free trade relative price difference becomes

$$p^T = \frac{p_y^T - p_x^T}{p_z^T} = w^{*T} a_y^* - w^T a_x, \tag{13}$$

if all goods are produced in equilibrium. Since in this situation both countries can serve the maximum world demand for either network good, wages can be deduced from marginal cost pricing in the non-network good production, that is, $w^{*T} = 1/a_z^*$ and $w^T = 1/a_z$. The free trade price becomes then

$$p^T = \frac{a_y^*}{a_z^*} - \frac{a_x}{a_z} \equiv \widetilde{a}, \tag{14}$$

where $\widetilde{a}$ reflects the price difference of network goods in terms of the composite good, when countries produce according to their comparative advantage. In (14) it is assumed that all goods are produced in equilibrium. Similar to Lemma 2 for autarky, however, nothing is lost by assuming that the price under free trade is given by (14) even when both countries are homogenous under free trade.

It is now easy to see that condition (12) implies $a > \widetilde{a} > a^*$.

One may conjecture that $\widehat{\lambda}^T = \widehat{\lambda}^{*T}$ since countries are symmetric except for technology and they face the same price vector. This is true when the equilibrium is interior in terms of λ, but not in the case of multiple corner solutions. Lemma 1 shows that the consumption behavior is unique when λ is interior, and for a price p that leads to an interior equilibrium there cannot exist a corner equilibrium simultaneously. However, the same lemma demonstrates that for a certain price range both $\lambda = 0$ and $\lambda = 1$ are solutions to the fixed point problem. For this reason it is possible that the two countries adopt different consumption patterns (but both are homogenous) even though they face the same price vector and are identical except for technology.

The proof of the following result then follows from Prop. 1 by replacing a with $\widetilde{a}$, taking into account the possibility that countries differ in consumption behavior for certain parameter values.

Proposition 2. In a free trade equilibrium $p^T = \widetilde{a}$.

a) If $\overline{b} - I > \max\{\widetilde{a}, -\widetilde{a}\}$, the equilibrium is unique and each country is diverse (network competition), where $\widehat{\lambda}^T = \left(1 + \frac{\widetilde{a}}{\overline{b}-I}\right)/2$.

b) If $\overline{b} - I \leq \max\{\widetilde{a}, -\widetilde{a}\}$, each country is homogenous (network monopoly). The equilibrium is unique if $\min\{\widetilde{a}, -\widetilde{a}\} \leq \overline{b} - I \leq \max\{\widetilde{a}, -\widetilde{a}\}$. Each country is homogenous in x ($\widehat{\lambda}^T = 1$) if $\widetilde{a} > 0$, and homogenous in y ($\widehat{\lambda}^T = 0$) if $\widetilde{a} < 0$. There exist multiple equilibria, in which each country is homogenous in either one of the two network goods (and each country's choice is independent from the other) if $\overline{b} - I < \min\{\widetilde{a}, -\widetilde{a}\}$.

The possibility that the two countries specialize in different network goods under free trade can occur only in the presence of multiple equilibria, which in turn requires that the distribution of tastes is narrow relative to the reduction in utility when network size is not maximal.

Under free trade the equilibrium utility level for each type of consumer at Home is

$$\begin{aligned} u^T(x,b) &= \frac{1-a_x}{a_z} + b + \widetilde{I} - (1-\widehat{\lambda}^T)I \\ u^T(y) &= \frac{1}{a_z} - \frac{a_y^*}{a_z^*} + \widetilde{I} - \widehat{\lambda}^T I. \end{aligned} \tag{15}$$

The next section deals with the welfare effects of trade liberalization.

5 Welfare Effects of Trade Liberalization

This section compares autarky and free trade and thus provides an assessment of the welfare effects of trade liberalization. As a first step it is helpful to compare society's consumption pattern in the two situations. As noted above, the consumption pattern is the same in both countries under free trade for certain conditions. In that case $\widehat{\lambda}^T = \widehat{\lambda}^{*T}$. More precisely, we have

Lemma 3. a) If $\widehat{\lambda}^A = \widehat{\lambda}^{*A}$, then countries cannot be diverse under autarky. b) The network consumption pattern under free trade is bounded by the consumption pattern under autarky in the following sense: $\widehat{\lambda}^T \leq \widehat{\lambda}^A$ when $\widehat{\lambda}^A > 0$, and $\widehat{\lambda}^{*T} \geq \widehat{\lambda}^{*A}$ when $\widehat{\lambda}^{*A} < 1$.

Proof: a) Assume $\widehat{\lambda}^A = \widehat{\lambda}^{*A} \in (0, 1)$, where the values of the consumption patterns are given by (9) with $p^A = a = a^* = p^{*A}$. But this contradicts (12), as shown above.

b) I analyze the case of Home first. The result holds trivially when $\widehat{\lambda}^A = 1$. Consider next that Home is diverse under autarky and assume to the contrary $\widehat{\lambda}^T > \widehat{\lambda}^A$. When both values are interior, this requires

$$\widehat{b}(\widehat{\lambda}^T, p^T) < \widehat{b}(\widehat{\lambda}^A, p^A),$$

which after using the definition of $\widehat{b}$ and using $p^T = \widetilde{a} < a = p^A$ is equivalent to $1 < -I/(\overline{b} - I)$. This is a contradiction because an interior solution requires $\overline{b} - I > 0$.

Consider next the possibility that $\widehat{\lambda}^T = 1$, while under autarky Home is diverse. From Propositions 1 and 2 follows that this requires

$$\max\{a, -a\} < \overline{b} - I < \max\{\widetilde{a}, -\widetilde{a}\}.$$

The inequalities cannot hold when both a and $\widetilde{a}$ are positive since $a > \widetilde{a}$. Of course, this rules out also the case $\widetilde{a} > 0 > a$. We are left with the two cases $\widetilde{a} < a < 0$ and $a > 0 > \widetilde{a}$. In the former case $\widehat{\lambda}^T = 1$ requires $\overline{b} - I < \widetilde{a}$ according to Prop. 2. In addition, an interior value for λ under autarky calls for $\overline{b} - I > -a$, given parameter signs. The two conditions cannot hold simultaneously because $\widetilde{a} < 0$ and $-a > 0$. The second case, $a > 0 > \widetilde{a}$, requires due to Prop. 1 and 2

$$a < \overline{b} - I < \widetilde{a},$$

a contradiction.

A similar logic can be used to demonstrate $\widehat{\lambda}^{*A}$ when $\widehat{\lambda}^{*A} < 1$. ■

Lemma 3 is useful because it allows us to make predictions about how the pattern of network consumption changes qualitatively when moving from autarky to free trade. The lemma is somewhat incomplete in the sense that it does not provide a characterization for all possible values of λ under autarky. In particular I cannot rule out the possibility that Home switches from consuming only y under autarky to only x under trade (what can be ruled out is the switch from $\widehat{\lambda}^{A} = 0$ to $\widehat{\lambda}^{T} \in (0, 1)$, not shown here). In the following, however, I focus on the natural case where countries are not specialized in the good under autarky in which they have a comparative disadvantage.

For welfare evaluation we can now distinguish three *potential* groups at Home (although not all three are always relevant): Those who consume good x under trade and autarky, those who consume good y under both regimes, and those who switch from x to y (the "switchers"). No consumer at Home switches from consuming good y to good x, given the assumption on technology (and assuming $\widehat{\lambda}^{A} > 0, \widehat{\lambda}^{*A} < 1$). To see this, note from (5) that $\widehat{b} = I(1 - 2\lambda) - p$ and thus

$$\widehat{b}(\widehat{\lambda}^{T}, p^{T}) > \widehat{b}(\widehat{\lambda}^{A}, p^{A})$$

because $p^{T} = \widetilde{a} < a = p^{A}$ and $\widehat{\lambda}^{T} \leq \widehat{\lambda}^{A}$ by Lemma 3. When an individual prefers good y under autarky, so it must under trade. The reverse is not true.

For each of the three potential cases the utility difference can now be stated under the assumption of Lemma 3 ($\widehat{\lambda}^A > 0$)

$$
\begin{aligned}
u^T(x,b) - u^A(x,b) &= (\widehat{\lambda}^T - \widehat{\lambda}^A)I \leq 0 \\
u^T(y) - u^A(y) &= \left(\frac{a_y}{a_z} - \frac{a_y^*}{a_z^*}\right) - (\widehat{\lambda}^T - \widehat{\lambda}^A)I > 0 \qquad (16) \\
u^T(y) - u^A(x,b) &= -\widetilde{a} - b - (\widehat{\lambda}^A + \widehat{\lambda}^T - 1)I
\end{aligned}
$$

Several insights follow immediately. Individuals who under both regimes consume good x cannot gain from trade, and lose if some people switch from x to y. Intuitively, Home is the cheapest source of producing good x and trade could change society's consumption pattern only away from this good. By contrast, individuals who consume y under both situations must gain for two reasons. One is the traditional source of the gains from trade, as Foreign can produce good y more cheaply. In addition such consumers potentially gain from the favorable change in society's consumption pattern toward their preferred network good. Regarding the last group, the switchers from x to y, the welfare change is not clear immediately.

Similarly, the utility differentials for foreign consumers are (assuming $\widehat{\lambda}^{*A} < 1$)

$$
\begin{aligned}
u^{*T}(y) - u^{*T}(y) &= -(\widehat{\lambda}^T - \widehat{\lambda}^{*A})I \leq 0 \\
u^{*T}(x,b) - u^{*A}(x,b) &= \left(\frac{a_x^*}{a_z^*} - \frac{a_x}{a_z}\right) + (\widehat{\lambda}^T - \widehat{\lambda}^{*A})I > 0 \qquad (17) \\
u^{*T}(x,b) - u^{*A}(y) &= \widetilde{a} + b - (\widehat{\lambda}^T + \widehat{\lambda}^{*A} - 1)I
\end{aligned}
$$

The last line gives the utility change for switchers from y to x. No individual in Foreign switches in the opposite direction (when Foreign is not homogenous in x under autarky).

Proposition 3. Free trade is not Pareto inferior to autarky if the free trade equilibrium is unique.

Proof: It is sufficient to show that at least one consumer gains. This is the case when there are y consumers at Home under autarky and trade (see 16), or when there exists a consumer in Foreign who consumes x in both situations (see 17). Obviously, this requirement is fulfilled when $(\widehat{\lambda}^A, \widehat{\lambda}^{*A}) \in (0,1)$ by Lemma 3.

A similar argument applies when only one country is diverse under autarky, say $\widehat{\lambda}^A = 1 > \widehat{\lambda}^{*A} > 0$. Foreign x consumers under trade and autarky always gain. For the same reason Home y consumers gain when only Foreign is homogenous under autarky.

Next assume both countries are homogenous under autarky, but in different goods, that is $\widehat{\lambda}^{*A} = 0$ and $\widehat{\lambda}^A = 1$. If $0 < \widehat{\lambda}^T = \widehat{\lambda}^{*T} < 1$, the utility change for the switcher at Home with the lowest preference for good x, $b = -\overline{b}$, is

$$u^T(y) - u^A(x, -\overline{b}) = -\widetilde{a} + \overline{b} - \widehat{\lambda}^T I > 0,$$

which must be positive by the condition that both countries are diverse under free trade (Prop. 2). When $\widehat{\lambda}^{*T} = 1$, some switchers in Foreign gain as the utility change for the person with highest preference for good x equals

$$u^{*T}(x, \overline{b}) - u^{*A}(y) = \widetilde{a} + \overline{b} > 0$$

because $\widetilde{a} > 0$ by Proposition 2b when the corner equilibrium in x is unique. A similar argument applies when $\widehat{\lambda}^T = 0$, that is, $u^T(y) - u^A(x, -\overline{b}) = -\widetilde{a} + \overline{b}$ is positive when the corner equilibrium in y is unique ($\widetilde{a} < 0$). ■

An intuitive way to understand Proposition 3 is to note that for consumers who consume the same set of goods under both trade and autarky consumption of good z cannot decline. It is clear then that if both countries are diverse under autarky and trade somebody must be better off. The only problem could arise when a good is not consumed in either autarky or trade. Uniqueness of the free trade equilibrium is sufficient to make somebody better off. The case where the free trade equilibrium is not unique plays a role further down.

The uniqueness condition can be further explained by noting that for home consumers, who switch from x to y, the change in z consumption equals

$$c_z^T(y) - c_y^A(x, b) = \frac{1}{a_z} - \frac{a_y^*}{a_z^*} - \left(\frac{1}{a_z} - \frac{a_x}{a_z}\right) = -\widetilde{a},$$

and for switchers in foreign from y to x it equals $\widetilde{a}$. In other words, uniqueness means that there are some consumers who gain in terms of non-cultural good consumption.

How restrictive is the assumption? Note that it is only a sufficient, not a necessary condition. From Prop. 2b it is known that corner equilibria are unique if $\min\{\widetilde{a}, -\widetilde{a}\} \leq \overline{b} - I \leq \max\{\widetilde{a}, -\widetilde{a}\}$, that is, taste diversity is not too large relative to the differential in labor units of producing cultural goods (in terms of good z). The condition can easily be fulfilled: When $\overline{b} - I = 0$, $a_z = a_z^*$, any $a_y^* \neq a_x$ is sufficient. The next result sheds light on the question whether trade is Pareto superior.

Proposition 4. a) If both countries are diverse under free trade, trade is not Pareto superior to autarky. b) If both countries are homogenous in the same network good under free trade, trade is Pareto superior to autarky for some parameter values.

Proof: a) Follows immediately from Lemma 3a and utility comparison for both Home and Foreign (see 16 and 17) if $\widehat{\lambda}^T \in (0, 1)$. b) Assume both countries are homogenous under free trade in the same good, say $\widehat{\lambda}^T = \widehat{\lambda}^{*T} = 0$, and $\widehat{\lambda}^{*A} = 0$. Thus in Foreign all individuals are indifferent between autarky and free trade. In Home, assume $\widehat{\lambda}^A \in (0, 1)$ which requires $\overline{b} - I > \max\{a, -a\}$. There are no individuals who consume x under both regimes. Those who consume y under both regimes are obviously better off (see 16). It remains to be seen whether all switchers are no worse off. Consider therefore the individual with type $b = \overline{b}$ who has the smallest gain from switching from x to y. The utility change equals $-\widetilde{a}-\overline{b}-(\widehat{\lambda}^A-1)I$, which is positive if $\overline{b} - I < -\widetilde{a} - \widehat{\lambda}^A I$. This must be consistent with the assumption that Foreign under autarky and both countries under trade are homogenous in y, which holds if $\overline{b} - I < -a^*$, where $a^* < 0$ (by Prop. 1 applied to Foreign), and $\overline{b} - I < -\widetilde{a}$ for $\widetilde{a} < 0$ (by Prop. 2). Since $\widetilde{a} > a^*$, the binding assumption is simply that the utility change is positive, that is $\overline{b} - I < -\widetilde{a} - \widehat{\lambda}^A I < -\widetilde{a} < -a^*$. Parameter values exist that fulfill this condition, as an example below further illustrates. ■

Proposition 4 is perhaps surprising in several ways. Recall that in a standard Ricardian model trade is always weakly Pareto superior. A country does not gain from free trade relative to autarky if its terms of trade do not change. If this happens, however, then the other country must have gained, assuming relative labor input coefficients differ across countries. The logic does no longer apply when network externalities are considered and both countries are diverse under free trade. The latter means that some people consume the same set of goods under autarky and trade. Opening up for trade then must imply an unfavorable shift in society's consumption behavior for some individuals.

The second part of Proposition 4 is noteworthy as well. It should be emphasized that the result holds only for some parameter values, but not in general. Intuitively, trade is Pareto improving when one country is a 'little' diverse in the closed economy, and the production of the 'minority' network good is relatively costly. In the open economy those 'minority' consumers can be attracted to buy the other network good if this is relatively cheaply produced elsewhere. At the same time there is no longer a loss due to the existence of network diversity. If sufficiently large, these gains outweigh the loss from having a high preference for the original 'minority' network good. As mentioned above, the following example illustrates the point.

Example 1. Let the parameter values be[6]

$$\begin{aligned} a_x &= 7, a_y = 4, a_z = 4, \\ a_x^* &= 9, a_y^* = 1, a_z^* = 4 \\ \bar{b} &= 3, I = 2. \end{aligned}$$

This gives $a = -3/4, \widetilde{a} = -3/2$ and $a^* = -2$. Home consumes mostly y under autarky as $\widehat{\lambda}^A = 1/8$, while Foreign consumes only y ($\widehat{\lambda}^{*A} = 0$). Under free trade both countries are homogenous in y ($\widehat{\lambda}^T = \widehat{\lambda}^{*T} = 0$). All conditions are satisfied for Pareto improving trade because $-a = 3/4 < \bar{b} - I = 1 < 5/4 = -\widetilde{a} - \widehat{\lambda}^A I < 3/2 = -\widetilde{a} < -a^* = 2$.

The previous results are concerned with a global comparison of autarky and free trade in terms of the Pareto criterium. The last result focuses on the welfare effects of complete trade liberalization in one country.

Proposition 5. For some parameter values everybody in a country can lose from free trade.

<u>Proof:</u> Consider the following parameter values:

$$-a < \bar{b} - I < -\widetilde{a} < 0.$$

The first inequality together with $a > 0$ implies that Home is homogenous in x under autarky by Prop. 1. This equilibrium is unique. The second inequality together with $\widetilde{a} > 0$ implies

[6] For ease of exposition I choose "large" parameter values, which requires a sufficiently small labor force, so that each country alone can serve the entire world with each cultural good.

that free trade has two corner equilibria, in which both countries are homogenous in either of the network goods. Assume now that both countries are homogenous in y under free trade. Then the individual at Home with the lowest preference for good x ($b = -\overline{b}$), i.e. the person who gains the most from free trade among the switchers, has utility change

$$u^T(y) - u^A(x, -\overline{b}) = -\widetilde{a} + \overline{b}.$$

The change is negative, and hence everybody at Home loses, if $\overline{b} < \widetilde{a}$. Together with the initial assumption above this requires $\overline{b} < \widetilde{a} < I - \overline{b}$ and therefore $\overline{b} < I/2$. ■

A simple example may illustrate the result.

Example 2. Let the parameter values be

$$\begin{aligned} a_x &= 4, a_y = 10, a_z = 2, \\ a_x^* &> 4, a_y^* = 6, a_z^* = 2 \\ \overline{b} &= 1/2, I = 5/2. \end{aligned}$$

This gives $a = 3$, $\widetilde{a} = 1$ and $\overline{b} - I = -2$. Prop. 1b shows that home is homogenous in x under no trade, $\widehat{\lambda}^A = 1$ (because $-3 < \overline{b} - I = -2 < 3$), while both corner equilibria are possible under free trade according to Prop. 2b ($\overline{b} - I = -2 < -1 < 1$).

Proposition 5 undermines some of the positive light shed on equilibria with a network monopoly under free trade as given in the previous result. Note the difference here though. The example underlying Proposition 5 is based on corner equilibria under autarky and free trade ($\overline{b} - I < 0$). There is no utility loss due to competing networks under both regimes. The problem arises because of a coordination failure when multiple equilibria exist under free trade. By contrast, the Pareto improvement in Prop. 4 is partly driven by the gains from eliminating losses due to competing networks, which required $\overline{b} - I > 0$ for the country that is diverse under autarky.

The scenario described above can also make free trade Pareto worse than autarky if $-a < \overline{b} - I < -\widetilde{a} < -a^* < a^*$, so that $\widehat{\lambda}^{*A} = \widehat{\lambda}^T = 0$. While in Home everybody is worse off under free trade, the above parameter values imply that all individuals in Foreign are indifferent between autarky and free trade. Clearly, the multiplicity of equilibrium under free trade is an essential part of the result, because otherwise it would contradict Proposition 3.

6 Extensions

The model can easily be extended to handle additional issues.

Non-unitary demands

The unit purchase restriction for the network good can be relaxed. Assume that each consumer buys two units of network goods (same or different ones) and let countries differ in their preferences for one of the two: Home consumers always buy one unit of x, and consumers in Foreign buy one unit of y regardless of network effects. Each consumer chooses the second network unit. This model works almost identically to the above version. The main change comes in the consumer's budget constraint, as now two units must be purchased, which tends to lower the consumption of good z. Economically, however, the modification is in contrast to the base model, and allows me to differentiate between individuals who have a preference for homogeneity (i.e., consumers who buy two units of x or y) and those who like diversity (i.e., a consumer who buys one unit each). Free trade consumption patterns are consistent with diversity within and across countries. For example, the analog to Prop. 2a (diversity under free trade) is that now both countries have consumers who have preferences for diversity, but at the same time there are consumers who have a taste for homogeneity, albeit for different goods in Home and Foreign.

Country Differences

Differences in population size have no direct effect under certain conditions. For example, assuming that the taste distribution is the same in both countries, the properties of the autarky equilibrium are invariant to country size. This can be seen from condition (6) for the fixed point requirement. Country size would enter multiplicative on both sides and thus simply cancels out. In the open economy country size typically doesn't matter either, as long as the consumption pattern in both countries continues to be the same. It may change if a country becomes too small to serve a particular network good to the entire world.

Another asymmetry is to introduce differences in the distribution of the parameter b. Comparative statics for the maximum preference for good x, $\bar{b}$, is easily done for the closed economy. A decrease in $\bar{b}$, while holding technology parameters constant, makes it more likely that the country is homogenous under autarky (see *Figure 3)*. In the open economy consumption patterns across countries typically differ now. Intuitively, however, the properties of Lemma 3, showing that the consumption patterns are bounded by the autarky patterns, should still be true.

International Consumption Links

In the present model an individual's network consumption decision depends on prices and the consumption behavior in her country. In reality individual consumption choices are often driven by foreign consumption patterns. This can be modelled by interpreting λ as the fraction of the *world* population that consumes good x. When countries are symmetric in size and taste distribution, results should not change as long as countries have symmetric consumption patterns in the present model (which is the case except when multiple corner equilibria occur). By contrast, when asymmetry in country size and taste distributions are combined with international consumption links new issues may arise. In this case the larger country dominates the worldwide consumption behavior under free trade and may lead the smaller country to radically change its consumption behavior. It is conceivable that a small country loses when its preference for one network good is swamped by the preference for the other network good by the large country.

7 Conclusion

This paper has developed a simple model of international trade in the presence of network effects. In contrast to the new trade theory or other models of trade in cultural goods, this paper does not rely on increasing returns to scale on the production side of the economy or on country size differences. Network goods differ from other goods in that they create an interdependence among individual consumption decisions. The present paper shifts the attention away from the production side to the consumer side of the economy. This becomes clear when the distributional effects of trade liberalization are considered. In a Heckscher-Ohlin model the factor that is used in intensively in the production of the export good gains while the factor used intensively in the import good loses when trade is liberalized. By contrast, in the present model gainers are those individuals who consume under autarky and free trade the network good which is imported under trade. Individuals who consume the network good exported under free trade tend to lose. This raises the question of compensation of losers from gainers. An aspect for future research should be if and how compensation is feasible if one assumes realistically that individual taste parameter b is not observable. This suggests that compensation must be at a level that makes the person most harmed by trade indifferent to autarky. Individuals with less extreme preferences are then overcompensated, raising the possibility that such a compensation scheme is not feasible.[7]

General policy implications need to be carefully made. On the one hand, the emphasis by economists on the traditional gains from trade is not undercut even when network externalities are allowed for. Some people always gain as long as the free trade equilibrium is unique. On the other hand, trade is not always Pareto superior to no trade. In fact, the presence of diverse consumption pattern under trade is an indicator that trade is not Pareto superior. Ironically though, it is the lack of diverse consumption pattern under free trade that for some parameter values is consistent with all individuals in both countries gaining. In this case the maximal network size avoids costly consumption externalities. Network monopolies under free trade are compatible with completely opposite welfare results however. As in other models with network effects, mutltiple equilibria are a common phenomenon. The above analysis has shown that all individuals in a country lose when the economy switches from a unique good corner equilibrium under no trade to the bad of two corner equilibria under trade. The parameter condition for this to happen appear restrictive, but point to the need for further understanding of the nexus between trade liberalization and welfare when consumption choices are independent.

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[7] See an earlier version of this paper (Janeba 2004) for a slightly longer discussion of government intervention options.

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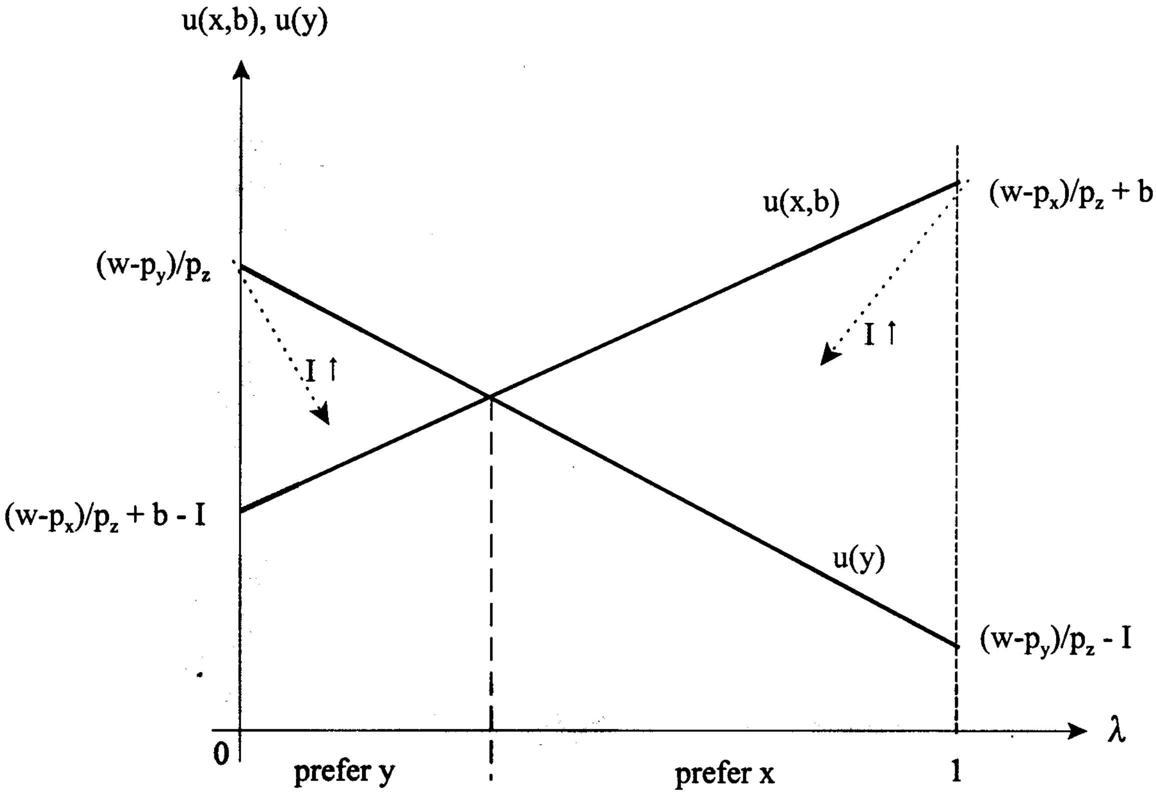

Figure 1: Choice of cultural good for individual with taste parameter b given λ and p

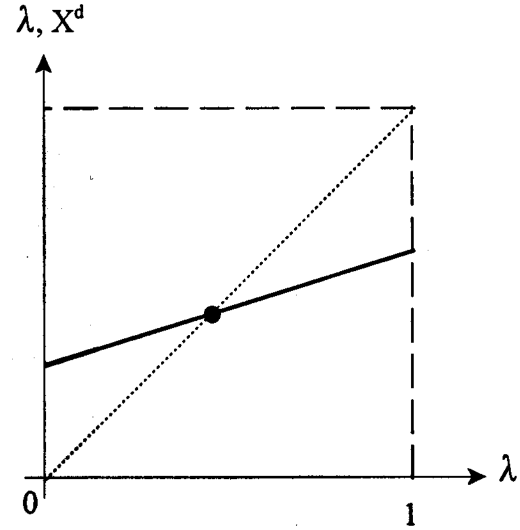

Figure 2a
Unique, stable interior fixed point

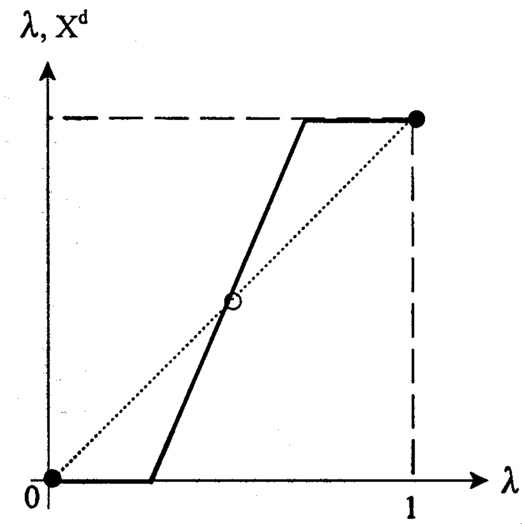

Figure 2b
Two stable corner fixed points
Interior fixed point unstable

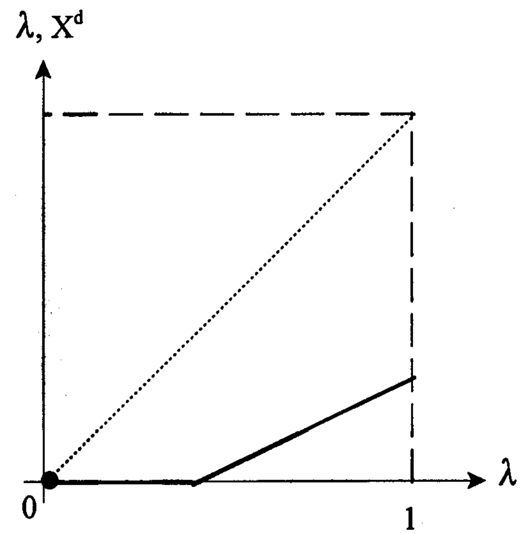

Figure 2c
Unique, stable corner fixed point

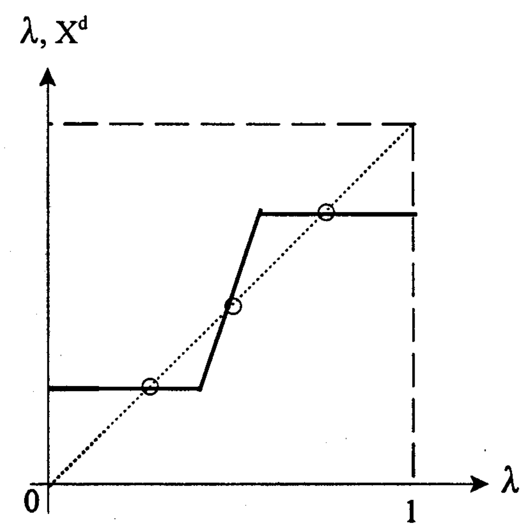

Figure 2d
Impossible configuration

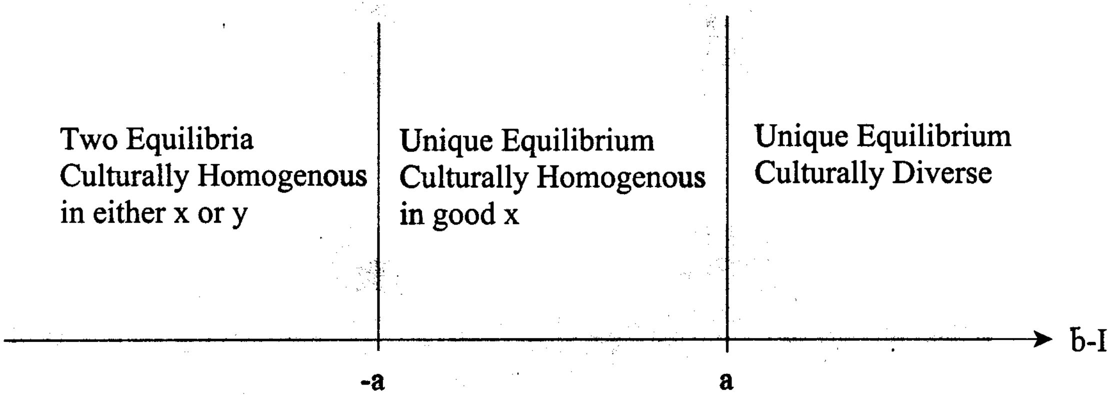

Figure 3: Autarky Equilibria when a>0