The Extensive Margin and the Quality Margin of International Trade

Master Thesis

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Abstract

I develop a model of international trade in which rich and poor countries trade in horizontally and vertically differentiated products. Trade data suggests a positive relationship between both a country's extensive and quality margin of exports and imports, and the trading partner's per-capita income. I incorporate consumption indivisibilities and vertical innovation into Krugman's (1980) variety model to provide a demand-related rationale for quality differentiation. Instead of abstaining from exporting, internationally active firms may respond to a threat of parallel trade by selling a high quality version of their good to rich consumers and a low quality version to poor consumers. I provide conditions under which such an outcome is likely to occur. In this framework, rich countries profit from a trade liberalization, whereas welfare effects are generally ambiguous for poor countries. My model complements a flourishing literature that highlights various supply-side determinants of quality differentiation.

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Contents

1 Introduction

The value of trade can be decomposed into the number of varieties traded, the traded volume of each variety and the price a variety is sold for. Typically, sizable between-country differences along these three dimensions are found when investigating disaggregated trade data. Although most countries tend to import and export similar varieties, some countries trade more varieties than others (extensive margin)(Schott, 2004, Hummels and Klenow, 2005, Bernasconi and Wuergler, 2013). Maybe more astonishing, some countries trade higher volumes of a variety (intensive margin) at higher prices than others (Hummels and Klenow, 2005). This observation suggests that there must be substantial differences in qualities of a traded varieties across countries (quality margin). Otherwise, if products within a variety, i.e. watches, where homogeneous, such observations should not occur in trade data. Recent empirical research shed light on how country characteristics might be related to the observed trading behavior along the three margins and found remarkably congruent patterns.

A starting point was the seminal paper by Schott (2004) who analyzed disaggregated data on U.S. imports. While increasingly sourcing the same varieties from both low- and high-wage countries, he found that the United States tends to import products with high unit values[1] from capital- and skill-abundant high-wage countries and products with low unit values from labor-abundant low-wage countries. An illustrative example are men's cotton shirts imported from Japan which are supposed to be roughly 30 times as expensive as the identically classified variety originating in the Philippines. Another interesting finding in Schott's analysis is that over time skill- and capital deepening countries experience an increase in unit values relative to the countries they leave behind.

Many subsequent contributions found interesting patterns when considering the trade margins together with per-capita income. Hummels and Klenow (2005) observe that for a given variety, richer countries export the good in higher quality than poorer countries. Moreover, they find that richer countries tend to export a larger set of varieties than poor countries. The same pattern is observed for imports. If two countries share roughly the same GDP, the richer country tends to import more in terms of value and exceeds the poorer country in all three margins (Bernasconi and Wuergler, 2013). Similarly, Hallak (2006) finds that when comparing imports of some product category, higher-quality goods are imported disproportionately from countries with a higher per-capita income. Lastly, Föllmi et al. (2013) relate per-capita income to the extensive margin and report that export probabilities are strongly increasing in per-capita

[1] Unit values are calculated by dividing the total value of trade of a product category by the quantity traded. Unit values serve as a proxy for quality (Schott, 2004).

income of a potential importer.

An early theoretical contribution relating per-capita income, quality differentiation, and trade intensity is the famous Linder hypothesis (1961). Linder argued that if richer countries spend proportionally more on high quality goods they have a comparative advantage in producing such goods due to closeness to demand. From this insight, he drew the conclusion that countries with a similar per-capita income should have a higher trade intensity. While the Linder hypothesis constitutes a demand-related explanation for quality and trade, more supply-related theories were developed in the past two decades. Presumably the most popular theoretical explanation is that high-skilled, high-wage countries use quality differentiation to escape the price competition induced by low-skilled, low-wage countries. Since the invention and the production of high quality goods often afford higher technologies than low quality goods, rich countries tend to have a comparative advantage in producing high quality goods because they are endowed with higher-skilled labor. Trade models encompassing such a supply-side reasoning can be found for example in Flam and Helpman (1987), Murphy and Shleifer (1997), Matsuyama (2000) and Baldwin and Harrigan (2011). These models match the empirical findings by Schott (2004) pretty well.

A rationale that is similar in nature might emerge also on the demand side of trade theory. Notice that many supply-side explanations leave no space for demand forces of different countries due to the analytically convenient but empirically rejected assumption of homothetic preferences[2] (Matsuyama, 2000). In a Krugman (1980) type trade model with differences in per-capita income and non-homothetic preferences, Föllmi et al. (2013) provide a purely demand-related explanation for the prevalence of "export zeros" in trade data as a counter-part to the purely supply-related heterogeneous firms model by Melitz (2003). They show that if consumers from rich countries have a significantly higher willingness to pay[3] for differentiated products than consumers from poor countries, firms selling products globally face a threat of parallel trade, forcing them to charge a lower price in the rich countries as they could have charged in autarky. The threat of parallel trade then leads some firms located in the rich country to abstain from exporting and sell their good at a higher price exclusively in the rich market at the expense of losing the market share in the poor countries. Similar to making use of quality differentiation to escape from the price competition, I use the model by Föllmi et al. (2013) to show that quality differentiation might also be a helpful strategy to weaken the threat of parallel trade. Hence,

[2]Under the assumption of homothetic preferences, countries that have the same GDP but differ in population size and per-capita income, are observationally equivalent actors. An exception is Matsuyama (2000) who employs the same type of preferences as used in this analysis in a ricardian model of trade.

[3]Emerging from a higher per-capita income and non-homothetic preferences.

the observed differences in the extensive margin and the quality margin of trade are unlikely to be pure artifacts of comparative advantage.

The main challenge of my master thesis is to combine a static version of the endogenous growth model in "The macroeconomics of model T" by Föllmi et al. (2014) with the trade model in "International Arbitrage and the Extensive Margin of Trade between Rich and Poor Countries" by Föllmi et al. (2013). That is, I study a Krugman (1980) type trade model in which R&D is not only designated to invent new goods (product innovation), but also to make production of existing goods more efficient (process innovation). The basic idea is that newly invented goods are of high quality, but cause high production costs. By undertaking a process innovation, firms obtain the know-how to produce a lower quality version of the invented good that has lower production costs. Moreover, I assume that consumer goods are indivisible and households purchase either one unit of a particular good in high quality, one unit in low quality or do not purchase at all. Such preferences are non-homothetic in the sense that consumption bundles of rich and poor households differ along the extensive margin and the quality margin.

As in Föllmi et al. (2013), I show that if per-capita income differences of the trading countries are large, some firms in the rich country abstain from exporting to the poor country due to a threat of international arbitrage (parallel trade). A key finding is that globally selling firms may be able to weaken the threat of arbitrage by undertaking a process innovation and selling the good in high quality to the rich and in low quality to the poor. In equilibrium, more firms in the rich country engage in international trade than in the absence of quality differentiation. Furthermore, I show that such a separating strategy is particularly likely to be adopted by internationally active firms if the size of the rich market is small compared to the size of the poor market, and if the cost-saving potential of the process innovation is neither too high nor too low. Otherwise, globally selling firms prefer to sell their good in single quality.

My analysis highlights two further points. First, I show that closed-form solutions exist when globally selling firms located in the rich country disagree on the optimal marketing strategy with firms located in the poor country. In the presence of trade costs, it can happen, for example, that firms in the rich country choose to serve both markets with high quality goods while firms in the poor country find it optimal to serve both markets with low quality goods. In such a situation, the prices firms of both countries charge in equilibrium are going to be different. But if preferences are such that households only choose along the extensive and the quality margin, differences in optimal prices are determined in equilibrium, and hence, closed-form solutions still exist.

Second, I show that the specification of trade costs plays a crucial role when discussing welfare effects of a trade liberalization. Föllmi et al. (2013) model a bilateral trade liberalization as a reduction of iceberg trade costs and find that when between-country inequality is significant, the poor country loses while the rich country profits from a trade liberalization. The reason is that a trade liberalization increases the threat of arbitrage inducing less rich-country firms to export to the poor country. If the reduction in imported varieties is larger than the increase in home-produced varieties (due to a cost reduction effect), the poor country is going to lose. However, I show that in a per-unit trade cost specification, the increase in home-produced varieties only overcompensates the reduction in imported rich-country varieties if the market size of the poor country is smaller than the market size of the rich country. This difference is of potential relevance, since empirical research on the structure of trade costs rejects pure iceberg cost specifications (Hummels and Skiba, 2004, Irarrazabal et al., 2010)

The model complements two recent contributions that provided a demand-related rationale for quality differentiation. Bernasconi and Wuergler (2013) and Fajgelbaum et al. (2011) both provide frameworks in which firms choose quality levels endogenously after having invented a new product. They implicitly assume that quality differentiation is possible without any further efforts in R&D. Nevertheless, the model by Bernasconi and Wuergler (2013) is similar in a sense that quality differentiation results out of a threat of parallel trade and hence, they also find an equilibrium where internationally active firms engage in quality differentiation and some firms in the rich country abstain from exporting.

The remainder of the paper is organized as follows. In the next section, I present the basic assumptions and discuss the autarky equilibrium. In Section 3, I use the framework to compare trade equilibria in which internationally active firms sell their good in single quality to an equilibrium where firms engage in quality differentiation. In Section 4, I discuss the optimal choice of marketing strategies given the prevailing constellation of parameters. In Section 5, I present a model with a per-unit trade costs specification and compare it to the standard model that incorporates iceberg trade costs. Section 6 concludes.

All contents and ideas stemming from "The macroeconomics of model T" by Föllmi et al. (2014) and "International Arbitrage and the Extensive Margin of Trade between Rich and Poor Countries" by Föllmi et al. (2013) are *not cited* in text.[4] This is authorized by Prof. Dr. Josef Zweimüller, co-author of the above contributions, who acted as supervisor and acts as (potential) co-author for the full content of my master thesis.

[4]The explicit assignment for my master thesis (supervised by Prof. Dr. Josef Zweimüller) was to combine the ideas from the two contributions to enhance theory and gain new insights in international trade.

2 Autarky

I start by presenting the two autarky regimes. The economy is populated by P identical households. Each household is endowed with L units of labor, the only production factor. Labor is perfectly mobile within countries and immobile across countries. The labor market is competitive and the market clearing wage is W.

Consumers. Households spend their income on a continuum of differentiated goods. I assume that goods are indivisible and a given product j yields positive utility only for the first unit and zero utility for any additional units. The household has to decide whether or not to consume good j, and if yes, whether to consume it in high or low quality. There are three outcomes: either a household consumes (i) one unit in high quality, (ii) one unit in low quality, or (iii) does not consume at all. Denote by $x(j)$ an indicator function that takes value 1 if a household consumes good j, and takes value 0 if not. Similarly, denote by $q(j)$ the chosen quality level which can take only one of the two values $\{q_h, q_l\}$[5] . For simplicity, but without loss of generality, I assume $\{q_h, q_l\} = \{1, q\}$, where $q \in (0, 1)$. The household's utility function takes the form

$$U = \int_0^\infty q(j)x(j)dj.$$

Since the function is additively separable, the household's utility is simply the sum of the quality levels of the consumed goods[6].

Consider a household with income y who chooses among (a measure of) N goods supplied at prices $\{p(j, q(j))\}$. The problem is to choose $\{x(j), q(j)\}$ to maximize the utility function subject to the budget constraint $\int_0^N p(j, q(j))x(j)dj = y$. Denoting λ as the household's marginal utility of income, the first order conditions for the discrete consumption choice of good j are given by

$$\{x(j), q(j)\} = \begin{cases} \{1, q_h\} & \text{if} \quad q_h/\lambda - p(j, q_h) \geq \max\left[0, q_l/\lambda - p(j, q_l)\right], \\ \{1, q_l\} & \text{if} \quad q_l/\lambda - p(j, q_l) \geq \max\left[0, q_h/\lambda - p(j, q_h)\right], \\ \{0\} & \text{else,} \end{cases} \tag{1}$$

These first order conditions are very intuitive. The condition in the first line of (1) says that good j will be consumed in high quality if the consumer's willingness to pay for the high quality q_h/λ is sufficiently larger than its price $p(j, q_h)$, so that both alternatives (purchasing not at all and purchasing the low quality) lead to a worse outcome. In other words, there needs to

[5]Throughout the paper, subscript h is used for the high quality and subscript l is used for the low quality if necessary.

[6]Notice that the integral in the utility function runs from zero to infinity. While preferences are defined over an infinitely large measure of potential goods, the number of goods actually supplied is limited by firm entry, i.e. only a subset of potentially producible goods can be purchased at a finite price.

be a utility gain[7] and it needs to be larger than the utility gain from purchasing the low quality. Similarly, the consumer will purchase the low quality if there is a utility gain that is larger than when purchasing the high quality. Otherwise, the household does not consume good j at all.

Technology. Production activities are undertaken in monopolistic firms that supply differentiated products and operate with an increasing returns-to-scale technology. The creation of a firm requires a *product innovation*, i.e. an investment of F units of labor that yields the blueprint for a completely new product. Once such a product innovation has been made, the innovating firm obtains a patent granting the exclusive right to market this product. I assume that a new product has quality $q_h = 1$ and requires a (high) labor input $a_h = 1$ per unit of output. Additionally, a firm has the option to undertake a *process innovation*, that cuts both the quality of the product and its production cost. Namely, a firm can invest G units of labor to get access to a more productive technology where the invented product can also be supplied in lower quality $q_l = q$. I assume that the low quality version of the good requires a labor input $a_l = a$ per unit of output where the resulting quality-cost ratio is higher than that of the high quality version, i.e. $q/a > 1$.

Equilibrium. Since both firms and households are identical, the equilibria are symmetric. Similiar to the standard monopolistic competition model, the information on other firms' prices is summarized in the shadow price λ. Depending on the constellation of parameters, all firms will supply their good either (i) only in high quality to all households or (ii) only in low quality to all households. At the border of the two regimes, firms as well as households will be indifferent between the two qualities.

Lemma 1 *For each quality, there is a single price $p(q_h) = 1/\lambda$ resp. $p(q_l) = q/\lambda$ in all markets and all goods are purchased by all consumers.*

Proof. By symmetry, (1) shows that the aggregate demand for good j is a function of λ and the quality levels $\{q_h, q_l\}$ only. Consequently, the pricing decision of a monopolistic firm is independent of the prices set by other competitors. It is profit maximizing to set $p(q_h) = 1/\lambda$ for the high quality version of the good and $p(q_l) = q/\lambda$ for the low quality as long as the firm realizes a non-negative profit. To prove the second part of the Lemma, assume to the contrary that only a fraction ν of consumers purchases the product at price $p(q_h) = 1/\lambda$, resp. $p(q_l) = q/\lambda$. However, this cannot be an equilibrium, as the firm could undercut the price slightly and sell to all consumers. ■

[7] In fact, the utility gain $q(j)/\lambda - p(j, q(j))$ is the consumer surplus.

Without loss of generality, I choose labor as the numéraire, $W = 1$. Two conditions characterize the autarky equilibria. The *first* is the zero-profit condition, ensuring that operating profits cover the entry costs but do not exceed them to deter further entry. For (i), the entry costs are $FW = F$ and operating profits are $(p - W)P = (p - 1)P$. The equilibrium price for the high quality is then $p_h = \frac{F+P}{P}$. For (ii), where firms undertake a process innovation and supply the low quality, the entry costs are $(F + G)W = F + G$ and operating profits are $(p - Wa)P = (p - a)P$. The equilibrium price is given by $p_l = \frac{F+G+Pa}{P}$.

The *second* equilibrium condition is a resource constraint ensuring that there is full employment: (i) $PL = N(F + P)$, (ii) $PL = N(F + G + Pa)$. From this latter equation, equilibrium product diversity (both in production and consumption) in the decentralized equilibrium is given by

$$\text{(i) } N_h = \frac{P}{F+P}L; \text{ and (ii) } N_l = \frac{P}{F+G+Pa}L.$$

Besides price setting, the optimal choice of the quality level belongs to a firm's marketing strategy[8]. Hence, a price setting equilibrium only exists if it constitutes a Nash equilibrium in the firms' quality choice. In the case of autarky, the intuition is simple. Because firms and households are symmetric, all firms prefer to supply either the high quality or the low quality; or all firms are indifferent between both qualities.

Proposition 1 *Define $q^A \equiv \frac{F+G+Pa}{F+P}$. a) If $q < q^A$, the high quality is supplied in all markets. b) If $q > q^A$, the low quality is supplied in all markets. c) If $q = q^A$, firms are indifferent between the two strategies.*

Proof. First, assume the prevailing regime to be (i), where the willingness to pay for the high quality is $1/\lambda = p_h$. A deviation to the strategy where only the low quality is supplied is profitable if $qp_hP - (F + G + Pa) > 0$, or $q > \frac{F+G+Pa}{F+P} = q^A$. Second, assume the prevailing regime to be (ii), where the willingness to pay for the low quality is $q/\lambda = p_l$. A deviation to the strategy where only the high quality is supplied is profitable if $(1/q)p_lP - (F + P) > 0$, or $q < \frac{F+G+Pa}{F+P} = q^A$. If $q = q^A$, deviations from both equilibrium strategies yield zero profits so that firms are indifferent between supplying the high or the low quality. ∎

Due to increasing returns-to-scale, the critical quality level q^A depends on the market size P. The larger the market to spread over the additional fix cost G, the more "unattractive", i.e. the lower the difference between the quality level and the unit costs a, the lower quality can be so that firms are still incentivized to undertake the process innovation.

[8] I refer to some arbitrary choice of product prices and qualities as a firm's marketing strategy.

3 Trade between a rich and a poor country

I will now consider a world economy where a rich and a poor country trade with each other. I denote variables of the rich country with superscript R and those of the poor country with superscript P. To highlight the relative importance of differences in per-capita incomes and population sizes, I let the two countries differ along both dimensions, hence $L^R > L^P$ and $P^R \gtreqless P^P$. I assume trade is costly and costs are of standard iceberg type: For each unit sold to a particular destination, $\tau > 1$ have to be shipped and $\tau - 1$ units are lost during transportation.

Depending on the magnitude of inequality, two types of trade equilibria emerge. If the income gap between the rich and the poor country is sufficiently small, all goods are traded internationally. I refer to this sort of equilibria as *full trade equilibria.* Analog to the autarky case, it is optimal for firms to set prices equal to the households' willingnesses to pay, hence I have $\{p_h^R, p_l^R\} = \{1/\lambda^R, q/\lambda^R\}$ and $\{p_h^P, p_l^P\} = \{1/\lambda^P, q/\lambda^P\}$. Since the rich country is wealthier than the poor country, prices for goods with identical quality will be higher in the rich country.[9] By symmetry, the prices of imported and home-produced goods are identical within each country.

Alternatively, if the income gap becomes sufficiently large, full trade ceases to be an equilibrium outcome. Arbitrageurs could purchase the good in the market of the poor country, ship it to the rich country and underbid the price charged by firms[10]. Firms anticipate this arbitrage opportunity and adjust their marketing strategies accordingly, inducing some country-R firms to abstain from exporting to the poor country. The reason is that under a threat of arbitrage, it is not possible for globally selling firms (exporters) to skim the entire consumer surplus of a rich household. However, firms serving the rich market exclusively (exclusive producers) do not face such a threat and maintain the ability to fully exploit the rich households' high willingness to pay. In equilibrium, country-R firms are indifferent between a marketing strategy, where the rich market is served exclusively and a strategy where the good is sold internationally. In principle, selling exclusively to households of the rich country is also an option for country-P producers. I will show later that in none of the equilibria they will adopt this strategy due to a cost disadvantage caused by trade costs yielding a negative profit. This change in firm behavior gives rise to the second type of equilibria which I refer to as *partial trade equilibria.*

The option of undertaking a process innovation introduces a quality dimension into the trade model that potentially enables firms in both countries to apply a larger set of marketing strategies. In the case of full trade, each firm could sell its good either (i) in high quality worldwide, (ii) in low quality worldwide, (iii) in high quality to the rich and in low quality

[9] $1/\lambda^R > 1/\lambda^P$; $p_h^R > p_h^P$ and $p_l^R > p_l^P$.

[10] I will show below, that this threat of arbitrage occurs as soon as $1/\lambda^R > \tau/\lambda^P$.

to the poor, or (iv) in low quality to rich and in high quality to the poor. In a partial trade situation, country-R firms additionally have to decide whether to engage in trade or not, and in case of choosing to serve the rich market exclusively, they also have to decide whether or not to invest in process innovation.

By symmetry, exporters (and exclusive producers) within a country will choose the same marketing strategy in equilibrium. Since exporters in both countries operate under identical technology, marketing strategies are expected to be symmetric across countries as well. Due to the presence of trade costs, however, the subset of the parameter space where exporters are indifferent between two given marketing strategies is generally similar but not exactly identical for country-R and country-P exporters. This fact gives rise to "gray areas" in which the optimal marketing strategies of exporters will differ.

In the remainder of this section, I assume that the income gap between the rich and the poor country is sufficiently large such that only a subset of country-R firms engage in trade. I characterize four partial trade equilibria that are of special interest.

3.1 "Arbitrage" regimes

Among the partial trade equilibria, there exist three different equilibria which I refer to as *arbitrage regimes*. In an arbitrage regime, exporters in both countries adopt the same "pooling" strategy, i.e. they sell their good in the same quality worldwide and are thus fully constrained by the threat of arbitrage. In regime **A1**, all producers sell their product in high quality. A subset of rich-country producers sells their product exclusively in the rich country, while the remaining rich-country producers sell their product both in the rich and in the poor country. All poor-country producers sell their product worldwide[11]. In regime **A2**, a subset of rich-country producers sells their product in high quality exclusively in the rich country. The remaining rich-country producers and all poor-country producers sell their product in low quality worldwide. Finally, in regime **A3**, all producers sell their product in low quality in the same way as described in A1.

To see why only a fraction of rich-country producers export their products, consider the alternative situation in which all rich-country producers trade their products internationally. If all firms charged a price that prevents arbitrage, all goods would be priced below rich households' willingness to pay. In that case, however, rich households do not spend all their income, generating an infinitely large willingness to pay for additional products. This would incentivize country-R firms to sell their product only on their home market. Thus, in all arbitrage regimes

[11] This equilibrium is identical to the arbitrage equilibrium described in Föllmi et al. (2013).

both types of firms will exist and the fraction of firms selling exclusively on the local market is determined endogenously.

An arbitrage regime where non-traded goods are sold in low quality and traded goods in high quality does not exist. Remember from the autarky case that any firm's willingness to invest in process innovation depends positively on the market size. Obviously, globally selling firms face a strictly bigger market size than firms selling exclusively on the local market. Loosely speaking, by the time exclusive producers decided to change the marketing strategy and undertake a process innovation, exporters would have already done so.

To solve for the equilibria, denote the price in the poor country by p^P. Furthermore, I denote the price in the rich country of traded and non-traded goods by p^R_T and p^R_N, respectively. The price of non-traded goods is equal to a rich household's willingness to pay, which is $p^R_N = \{1/\lambda^R, q/\lambda^R\}$. Anticipating the threat of parallel trade, the price of traded goods may not exceed and exactly equals the price in the poor country plus trade costs, $p^R_T = \{\tau/\lambda^R, \tau q/\lambda^R\}$, in equilibrium. The price of a product in the poor country is equal to a poor household's willingness to pay, which is $p^P = \{1/\lambda^P, q/\lambda^P\}$. The following lemma proofs that this is a Nash equilibrium.

Lemma 2 *In an arbitrage equilibrium, firms that sell their product in both countries (i) set* $p^P = \{1/\lambda^P, q/\lambda^P\}$ *in country P and* $p^R_T = \tau p^P$ *in country R, and (ii) sell to all households in both countries.*

Proof. Suppose exporters supply the high quality. (i) Assume $1/\lambda^P$ exceeds the marginal costs of exporting. In that case, the maximization problem of an exporting firm reduces to maximize total revenue $P^P p^P(j) + P^R p^R(j)$ s.t. $\tau p^P(j) \geq p^R(j)$ and $p^i(j) \leq 1/\lambda^i$. Applying Lemma 1, it is profit maximizing to set $p^i(j) = 1/\lambda^i$ if $\tau/\lambda^P \geq 1/\lambda^R$ (full trade equilibrium). If $\tau/\lambda^P < 1/\lambda^R$, the arbitrage constraint is binding, $\tau p^P(j) = p^R(j) = p^R_T$ and revenues are maximized when $p^P(j) = 1/\lambda^P$. (ii) Assume to the contrary that only a fraction ν of consumers purchases the product at price $p^P(j) = 1/\lambda^P$. As in Lemma 1, this cannot be an equilibrium, as the firm would lower $p^P(j)$ and $p^R(j)$ slightly and gain the whole market in the poor country. The logic of the proof is identical if exporters supplied the low quality instead. ■

Wages. As in Krugman's (1980) trade model, relative wages are determined by the zero-profit conditions of the internationally active producers. I denote the relative wage by $\omega \equiv W^P/W^R$. Consider the situation where an internationally active country-i producer sells only the high quality. The zero-profit condition is given by $p^R_T P^R + p^P P^P = W^i[F + P^i + \tau P^{-i}]$ [12]. These

[12] $-i = P$ if $R = i$ and vice versa.

firms' total revenues do not depend on the location of production, but the required labor input depends on location. Differences in population sizes generate differences in (total) transport costs, and relative wages equalize these differences. Combining the zero-profit conditions of country-R and country-P exporters yields

$$\omega_h = \frac{F + P^R + \tau P^P}{F + \tau P^R + P^P},$$

where the subscript h indicates that exporters sell all goods in high quality. If the prevailing regime is A1, the relative wage equals ω_h. In a situation where an internationally active country-i producer has undertaken a process innovation and sells only the low quality instead, the zero-profit condition changes to $p_T^R P^R + p^P P^P = W^i[F + G + a(P^i + \tau P^{-i})]$. Similarly, the relative wage is then given by

$$\omega_l = \frac{F + G + a(P^R + \tau P^P)}{F + G + a(\tau P^R + P^P)},$$

where the subscript l indicates that exporters sell all goods in low quality. ω_l will be the relative wage if either regime A2 or A3 prevails.

When the two countries differ in population size, wages (per efficiency unit of labor) are higher in the larger country. Why are wages higher in larger countries? The reason is that labor is more productive in a larger country. To see this, consider the amount of labor needed by a firm in country i to serve the world market. When country R is larger than country P, firms in country R need less labor to serve the world market because there are less losses during transportation, and this is reflected exactly in relative wages. There are two cases in which wages are equalized: (i) $\tau = 1$. When there are no trade costs, the productivity effect of country size vanishes. (ii) $P^R = P^P$. When the two countries are of equal size, productivity differences vanish because transportation losses become equally large. Note further that $\tau^{-1} < \omega < \tau$. When the poor country becomes extremely large, $\omega \to \tau$, and when the rich country becomes extremely large, $\omega \to \tau^{-1}$. In the remainder of the paper, I choose the wage in the rich country as the numéraire[13] such that $W^P = \omega$.

Prices. The zero-profit conditions also lets me derive the equilibrium prices for the various products. Using $p_T^R = \tau p^P$ I get

$$p^P = \begin{cases} \frac{F+P^R+\tau P^P}{\tau P^R + P^P} & \text{if the quality of traded goods is } q_h \text{ (regime A1),} \\ \frac{F+G+a(P^R+\tau P^P)}{\tau P^R+P^P} & \text{if the quality of traded goods is } q_l \text{ (regimes A2, A3); and} \end{cases}$$

$$p_T^R = \begin{cases} \tau\frac{F+P^R+\tau P^P}{\tau P^R + P^P} & \text{if the quality of traded goods is } q_h \text{ (regime A1),} \\ \tau\frac{F+G+a(P^R+\tau P^P)}{\tau P^R+P^P} & \text{if the quality of traded goods is } q_l \text{ (regimes A2, A3).} \end{cases}$$

[13] I set $W^R = 1$.

The zero-profit condition for an exclusive rich-country producer is $p_N^R P^R = F + P^R$ if the good is sold in high quality, and $p_N^R P^R = F+G+aP^R$ if the good is sold in low quality. Consequently, the equilibrium price of a non-traded variety is given by

$$p_N^R = \begin{cases} \frac{F+P^R}{P^R} & \text{if the quality of non-traded goods is } q_h \text{ (regimes A1, A2),} \\ \frac{F+G+aP^R}{P^R} & \text{if the quality of non-traded goods is } q_l \text{ (regime A3).} \end{cases}$$

Varieties. I denote the number of active firms in the poor country by N^P. N^P is determined by the poor country's resource constraint that must be binding in equilibrium: the total amount of labor $P^P L^P$ is fully employed to set up and run N^P firms each of them employing either $F + \tau P^R + P^P$ units of labor if the high quality (q_h) is supplied; or $F + G + a(\tau P^R + P^P)$ units of labor if the low quality (q_l) is supplied. Hence, the variety of goods produced in the poor country is given by

$$N_P = \begin{cases} \frac{P^P L^P}{F+\tau P^R+P^P} & \text{if} \quad q_h \text{ is supplied (regime A1),} \\ \frac{P^P L^P}{F+G+a(\tau P^R+P^P)} & \text{if} \quad q_l \text{ is supplied (regimes A2, A3).} \end{cases}$$

In the rich country, both traded and non-traded goods are produced which I denote by N_T^R and N_N^R, respectively. Solving for the rich-country variety of traded goods is straightforward. Using N_P toghether with the trade balance condition $N_T^R p^P P^P = N^P p_T^R P^R$ and the terms or trade $p_T^R / p^P = \tau$ I get

$$N_T^R = \begin{cases} \frac{\tau P^R L^P}{F+\tau P^R+P^P} & \text{if} \quad q_h \text{ is supplied (regime A1),} \\ \frac{\tau P^R L^P}{F+G+a(\tau P^R+P^P)} & \text{if} \quad q_l \text{ is supplied (regimes A2, A3).} \end{cases}$$

Finally, rearranging the budget constraint of a rich household yields the following expression for the variety of non-traded goods,

$$N_N^R = \frac{1}{p_N^R} \left[L_R - p_T^R (N_T^R + N_P) \right].$$

After having bought all available traded goods, rich households spend all their leftover income, $L_R - p_T^R(N_T^R + N_P)$, on exclusive goods. Therefore, the equilibrium variety of exclusive goods is given by a rich household's leftover income divided by the price for exclusive goods p_N^R. The equilibrium value of the leftover income is determined by a poor household's budget constraint, since the poor spend their entire income on all traded varieties. Thus, the value of traded varieties must be $N_T^R + N_P = \omega L^P / p^P$. Together with the rich household's budget constraint the general expression for the variety of non-traded goods is given by

$$N_N^R = \frac{1}{p_N^R} \left[L_R - \frac{p_T^R}{p^P} \omega L^P \right]. \tag{2}$$

Note that (2) must hold for any price setting strategy for which an equilibrium exists. In case of the arbitrage regimes, I have $p_T^R/p^P = \tau$. Together with the price for non-traded goods and the relative wage I get

$$N_N^R = \begin{cases} \frac{P^R}{F+P^R}(L^R - \tau\omega_h L^P) & \text{in regime A1,} \\ \frac{P^R}{F+P^R}(L^R - \tau\omega_l L^P) & \text{in regime A2,} \\ \frac{P^R}{F+G+aP^R}(L^R - \tau\omega_l L^P) & \text{in regime A3.} \end{cases}$$

The equilibrium prices and varieties of the arbitrage regimes are intuitive. First, the size of inequality is only reflected in varieties but not in prices, because prices are fully determined by zero-profit conditions and the arbitrage constraint. It must follow that the larger the inequality and hence the more income is left over for rich households to buy exclusive products, the larger the variety of exclusive products on the market in equilibrium. Indeed, the number of non-traded goods N_N^R is the only equilibrium quantity that depends on the difference of L^R and L^P. Second, prices are independent of the quality levels within a given marketing strategy. With such "0-1" preferences only the extensive and the quality margin of consumption is modeled, implying a discrete quantity-quality trade-off in the consumption of goods. Moreover, the firm's cost function is not continuous in the quality level either. If a firm produces a good in low quality, $q_l = q$, marginal costs are equal to a and do not react to a marginal change in q.

3.2 The "separating" regime

At first glance, the quality reduction may seem to be little more than an annoying by-product of the undertaken process innovation in attempt to reduce costs. But since firms do not lose the technology to produce the good in high quality after the process innovation, they can employ quality differentiation as part of their marketing strategy. Consider again a situation where the price setting of internationally active firms is constrained by the threat of arbitrage. The arbitrage constraint can be weakened simply by selling the high quality to the rich consumers and the low quality to the poor consumers. As a consequence, arbitrageurs still compete in the rich market if prices set by exporters are (too) high, but they have to offer the good in low quality for which the willingness to pay is lower. I refer to such a marketing strategy as a "separating" strategy[14].

[14] I show below that exporters can separate the rich into the low quality and the poor into the high quality, if the relative willingness to pay is relatively low and trade costs and/or the level of the low quality are high. In absence of trade costs, however, it is impossible to implement such a separating strategy.

The *separating regime* looks as follows. Exporters charge a price equal to the willingness to pay for the low quality, $p^P = q/\lambda^P$, in the poor country. In the rich country, exporters have to make sure that the households utility gain of consuming the high quality, $1/\lambda_R - p_T^R$ is at least as large as the utility gain of consuming an imported low quality version of the same good, $q/\lambda_R - \tau p^P$. They set a price $p_T^R = \tau q/\lambda^P + (1-q)/\lambda_R$, where rich households are indifferent between consuming the good in high or in low quality. Notice that also with a separating strategy, exporters cannot fully exploit the willingness to pay of the rich households. Hence, by the same argument as in the arbitrage regimes, there must exist varieties of non-traded high quality goods sold to rich households at price $p_N^R = 1/\lambda^R$.

Lemma 3 *In a separating equilibrium, firms that sell their product in both countries (a) set $p^P = q/\lambda^P$ in country P and $p_T^R = \tau q/\lambda^P + (1-q)/\lambda_R$ in country R, and (b) sell to all households in both countries.*

Proof. See Appendix A. ■

Wages. The zero-profit condition for a rich-country exporter is given by $p_T^R P^R + p^P P^P = W^R[F + G + P^R + \tau a P^P]$. While poor-country exporters earn the same revenues, they face total costs $W^P[F + G + aP^R + \tau P^P]$, yielding the relative wage

$$\omega_{h,l} = \frac{F + G + P^R + \tau a P^P}{F + G + \tau P^R + aP^P},$$

where the subscript h, l indicates that exporters sell their good in high quality to the rich and in low quality in the poor. While no productivity differences were present in the arbitrage regimes if the two countries were of equal size, this changes in the separating regime. Under the assumption of iceberg trade costs, where trade costs are proportional to (variable) production costs of a good, country-R exporters save trade costs by shipping the low quality. Hence, $\omega_{h,l} \leq 1$ for $P^R \geq aP^P$ and vice versa[15].

Prices. Using $p^P = q/\lambda^P$ and $p_N^R = 1/\lambda^R$, the price exporters charge for the high quality in the rich market can be expressed as $p_T^R = \tau p^P + (1-q)p_N^R$. Together with the zero-profit condition and $P_N^R = \frac{F+P^R}{P^R}$ I get[16]

$$p^P = \frac{q(F + P^R) + G + \tau a P^P}{\tau P^R + P^P} \quad \text{and} \quad p_T^R = \frac{\left[\tau + (1-q)\frac{P^P}{P^R}\right](F + P^R) + \tau(G + \tau a P^P)}{\tau P^R + P^P}.$$

[15] Asymptotic properties remain the same as for ω_h and ω_l; $\omega_{h,l} \in (\tau^{-1}, \tau)$. Moreover, $\omega_{h,l} = 1$ if $\tau = 1$.

[16] Calculations on page 40.

Because of the quality differentiation, prices of traded goods are, unlike in the arbitrage regimes, a continuous function of the quality levels. If the difference between the two qualities is big, i.e. q is low, the price for the high quality that sets a rich household indifferent between the two qualities is high and vice versa.

Varieties. The number of active firms in the poor country is again determined by the resource constraint, $P^P L^P = N^P(F + G + \tau P^R + aP^P)$,

$$N^P = \frac{P^P L^P}{F + G + \tau P^R + aP^P} = \omega_{h,l} L^P \frac{P^P}{F + G + P^R + \tau a P^P}.$$

Employing the budget constraint of a poor household, $\omega_{h,l} L^P = p^P(N_T^R + N^P)$ the variety of traded goods in the rich country can be expressed as $N_T^R = \frac{\omega_{h,l} L^P}{p^P} - N^P$. Plugging in p^P and N^P I get

$$N_T^R = \omega_{h,l} L^P \left[\frac{\tau P^R + P^P}{q(F + P^R) + G + \tau a P^P} - \frac{P^P}{F + P^R + G + \tau a P^P} \right].$$

Finally, using (2) and the price setting strategy for country-R traded goods, $p_T^R = \tau p^p + (1-q) p_N^R$, the variety of non-traded goods can be written as

$$N_N^R = \frac{1}{p_N^R}(L^R - \tau \omega_{h,l} L^P) - (1 - q)\omega_{h,l} L^P \frac{1}{p^p} \text{ , or}$$

$$N_N^R = \frac{P^R}{F + P^R}(L^R - \tau \omega_{h,l} L^P) - (1 - q)\omega_{h,l} L^P \frac{\tau P^R + P^P}{q(F + P^R) + G + \tau a P^P}.$$

Comparing the equilibrium variety of non-traded goods of the arbitrage regimes and the separating regime nicely shows that less country-R firms abstain from exporting in the separating regime. The positive part of N_N^R, $\frac{P^R}{F+P^R}(L^R - \tau \omega_{h,l} L^P)$, is approximately equal to the number of non-traded goods in the arbitrage regimes. The negative part turns out to be simply a fraction of the equilibrium variety of traded goods; $(1 - q)\omega_{h,l} L^P / p^p = (1 - q)(N_T^R + N^P)$. As expected, a larger quality gap (a lower q) comes with a lower variety of non-traded goods, $\partial N_N^R / \partial q > 0$. A larger quality differential between the two versions of the goods enables exporters to skim a bigger part of the consumer surplus of the rich, leaving them less "residual" income to purchase exclusive goods. Consequently, less exclusive producers exist in the separating regime.

4 Partial trade regimes

In the last section, I presented the separating strategy as some sort of an exporter's solution to the parallel trade problem when income differences between countries are significant. But the way process innovation and quality differentiation is specified strongly suggests that it depends on parameters whether the separating strategy is a valuable alternative to the pooling strategies.

For instance, if the process innovation brings about a massive reduction in marginal costs, whereas the loss in the good's quality is relatively moderate, it is easy to imagine that the separating strategy becomes unattractive. If the costs of a process innovation G are sufficiently low, exporters will supply the lower quality at a relatively high price globally while saving considerable costs in production. When G is prohibitively high instead, exporters are not willing to undertake a process innovation and sell only the high quality in both countries. Is the purpose of this section to closer examine what the optimal marketing strategies of firms are going to be given the constellation of parameters.

4.1 Borders of regimes

A regime exists if there exists a non-empty subset of the parameter space such that the firms' chosen marketing strategies constitute a Nash equilibrium. Therefore, borders of regimes are characterized by subsets of the parameter space where firms are indifferent between the regime's marketing strategy and the respective deviating strategies. As in Proposition 1, an intuitive way to determine these subsets is to find conditions on q that must be satisfied for a given partial trade regime to prevail. Checking the profitability of deviating strategies for each regime by all agents (exclusive producers, country-R exporters and country-P exporters) yields values for q as functions of cost parameters where agents are indifferent between the equilibrium strategy and the deviating strategy.

Symmetric regimes. I start by determining the borders of the symmetric regimes described in the previous section. I call a partial trade regime symmetric when exporters of the rich and the poor country adopt the same marketing strategy in equilibrium[17]. The following proposition states necessary conditions on q for each symmetric partial trade regime. These conditions will not be sufficient though since they do not guarantee partial trade. One could easily find parameter constellations satisfying the conditions on q where either all firms trade, because the income gap is too low (full trade); or firms do no trade at all, because trade costs (τ) are too high (autarky).

Proposition 2 *(a) In the separating regime* ***S*** *the following two conditions are satisfied: (i)* $q > \frac{G+(1+(\tau-1)\theta)aP^P}{(1+a(\tau-1)\theta)P^P} \equiv q_1^P$*, where* $\theta \equiv \frac{F+G\frac{P^R}{aP^P}+(1+\tau)P^R}{F+G+P^R+\tau aP^P}$*; and (ii)* $q < \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R} \equiv q_2^P$.

(b) In arbitrage regime ***A1*** *the following two conditions are satisfied: (i)* $q < \frac{G+\tau aP^P}{\tau P^P} \equiv q_1^R$*; and (ii)* $q < \frac{F+G+a(P^R+\tau P^P)}{F+P^R+\tau P^P} \equiv q_3^R$ *if* $P^P \geq P^R$*, and* $q < \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P} \equiv q_3^P$ *if* $P^P \leq P^R$.

[17] Strictly speaking, all partial trade equilibria are asymmetric in nature, since exclusive producers do not exists in the poor country.

(c) In arbitrage regime ***A2*** *the following three conditions are satisfied:*
(i) $q > q_3^R$ *if* $P^P \leq P^R$*, and* $q > q_3^P$ *if* $P^P \geq P^R$*; (ii)* $q > \frac{F+aP^R}{F+P^R} \equiv q_2^R$*; and*
(iii) $q < \frac{F+G+aP^R}{F+P^R} \equiv q^E$*.*

(d) In arbitrage regime ***A3*** *the following condition is satisfied:* $q > q^E$*.*

Proof. See Appendix C. ■

It is striking that the union of A1, A2, A3 and S does not exhaust the subset of the parameter space where partial trade occurs. For example if $q \in (q_1^R, q_1^P)$ and $q < \{q_3^R, q_3^P\}$, country-P exporters prefer a high quality pooling strategy over a separating strategy while country-R exporters prefer the opposite. The reason for these gray areas is the presence of productivity differences varying across regimes. For example the cost advantage (disadvantage) for a country-P exporter is always lower (higher) in the separating regime than in the arbitrage regimes, while the opposite counts for a country-R exporter. This implies that for country-R exporters it becomes profitable to switch from a pooling strategy (regimes A1-A3) to a separating strategy (regime S) before it becomes profitable for country-P exporters. On the other side, it becomes profitable for country-P exporters to switch from a separating strategy to a pooling strategy before it becomes profitable for country-R exporters. Note that in the absence of productivity differences the gray area would disappear and there would be knife-edged borders between symmetric partial trade regimes[18].

Asymmetric regimes. What happens in these gray areas, where exporters of the two countries disagree on the optimal marketing strategy? Luckily, the answer is simple: the partial trade equilibria become asymmetric. In the gray area between the separating regime S and A1, for example, country-R exporters adopt the separating strategy, while country-P exporters sell the high quality to all households. The only problem is the exploitation of symmetry in marketing strategies in order to solve for the relative wage ω. Remember that if exporters in both countries adopt the same strategy they will realize the same revenues in equilibrium. Together with the zero-profit conditions, I then solved for ω. However, if country-R exporters adopt a different marketing strategy than country-P exporters, revenues will diverge making it impossible to solve for the relative wage and prices, in general.

The good news are that the difference in revenues is known. To see this, consider again the gray area between S and A1. By optimal price setting, country-P exporters set $p_P^P = 1/\lambda^P$ for the high quality in the poor country and $p_{T,P}^R = \tau p_P^P$ in the rich country[19]. Country-

[18] This is never the case under the assumption of iceberg trade costs, even if the two countries are of equal size. I show below that under the assumption of per-unit trade costs productivity differences disappear for $P^R = P^P$.

[19] Subscript P indicates that prices are set by a country-P exporter.

R exporters set optimal prices according to the separating strategy where $p_R^P = q/\lambda^P$ and $p_{T,R}^R = \tau p_R^P + (1-q)p_N^R$. But then $p_R^P = qp_P^P$ must hold in equilibrium. The zero-profit condition is given by $\tau p_P^P P^R + p_P^P P^P - \omega[F + \tau P^R + P^P] = 0$ for a country-P exporter and $(\tau p_R^P + (1-q)p_N^R)P^R - p_R^P P^P - [F + G + P^R + \tau a P^P] = 0$ for an exporter in the rich country. Using $p_R^P = qp_P^P$ and $p_N^R = \frac{F+P^R}{P^R}$, the latter zero-profit condition can be expressed as $\tau p_P^P P^R + p_P^P P^P - (1/q)[q(F + P^R) + G + \tau a P^P] = 0$. Combined with the zero-profit condition of the country-P exporters I have $\omega = \frac{q(F+P^R)+G+\tau a P^P}{q(F+\tau P^R+P^P)}$. Calculating equilibrium prices is then again straightforward. Other asymmetric partial trade equilibria can be solved in the same manner. Being capable of solving for asymmetric partial trade equilibria lets me state the following proposition.

Proposition 3 *In a partial trade equilibrium, it is optimal for a country-i exporters to adopt: (a) a high quality pooling strategy if $q < q_1^i$ and $q < q_3^i$; (b) a low quality pooling strategy if $q > q_2^i$ and $q > q_3^i$; (c) a separating strategy if $q_1^i < q < q_2^i$.*

Proof. See Appendix C. ■

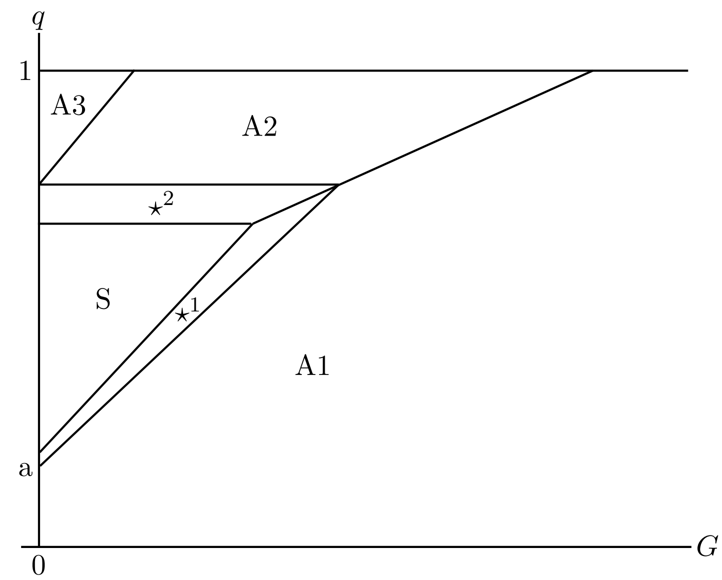
Proposition 3 determines the optimal marketing strategy of exporters in both countries given the prevailing constellation of parameters. To discuss the intuition, it is suggestive to provide a graphical illustration of the borders. As mentioned before, productivity differences and therefore the partitioning of the parameter space into symmetric and asymmetric regimes depends crucially on the relative population size of the two countries. For this reason, I take a closer look at three different cases where (i) the two countries are of equal size, (ii) the rich country is large and the poor country is small, and (iii) the rich country is small and the poor country is large. I discuss the intuition behind the influence of the cost parameters and the quality level on the regime borders in case (i). However, these intuitions do not change qualitatively when the countries vary in population size.

Two equally large countries. Figure 1 provides a graphical illustration of the partial trade regimes[20]. Exporters are equally productive in the arbitrage equilibria ($\omega_h = \omega_l = 1$) when countries are of equal size, i.e. $P^R = P^P$. They are indifferent between the high quality pooling and the low quality pooling strategy for the same quality levels $q_3^P = q_3^R$ implying that no asymmetric regime is present between the arbitrage regimes A1 and A2. Since country-P are always less productive under a separating strategy, they switch to a pooling strategy before

[20] Analog to Föllmi et al. (2014), I plot the critical levels of q against the process innovation costs G. For simplicity, q_1^P and q_2^P are graphed as linear functions in G. Note that q_1^P and q_2^P are indeed approximately linear in G since $\partial\theta/\partial G \approx 0$ and $\partial\omega_{h,l}/\partial G \approx 0$.

country-R exporters do. Therefore two asymmetric equilibria surrounding the separating regime always exist. In the area marked by ($\star^1$), country-P exporters adopt a separating strategy, while country-R exporters adopt a high quality pooling strategy. In the area marked by ($\star^2$), country-P exporters also adopt a separating strategy, while country-R exporters adopt a low quality pooling strategy instead. The size of the asymmetric regimes mainly depends on trade costs. The higher the trade costs the bigger these regimes.

Figure 1: Partial Trade Regimes ($P^R = P^P$)



The model provides interesting results about the role of the costs of product innovation (F) and process innovation (G). Clearly, supplying the low quality becomes more attractive when G is small. But it also becomes more attractive the smaller the cost of a product innovation F is[21]. The reason is that more products will be invented in equilibrium if the cost of a product innovation decreases. This lowers the willingness to pay for a single good since the income of the households is now spent on more and more goods. But the willingness to pay for the low quality does not drop as drastically as for the high quality while the drop on the cost side is identical. Consequently, supplying the low quality becomes more attractive for a lower F as well.

However, this explanation is not sufficient to understand the borders surrounding the separating strategy for two reasons. First, the border between S and A1 (q_1^R and q_1^P) depends on G as expected, but not on F[22]. As before, the willingness to pay for the low quality drops by less than for the high quality if F decreases which makes the low quality more attractive. But this effect only works for the market of the poor country, because in the rich country, exporters still supply the high quality. The price an exporter can charge for the high quality falls because the

[21] $\frac{\delta}{\delta F} q^E < 0$ and $\frac{\delta}{\delta F} q_3^R = \frac{\delta}{\delta F} q_3^P < 0$.

[22] Note that also $\partial\theta/\partial F \approx 0$ and $\partial\omega_{h,l}/\partial F \approx 0$.

willingness to pay drops if F decreases. But this price must fall even more because the difference between the willingness to pay for the high quality and the low quality is now smaller increasing the incentives for rich-country consumers to switch to the low quality. It seems that this effect compensates the potential gains of supplying the low quality in the poor country such that the overall effect of F is zero.

Second, the border between S and A2 (q_2^R and q_2^P) depends on F as expected, but not on G. If G decreases, the price exporters charge for the low quality in S decreases and thus, the price for the high quality must decrease as well to keep the rich buying the high quality. But one can easily observe that the prices the deviating exporter charges decrease by the exact same amount. Since exporters undertake a process innovation in both strategies, costs also decrease by the same amount. Therefore, the cost of a process innovation must be irrelevant if firms choose whether to sell the low quality only to the poor or to sell the low quality globally. In contrast, if F decreases, not only decreases the price an exporter charges for the low quality, but also the willingness to pay of the rich for the high quality. This decreases the price an exporter can charge for the high quality more drastically such that selling the low quality globally becomes more attractive.

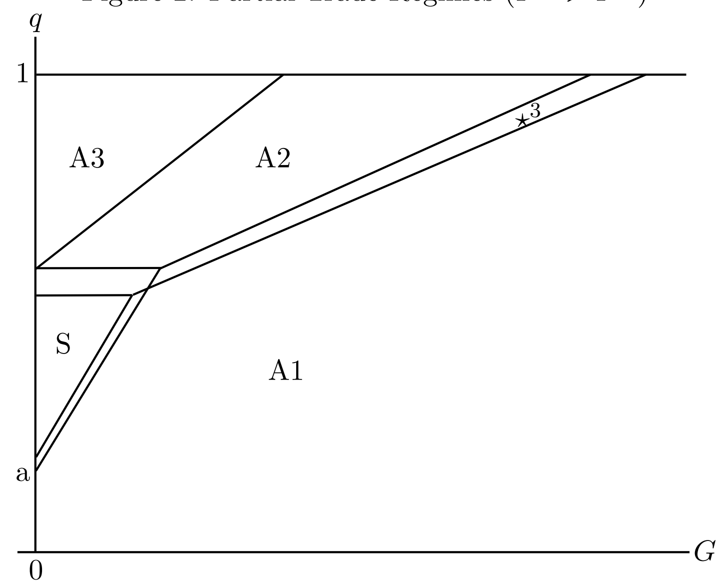
Supplying the low quality becomes more attractive the higher the difference of the quality reduction and the marginal cost reduction, $q - a$, of the process innovation is[23]. As a consequence, the prevalence of a separating equilibrium is impossible if the difference between the quality gap and the marginal cost gap is either too small or too large. If the difference is too small, the low quality is simply not profitable enough to serve the market of the poor country; if it is too large, exporters are no longer interested in separating the market. It is more profitable to sell only the low quality instead. The intuition is that the lower the price for a given quality level of the low quality[24], the higher is the incentive for the consumers in the rich country to import the low quality instead of buying the high quality in the home market. This forces the exporters to sell the high quality at a lower price to prevent the rich consumers of buying the low quality. Because the costs of (high quality) production remains unchanged, the margin shrinks, while at the same time the margin of the low quality increases, finally making it unattractive to separate the market. Furthermore, if the quality reduction is bigger than the marginal cost reduction ($q < a$), A1 will prevail with certainty, since it is never attractive to supply the low quality (even for $G = 0$).

[23]Note that with general quality and cost levels the difference could be written as $\frac{q_l}{a_l} - \frac{q_h}{a_h}$.

[24]Or the higher the level of the quality for a given price for the low quality.

A large rich country and a small poor country. A situation where the rich country is large and the poor country is small is illustrated in Figure 2. In that case the country-R exporters have lower costs in all strategies. As a result, an additional asymmetric regime, marked by ($\star^3$), exists between A1 and A2 where country-R exporters sell the high quality to all households, whereas country-P exporters sell only the low quality[25]. Country-P exporters are incentivized to deviate from a high quality pooling to a low quality pooling strategy before country-R exporters $q_3^P < q_3^R$ because the cost disadvantage is lower in A2.

Figure 2: Partial Trade Regimes ($P^R > P^P$)

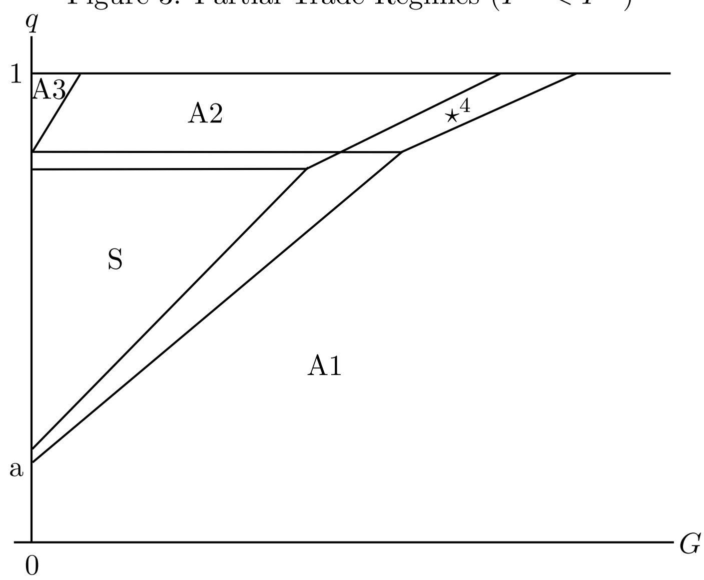


When the population in the rich country is much larger than in the poor, it becomes unlikely that the separating regime will prevail. The higher the population in the rich country, the lower will the rich households willingness to pay be for the high quality in equilibrium. But then the margin of the separating strategy becomes too low, since supplying the high quality to the rich comes at higher marginal costs. Therefore, the arbitrage regimes where exporters supply the low quality worldwide (A2 & A3) become more likely. In particular, A3 becomes more likely since exclusive producers face a high market size to spread the additional fix costs when undertaking a process innovation.

A small rich country and a large poor country. Finally, a case where the rich country is small and the poor country is large is illustrated in Figure 3.

[25] The border between A2 and A3 is always knife-edged, because it is determined only by deviation of exclusive producer which do not exist in the poor country.

Figure 3: Partial Trade Regimes ($P^R < P^P$)



When the poor country is very large compared to the rich country, it will have a cost advantage in all regimes. The cost advantage for the poor country is the highest in A1 and the lowest in S. Hence, country-P exporters again want to deviate to the pooling strategies before country-R exporters. Moreover, country-P exporter want to deviate from a high quality pooling to a low quality pooling strategy before country-R exporters ($q_3^P > q_3^R$), giving rise to an asymmetric regime, marked by ($\star^4$), where country-P exporter sell only the high quality and country-R exporters sell only the low quality globally.

The separating strategy becomes particularly attractive when the poor country is large and the rich country is small. On the one hand, the price exclusive producers can charge in equilibrium is going to be high, on the other hand, exclusive producers have to refrain from a huge market in the poor country. Needless to say that skimming the rich households' willingness to pay as much as possible by selling the high quality in the small rich market while selling the more efficient low quality in the large market of the poor country (benefiting from increasing returns-to-scale) tends to be a convincing strategy for an internationally active firm. Clearly, when both the size of the rich country and the poor country is small relative to the fix costs F and G, the arbitrage equilibrium A1 will be most likely to prevail.

4.2 Existence of equilibria

In a first step, I want to show under what conditions the above described partial trade regimes constitute indeed the only equilibrium outcomes where only a subset of the available varieties are traded. Thereafter, I note conditions ensuring that either partial trade, full trade, or no trade at all will occur in equilibrium.

I start with the proof that in a partial trade equilibrium, exclusive producers only exist in the rich country. Proposition 4 states that country-R exclusive producers realize strictly higher profits than country-P exclusive producers.

Proposition 4 *Denote by π_e^i the profit of an exclusive producer in country i, $i = R, P$. $\pi_e^R > \pi_e^P$ must hold in all partial trade equilibria.*

Proof. Assume exclusive producers supply their good in high quality. Then $\pi_e^R = p_N^R P^R - (F + P^R)$ and $\pi_e^P = p_N^R P^R - \omega(F + \tau P^R)$. It follows that $\pi_e^R > \pi_e^P$ if and only if $\omega > \frac{F+P^R}{F+\tau P^R}$. It is easy to see that ω satisfies this condition in all regimes. Assume now that exclusive producers supply their good in low quality. Then $\pi_e^R = p_N^R P^R - (F + G + aP^R)$ and $\pi_e^P = p_N^R P^R - \omega(F + G + \tau a P^R)$. It follows that $\pi_e^R > \pi_e^P$ if and only if $\omega > \frac{F+G+aP^R}{F+G+\tau a P^R}$ which is always true. ■

Clearly, π_e^R which is simply the zero-profit condition of a country-R exclusive producer, must be equal to zero in equilibrium. But then, by Proposition 3, country-P exclusive producers would realize negative profits forcing them to change strategy and sell their good to poor households as well. Country-P exclusive producers have a cost disadvantage since they are forced to ship their goods and thus face higher costs even when the relative wage is low.

Full trade or partial trade? Full trade equilibria all share the same two properties: (i) prices are set equal to willingnesses to pay of households in the two countries, i.e $p^P = \{1/\lambda^P, q/\lambda^P\}$ and $p^R = \{1/\lambda^R, q/\lambda^R\}$; and (ii) differences in per-capita incomes generate proportional differences in prices, i.e. $\frac{L^R}{\omega L^P} = \frac{p^R}{p^P}$. If firms adopt a pooling strategy in either quality, partial trade occurs as soon as $p^R > \tau p^P$ or if

$$\frac{L^R}{\omega L^P} > \tau \tag{3}$$

However, if firms adopt the separating strategy condition (2) is not sufficient to guarantee partial trade. By Lemma 2, the price that sets rich households indifferent between the high and the low quality is $p_T^R = \tau q/\lambda^P + (1-q)/\lambda^R$. Plugging in the full trade prices yields $p_T^R = \tau p^P + (1-q)p^R$. Partial trade occurs as soon as $p_N^R = p^R > \tau p^P + (1-q)p^R$ or if $p^R/p^P > \tau/q$. Hence, the condition for partial trade when firm adopt the separating strategy is

$$\frac{L^R}{\omega L^P} > \frac{\tau}{q} \; (> \tau). \tag{4}$$

Condition (3) is perfectly in line with the finding that the separating strategy indeed weakens the arbitrage constraint. Moreover, the variety of exclusive goods in the separating regime N_N^R becomes positive as soon as (3) is satisfied[26] and the variety of exclusive goods in the separating

[26] $N_N^R = \frac{1}{p_N^R}(L^R - \tau\omega_{h,l}L^P) - (1-q)\omega_{h,l}L^P\frac{1}{p^P} > 0$. Using $\frac{L^R}{\omega_{h,l}L^P} = \frac{p_N^R}{p^P}$ and solving yields $\frac{L^R}{\omega_{h,l}L^P} > \frac{\tau}{q}$.

regime is smaller than in the arbitrage regimes. Altogether, the possibility of customizing goods in the form of quality differentiation fosters trade.

Selling the low quality to the rich and the high quality to the poor? In contrast to the autarky model presented by Föllmi et al. (2014), separating the rich households into the low quality and the poor households into the high quality can only be ruled out if the following condition is satisfied.

Proposition 5 *Separating rich households into the low quality and poor households into the high quality is impossible for exporters if* $\frac{1/\lambda^R}{1/\lambda^P} > \frac{\tau - \frac{q}{\tau}}{1-q}$.

Proof. See Appendix D. ■

Unfortunately, this assumption is rather dissatisfying. Notice that the relative willingness to pay, $\frac{1/\lambda^R}{1/\lambda^P}$, is determined endogenously and is independent from the income gap in any partial trade equilibrium. Hence, assuming a large income gap does not rule out such a rather counter-intuitive marketing strategy. For example, assume the prevailing regime to be A3. Using $p_N^R = q/\lambda^R$ and $p^P = q/\lambda^P$, the assumption that rules out a deviation to such a "strange" separating strategy would be given by $\frac{p_N^R}{p^P} > \frac{\tau - \frac{q}{\tau}}{1-q}$. Obviously, the assumption is likely to be violated if trade costs are sufficiently large, or if q approaches unity. However, checking a such deviation for a country-R exporter in A3, shows that such a deviation would only be profitable if $q < a$, which is ruled out by assumption[27]. But when checking the deviation for a country-P exporter, it becomes more tedious to show whether such a deviation is possible for some parameter constellation. Moreover, deviations to such a strategy would have to be checked for all other partial trade regimes as well. In this analysis, however, I assume the above condition to hold.

Do firms trade? Up to now I have implicitly assumed that trade costs are sufficiently low so that the two countries will engage in trade. The following proposition proves existence of general equilibria with trade.

Proposition 6 *The two countries will trade with each other for all* $L^R/L^P \in (0, 1]$ *as long as* $\tau < \tau_h^* \equiv \sqrt{F/P^R + 1}$.

Proof. See Appendix E. ■

[27]Using $p_N^R = \frac{F+G+aP^R}{F+P^R}$ and $p^P = \frac{F+G+a(P^R+\tau P^P)}{\tau P^R + P^R}$, the deviation is profitable if $(\tau(1/q)p^P - (1-q)(1/q)p_N^R)P^R + (1/q)p^P P^P - [F + G + aP^R + \tau P^P] > 0$, or if $q < a$.

τ_h^* reflects the critical value that τ should fall below such that exporters in the arbitrage regime A1 are willing to engage in trade. In Appendix E, I showed that the critical values for τ in the other partial trade regimes (and the full trade regimes) are altogether higher than τ_h^*. Particularly, in the arbitrage regimes where exporters supply the low quality in all markets (A2 & A3), the critical value for τ, τ_l^*, turns out to be the highest. Thus, if $\tau > \tau_l^*$ none of the partial trade regimes exist. Note that under the assumption of iceberg trade costs, firms can lower their total trade costs by undertaking a process innovation and shipping the low quality which is produced at lower costs. This implies that in return trade costs can be higher such that exporting is still profitable.

5 The role of trade costs

Lastly, I want to discuss how some important findings of the above model crucially depend on the specification of trade costs. Since this work ought to be an advancement of the paper by Föllmi et al. (2013), I have so far assumed trade costs to be of standard iceberg type. However, the introduction of process innovation and the existence of a separating equilibrium unfolds a potential drawback of iceberg trade costs. Schröder & Sørensen (2012, p.3) accurately summarize that "iceberg cost specifications in a marginal cost heterogeneity setting have the undesirable side effect that firms with lower marginal cost are not only more productive in producing goods, but also more productive in transporting goods". This is exactly what makes the separating strategy systematically less attractive for country-P exporters. In the separating regime country-R exporters ship the more efficient low quality version of their product, making them more productive in trading their good. Moreover, by undertaking a process innovation, firms can save not only production costs, but also trade costs if they are of iceberg type.

The aim of this section, however, is not to generally criticize iceberg trade costs. Whether the side effect mentioned Schröder & Sørensen is indeed undesirable or not might also remain an empirical question. For instance, Irarrazabal et al. (2010) find in their analysis of WTO data on tariffs[28] that per-unit trade costs are substantial, being, on average, between 35 and 45 percent of the average consumer price. They reject a pure iceberg model and present a trade model encompassing both iceberg and per-unit trade costs finding that the modification has important consequences when firms are heterogeneous.

[28]WTO Integrated Database (IDB); see http://tariffdata.wto.org.

5.1 Per-unit trade costs

Similarly, let me now discuss some important consequences for the model under the assumption of per-unit trade costs[29]. I assume per-unit trade costs to be $t > 0$. In the separating regime, the relative wage changes to

$$\omega_{h,l} = \frac{F + G + P^R + aP^P + tP^P}{F + G + P^R + aP^P + tP^R}.$$

Notice that with per-unit trade costs the relative wage in the separating regime shares the same properties as the relative wages in the arbitrage regimes which are given by

$$\omega_h = \frac{F + P^R + P^P + tP^P}{F + P^R + P^P + tP^R} \quad \text{and} \quad \omega_l = \frac{F + G + a(P^R + P^P) + tP^P}{F + G + a(P^R + P^P) + tP^R}.$$

If the two countries are of equal size, $P^R = P^P$, the relative wage will be equal to unity, $\omega = 1$, also in the separating regime[30]. Using $p_R^T = p^P + t$ in the arbitrage regimes and $p_R^T = p^P + t + (1-q)p_N^R$ in the separating regime, together with the zero-profit conditions to calculate prices charged in the poor country yields

$$p^P = \begin{cases} \frac{F+P^R+P^P+t(P^P-P^R)}{P^R+P^P} & \text{in regime A1,} \\ \frac{F+G+a(P^R+P^P)+t(P^P-P^R)}{P^R+P^P} & \text{in regimes A2, A3; and} \end{cases}$$

$$p^P = \frac{q(F + P^R) + G + aP^P + t(P^P - P^R)}{P^R + P^P} \quad \text{in regime S.}$$

The profit when a country-R exporter in A1 deviates to a separating strategy becomes positive, i.e. $(qp^P + t + (1-q)p_N^R)P^R + qp^P P^P - (F + G + P^R + (a+t)P^P) > 0$, when

$$q > \frac{G + aP^P + t(P^P - P^R)}{P^P + t(P^P - P^R)} \equiv q_1^R.$$

Similarly, for a country-P exporter I have

$$q > \frac{G + aP^P + t(P^P - P^R)\phi}{P^P + t(P^P - P^R)\phi} \equiv q_{1'}^P \text{ , where } \phi = \frac{F + (1+t)P^R}{F + P^R + (1+t)P^P}.$$

It is easy to see that the critical quality level is identical for exporters when both countries are of the same size: $q_1^R = q_{1'}^P$ if $P^P = P^R$. Furthermore, exporters in S deviate to a high quality pooling strategy as soon as

$$q < \frac{G + aP^P + t(P^P - P^R)}{P^P + t(P^P - P^R)} = q_1^R$$

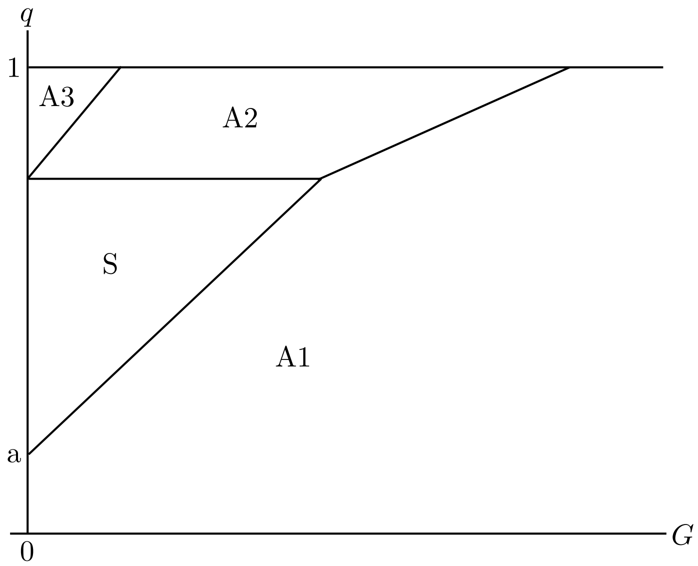
[29] Calculations on pages 46-53. A combination of both per-unit and iceberg trade costs, or an even more elaborate specification of trade costs would certainly be interesting. For the purpose of this section, however, it is sufficient to show the consequences by comparing the simple cases of per-unit trade costs and iceberg trade costs.

[30] Further properties are $\omega_l \geq \omega_{h,l} \geq \omega_h \geq 1$ for $P^P \geq P^R$ and vice versa; $\omega_h \in \{\frac{1}{1+t}, 1+t\}$, $\omega_{h,l} \in \{\frac{1}{1+t}, 1+\frac{t}{a}\}$, $\omega_l \in \{\frac{1}{1+\frac{t}{a}}, 1+\frac{t}{a}\}$.

$$q < \frac{G + aP^P + t(P^P - P^R)\theta}{P^P + t(P^P - P^R)\theta} \equiv q_1^P \text{ , where } \theta = \frac{F + (1+t)P^R}{F + G + P^R + (a+t)P^P},$$

showing that the border between the separating regime and the arbitrage regime A1 is knife-edged and $q_1^R = q_1^P = q_{1'}^P = \frac{G+aP}{P}$ when $P^P = P^R = P$. Because the relative wage is equal to unity in both regimes, neither country-R nor country-P exporters have a cost advantage under the deviating strategy. Implying that both are indifferent between strategies under the same parameter constellation. The same logic applies to all remaining borders as well. The relative wage adjusts for productivity differences within a regime. But productivity differences change discretely between regimes, incentivizing exporters from the less productive country to switch earlier to a strategy where productivity differences are diminished. Consequently, in absence of productivity differences, borders between symmetric regimes are knife-edge and asymmetric regimes are inexistent.

Figure 4: Partial trade regimes with per-unit trade costs ($P^R = P^P$)



After checking all possible deviations by both type of exporters in all regimes it follows that: (i) the subset of the parameter space where exporters are indifferent between a separating strategy (S) and a high quality pooling strategy (A1) is given by $q = \frac{G+aP^P}{P^P}$, (ii) the subset of the parameter space where exporters are indifferent between a separating strategy (S) and a low quality pooling strategy (A3 & A4) is given by $q = \frac{F+aP^R}{F+P^R}$, (iii) the subset of the parameter space where exporters are indifferent between a high quality pooling strategy (A1) and a low quality pooling strategy (A3 & A4) is given by $q = \frac{F+G+a(P^R+P^P)}{F+P^R+P^P}$. Figure 4 provides a graphical illustration of the partial trade regimes when both countries share the same population size. Notice that in absence of productivity differences, the borders do not depend on the amount of the per-unit trade costs since, in contrast to iceberg trade costs, exporters cannot save trade costs by undertaking a process innovation and producing the low quality. What remains unchanged is the intuition of the borders with respect to the cost parameters F, G and a.

5.2 Welfare effects of a trade liberalization

The specification of trade costs becomes particularly crucial when exploring how bilateral trade liberalizations affect welfare. In their partial trade model which is equivalent to an arbitrage regime with a single quality (A1 & A3), Föllmi et al. (2013) model a trade liberalization as a reduction in iceberg transportation costs τ and find that in an arbitrage regime the poor country is harmed by a trade liberalization, while the rich country profits. Indeed, it easy to show that this result holds in all arbitrage regimes if trade costs are of iceberg type. However, in a per-unit cost specification it turns out that in an arbitrage regime, the poor country profits (loses) from a trade liberalization if it is larger (smaller) than the rich country, i.e. $\partial U^P/\partial t \leq 0$ if $P^P \geq P^R$ and vice versa, while the rich country always profits.

What is the intuition behind this result? First, notice that higher trade costs must decrease the total variety of goods available because production now requires more resources. Second, higher trade costs imply a less tight arbitrage constraint motivating country-R firms to engage in trade. Due to these two effects it must follow that rich households which always consume all available varieties must benefit from a trade liberalization, while poor countries may or may not benefit since they consume only the subset of varieties that are traded internationally. Welfare in the poor country is given by either $U^P = N_T^R + N^P$ in A1, or $U^P = q(N_T^R + N^P)$ in A2 & A3. The variety of goods produced in the poor country, N^P, must decrease after an increase of trade costs because it is determined solely by the poor country's resource constraint that must be binding in equilibrium. Consequently, the poor country is harmed by a trade liberalization if the increase in domestically produced goods is overcompensated by the reduction of imported varieties from the rich country. This is what always happens if trade costs are of iceberg type. But if trade costs are per-unit, the arbitrage constraint is much less weakened if trade costs increase compared to iceberg costs. Imagine a situation where the poor country is very large and the rich country is small. Then an increase in trade costs generate relatively small additional revenues in the small rich market compared to the additional costs that have to be compensated. Consequently, the poor country tends to benefit more (or lose less) from a trade liberalization the larger it is. In the special case of a pure per-unit cost specification, the poor country benefits from a trade liberalization if its population size is bigger than in the rich country.

What about the separating regime? If trade costs are of iceberg type, the effect of a trade liberalization on welfare in the poor country becomes ambiguous. The poor country profits if the population size is sufficiently large, i.e. if

$$P^P \geq -[(1-a)P^P - (F+G)]\frac{\omega_{h,l}p^P}{a(1-q)p_N^R}.$$

I have shown before that in the separating regime, more country-R firms export since the separating strategy weakens the arbitrage constraint. If trade costs are further increased, enough additional country-R firms export their good to the poor country to compensate the decline of N^P only if the rich country is sufficiently big compared to the poor country. Otherwise, the cost effect dominates and the poor country profits from a trade liberalization. If trade costs are per-unit, instead, the result happens to be the same as in the arbitrage regimes. The poor country benefits from a trade liberalization if its population size is bigger than in the rich country.

6 Conclusions

In my Master thesis, I study a model of international trade in which quality differentiation can be generated primarily by demand forces. When per-capita income differences of trading partners are significant, quality differentiation enables exporters to skim more of the rich's consumer surplus arising out of a threat of parallel trade. If exporters sell the high quality to the rich and the low quality to the poor, arbitrageurs still enter the market if prices in the rich country are high. But they can only offer a lower quality version (imported from the poor country) for which the rich's willingness to pay is lower. Hence, exporters can charge a higher price in the rich country than a price which is equal to the willingness to pay of the poor plus trade costs.

In my model the ability to supply a vertically differentiated goods stems from a firm's investment in process innovation. This is different from other models where quality differentiation does not afford an additional investment. I show that a separating regime in which exporters make use of quality differentiation only prevails under certain conditions. If the cost of the investment or the quality loss is too high relative to the potential productivity gains, firms are not expected to undertake a process innovation and only sell the high quality. To the contrary, if productivity gains of a process innovations are substantial, firms are expected to sell all goods in low quality. The separating regime is likely to prevail if costs of a product innovation are high compared to the costs of a process innovation and the market size of the rich country is relatively small compared to the poor market. In such a situation, differences in the willingnesses to pay are going to be high in equilibrium, making quality differentiation particularly attractive.

I pointed out the crucial role of trade costs. First, if trading goods is costly, it may happen that rich- and poor-country exporters disagree on the optimal marketing strategy due to productivity differences. I show that even in this case the model stays tractable and that closed-form solutions exist. This becomes potentially interesting when comparative advantages are integrated into the model. Second, the specification of trade costs matters for the discussion of welfare effects of trade liberalizations. I show that in a separating regime, the rich country profits from a trade liberalization while the effect is generally ambiguous for the poor country. If trade costs are of iceberg type, the poor country is less likely to profit from a trade liberalization than under per-unit trade costs.

The separating regime accurately predicts some observed patterns of imports. Namely, rich countries import goods of higher quality than poor countries, on average. Unfortunately, exactly the opposite holds true for export patterns. The model predicts that rich countries export lower qualities than poor countries, which is clearly rejected empirically. This is not surprising, because it is assumed that even countries with huge differences in per-capita income have access to the same technology. For this reason, one should rather test whether the quality of exported relative to domestically sold goods within varieties is positively related to the export destination's per-capita income.

A synthesis of a demand- and supply-related trade model explaining the observed patterns of the extensive and the quality margin could be as follows. Motivated by Schott's evidence, rich countries have a comparative advantage in producing high quality goods because they are endowed with higher skilled workers. Newly invented goods of a rich country are therefore of higher quality than those of a poor country. When rich-country firms consider to export to a poor destination, they are incentivized to vertically differentiate their good via quality downgrading, i.e. process innovation. On the contrary, poor-country firms considering to export to a rich destination are incentivized to vertically differentiate their good via quality upgrading. Such a model would accurately predict that two rich countries trade higher qualities than two poor countries, a fact that cannot be explained with the model presented in this analysis.

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Appendix A: Proof of Lemma 3

(a) An exporter selling the high quality to the rich country and the low quality to the poor country faces the following profit maximization problem:

$$\max_{p_T^R, p^P} \left[P^R(p_T^R - 1) + P^P(p^P - \tau a) \right],$$

s.t. (i) $p_T^R \leq 1/\lambda_R$, (ii) $p^P \leq q/\lambda_P$,
(iii) $1/\lambda_R - p_T^R \geq q/\lambda_R - \tau p^P$, and (iv) $q/\lambda_P - p^P \geq 1/\lambda_P - \tau p_T^R$.

The constraints are based on the first-order conditions of the households (1). Constraints (i) and (ii) ensure that the households purchase the goods (typically referred to as rationality or participation constraints). (iii) and (iv) ensure that rich households prefer to buy the high quality instead of the low, and that poor households prefer to buy the low quality instead of the high (incentive-compatibility or self-selection constraints)[31].

Assume that the income cap between a rich and a poor household is sufficiently large. In particular, assume $1/\lambda_R > \tau/\lambda_P$. Constraint (iii) and $1/\lambda_R > \tau/\lambda_P$ imply $1/\lambda_R - p_T^R \geq q/\lambda_R - \tau p^P > q/\lambda_P - p^P$. Consequently, if constraint (ii) were inactive, so would be (i). But then the firm could increase both prices by the same amount without violating (iii) and (iv). Hence constraint (ii) must be active, $1/\lambda_R - p_T^R \geq q/\lambda_R - \tau p^P > q/\lambda_P - p^P = 0$, which implies that constraint (iii) must be active, too. Otherwise the firm could increase the price of the high quality without violating constraints (iii) and (i). If constraint (iii) is active, $1/\lambda_R - p_T^R = q/\lambda_R - \tau p^P > q/\lambda_P - p^P = 0$, constraint (i) cannot be active. From rewriting constraint (iv) as $\tau p_T^R - p^P \geq 1/\lambda_P - q/\lambda_P$ and using $p_T^R - \tau p^P = 1/\lambda_R - q/\lambda_R$ from constraint (iii), it follows that $\tau p_T^R - p^P > p_T^R - \tau p^P = 1/\lambda_R - q/\lambda_R > 1/\lambda_P - q/\lambda_P$, proving that constraint (iv) is not active as well. Hence constraints (ii) and (iii) are active and a separating exporter optimally sets prices $p^P = q/\lambda_P$ and $p_T^R = \tau q/\lambda^P + (1-q)/\lambda_R$. In a situation where $\tau/\lambda_P > 1/\lambda_R > 1/\lambda_P$, it is straightforward that to verify that only the participation constraints are active implying that exporters can exploit the full willingness to pay in both countries (full trade equilibrium).

(b) Assume to the contrary that only a fraction ν of consumers purchases the product at price $p^P(j) = q/\lambda^P$. As in Lemma 1, this cannot be an equilibrium, as the firm would lower $p^P(j)$ and $p^R(j)$ slightly and gain the whole market in the poor country.

[31] Notice that the price of the second best alternative has to be multiplied with the trade costs, since the good has to be imported. Apart from that, the proof is inherited from the monopolistic screening literature (Tirole, 1988).

Appendix B: Proof of Proposition 2

(a)[32] Assume the prevailing regime to be S with equilibrium prices

$$p_N^R = \frac{1}{\lambda^R} = \frac{F+P^R}{P^R}\ ;\ p^P = \frac{q}{\lambda^P} = \frac{q(F+P^R)+G+\tau a P^P}{\tau P^R + P^P}\ ;\ p_T^R = \tau p^P + (1-q)p_N^R,$$

and wage $\omega_{h,l} = \frac{F+G+P^R+\tau a P^P}{F+G+\tau P^R + a P^P}$. A country-$R$ exporter wants to deviate to a *high quality pooling* strategy if $\tau(1/\lambda^P)P^R + (1/\lambda^P)P^P - (F+P^R+\tau P^P) > 0$, i.e. if the deviation yields a positive profit[33]. Plugging in $1/\lambda^P = (1/q)p^P$ and solving for q yields

$$q < \frac{G+\tau a P^P}{\tau P^P} = q_1^R.$$

A country-P exporter wants to deviate if $\tau(1/\lambda^P)P^R + (1/\lambda^P)P^P - \omega_{h,l}(F+\tau P^R + P^P) > 0$. Plugging in $1/\lambda^P = (1/q)p^P$ and $\omega_{h,l}$ and solving for q yields

$$q < \frac{G+(1+(\tau-1)\theta)aP^P}{(1+a(\tau-1)\theta)P^P} = q_1^P,\ \text{ where }\ \theta = \frac{F+G\frac{P^R}{aP^P}+(1+\tau)P^R}{F+G+P^R+\tau a P^P}.$$

Because $q_1^P \geq q_1^R$, all exporters prefer the *separating* strategy to the *high quality pooling* strategy as long as $q > q_1^P$.

A country-R exporter wants to deviate to a *low quality pooling* strategy if $\tau(q/\lambda^P)P^R + (q/\lambda^P)P^P - (F+G+a(P^R+\tau P^P)) > 0$, or if

$$q > \frac{F+aP^R}{F+P^R} = q_2^R.$$

A country-P exporter wants to deviate if $\tau(q/\lambda^P)P^R + (q/\lambda^P)P^P - \omega_{h,l}(F+G+a(\tau P^R + P^P)) > 0$, or if

$$q > \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R} = q_2^P.$$

Because $q_2^P \leq q_2^R$, all exporters prefer the *separating* strategy to the *low quality pooling* strategy as long as $q < q_2^P$.

A country-R exclusive producer deviates to selling the low quality if $(q/\lambda^R)P^R - (F+G+P^R a) > 0$. Using $q/\lambda^R = qp_N^R$ and solving for q yields

$$q > \frac{F+G+aP^R}{F+P^R} = q^E.$$

But since $q^E \geq q_2^P \geq q_1^P$, exclusive producers never want deviate to the low quality as long as exporters stick to the separating strategy. Hence, the borders of the separating equilibrium are determined by $q_2^P > q > q_1^P$.

[32] Calculations on pages 40-43.

[33] A "high quality pooling" strategy is a strategy where exporters sell their good in high quality worldwide. In practice, such a deviation would not be possible with the same good since process innovation costs G are irreversible. However, if the above condition is satisfied, agents could simply sell the old firm and invent a new good where no process innovation is undertaken.

(b) Assume the prevailing regime to be A1 with equilibrium prices

$$p_N^R = \frac{1}{\lambda^R} = \frac{F+P^R}{P^R}\ ;\ p^P = \frac{1}{\lambda^P} = \frac{F+P^R+\tau P^P}{\tau P^R+P^P}\ ;\ p_T^R = \tau p^P,$$

and wage $\omega_h = \frac{F+P^R+\tau P^P}{F+\tau P^R+P^P}$.

A country-R exporter wants to deviate to a *low quality pooling* strategy if $\tau(q/\lambda^P)P^R + (q/\lambda^P)P^P - (F+G+a(P^R+\tau P^P)) > 0$, or if

$$q > \frac{F+G+a(P^R+\tau P^P)}{F+P^R+\tau P^P} = q_3^R.$$

A country-P exporter wants to deviate if $\tau(q/\lambda^P)P^R+(q/\lambda^P)P^P-\omega_h(F+G+a(\tau P^R+P^P)) > 0$, or if

$$q > \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P} = q_3^P.$$

It is straightforward to see that $q_3^R \geq q_3^P$ if $P^R \geq P^P$ and vice versa.

A country-R exporter wants to deviate to a *separating* strategy if $(\tau(q/\lambda^P)+(1-q)/\lambda^R)P^R + (q/\lambda^P)P^P - (F+G+P^R+\tau a P^P) > 0$, or if

$$q > \frac{G+\tau a P^P}{\tau P^P} = q_1^R.$$

A country-P exporter wants to deviate if $(\tau(q/\lambda^P)+(1-q)/\lambda^R)P^R + (q/\lambda^P)P^P - \omega_h(F+G+\tau P^R + aP^P) > 0$, or if

$$q > \frac{G+(a+(\tau-1)\phi)P^P}{(1+(\tau-1)\phi)P^P} \equiv q_{1'}^P, \text{ where } \phi = \frac{F+P^R+\tau P^R}{F+P^R+\tau P^P}.$$

Because $q_1^R \leq q_{1'}^P$, all exporters prefer the *high quality pooling* strategy to the *separating* strategy as long as $q < q_1^R$. Exclusive producers never want to deviate to the low quality before exporters ($q^E \geq q_1^R$ and $q^E \geq \{q_3^R, q_3^P\}$). Consequently, the borders of the arbitrage regime A1 are: $q < q_1^R$ and $q < q_3^R$ if $P^R \leq P^P$; and $q < q_1^R$ and $q < q_3^P$ if $P^R \geq P^P$ [34].

(c) Assume the prevailing regime to be A2 with equilibrium prices

$$p_N^R = \frac{1}{\lambda^R} = \frac{F+P^R}{P^R}\ ;\ p^P = \frac{q}{\lambda^P} = \frac{F+G+a(P^R+\tau P^P)}{\tau P^R+P^P}\ ;\ p_T^R = \tau p^P,$$

and wage $\omega_l = \frac{F+G+a(P^R+\tau P^P)}{F+G+a(\tau P^R+P^P)}$.

A country-R exporter wants to deviate to a *high quality pooling* strategy if $\tau(1/\lambda^P)P^R + (1/\lambda^P)P^P - (F+P^R+\tau P^P) > 0$, or if $q < q_3^R$. A country-P exporter wants to deviate if $\tau(1/\lambda^P)P^R + (1/\lambda^P)P^P - \omega_l(F+\tau P^R+P^P) > 0$, or if $q < q_3^P$.

A country-R exporter wants to deviate to a *separating* strategy if $(\tau(q/\lambda^P)+(1-q)/\lambda^R)P^R + (q/\lambda^P)P^P - (F+G+P^R+\tau a P^P) > 0$, or if

$$q < \frac{F+aP^R}{F+P^R} = q_2^R.$$

[34] For $P^R = P^P$, $q < q_3^R = q_3^P$ and $q < q_1^R$.

A country-P exporter wants to deviate if $(\tau(q/\lambda^P)+(1-q)/\lambda^R)P^R+(q/\lambda^P)P^P-\omega_l(F+G+\tau P^R+aP^P)>0$, or if

$$q>\frac{F+P^R-\omega_l(1-a)\tau P^R}{F+P^R}\equiv q^P_{2'}.$$

Because $q_2^R \geq q^P_{2'}$, all exporters prefer the *low quality pooling* strategy to the *separating* strategy as long as $q>q_2^R$. It follows that the borders of regime A2 are given by: $q<q^E$, $q>q_2^R$, and $q>q_3^R$ if $P^R\geq P^P$; and $q<q^E$, $q>q_2^R$, and $q>q_3^P$ if $P^R\leq P^P$ [35].

(d) Assume the prevailing regime to be A3. with equilibrium prices

$$p_N^R=\frac{q}{\lambda^R}=\frac{F+G+aP^R}{P^R}\ ;\ p^P=\frac{q}{\lambda^P}=\frac{F+G+a(P^R+\tau P^P)}{\tau P^R+P^P}\ ;\ p_T^R=\tau p^P,$$

and wage $\omega_l=\frac{F+G+a(P^R+\tau P^P)}{F+G+a(\tau P^R+P^P)}$. A country-$R$ exclusive producer deviates to selling the *high quality* if $(1/\lambda^R)P^R-(F+P^R)>0$. Using $1/\lambda^R=(1/q)p_N^R$ and solving for q yields

$$q<\frac{F+G+aP^R}{F+P^R}=q^E.$$

By (a), (b) and (c), it follows that the border of regime A3 is $q>q^E$.

Appendix C: Proof of Proposition 3

Assume[36] a regime where country-P producers set prices $p_P^P=1/\lambda^P$ and $p^R_{T,P}=\tau/\lambda^P$ (high quality pooling), and country-R producers set $p_R^P=q/\lambda^P$ and $p^R_{T,R}=\tau q/\lambda^P+(1-q)/\lambda^R$ (separating). I have $p_R^P=qp_P^P$ and, together with the zero-profit conditions and $p_N^R=1/\lambda^R=\frac{F+P^R}{P^R}$, I get $\omega=\frac{q(F+P^R)+G+\tau aP^P}{q(F+\tau P^R+P^P)}$ and $p_R^P=\frac{q(F+P^R)+G+\tau aP^P}{\tau P^R+P^P}$.

A country-R exporters deviates to a high quality pooling strategy if $\tau(1/q)p_R^PP^R+(1/q)p_R^P-[F+P^R+\tau P^R]>0$, or if $q<q_1^R=\frac{G+\tau aP^P}{\tau P^P}$. A country-$P$ exporter deviates to a separating strategy if $(\tau p_R^P+(1-q)p_N^R)P^R+p_R^PP^P-\omega[F+G+\tau P^R+aP^P]>0$, or if $q>q_1^P=\frac{G+(1+(\tau-1)\theta)aP^P}{(1+a(\tau-1)\theta)P^P}$. A country-$P$ exporter deviates to a low quality pooling strategy if $\tau p_R^PP^R+p_R^PP^P-\omega[F+G+a(\tau P^R+P^P)]>0$, or if $q>q_3^P=\frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P}$.

Now, assume a regime where country-P producers set prices $p_P^P=q/\lambda^P$ and $p^R_{T,P}=\tau q/\lambda^P$ (low quality pooling), and country-R producers set $p_R^P=q/\lambda^P$ and $p^R_{T,R}=\tau q/\lambda^P+(1-q)/\lambda^R$ (separating). I have $p_R^P=p_P^P$ and, together with the zero-profit conditions and $p_N^R=1/\lambda^R=\frac{F+P^R}{P^R}$, I get $\omega=\frac{q(F+P^R)+G+\tau aP^P}{F+G+a(\tau P^R+P^P)}$ and $p_R^P=\frac{q(F+P^R)+G+\tau aP^P}{\tau P^R+P^P}$.

A country-R exporters deviates to a low quality pooling strategy if $\tau p_R^PP^R+p_R^PP^P-[F+G+a(P^R+\tau P^R)]>0$, or if $q>q_2^R=\frac{F+aP^R}{F+P^R}$. A country-$P$ exporter deviates to

[35] For $P^R=P^P$; $q<q^E$, $q>q_2^R$, and $q>q_3^R=q_3^P$.

[36] Calculations on pages 44-46.

a separating strategy if $(\tau p_R^P + (1-q)p_N^R)P^R + p_R^P P^P - \omega[F + G + \tau P^R + aP^P] > 0$, or if $q < q_2^P = \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R}$. A country-$P$ exporter deviates to a high quality pooling strategy if $\tau(1/q)p_R^P P^R + (1/q)p_R^P P^P - \omega[F + \tau P^R + P^P] > 0$, or if $q < q_3^P = \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P}$.

Now, assume a regime where country-P producers set prices $p_P^P = q/\lambda^P$ and $p_{T,P}^R = \tau q/\lambda^P$ (low quality pooling), and country-R producers set $p_R^P = 1/\lambda^P$ and $p_{T,R}^R = \tau 1/\lambda^P$ (high quality pooling). I have $p_R^P = p_P^P/q$ and, together with the zero-profit conditions and $p_N^R = 1/\lambda^R = \frac{F+P^R}{P^R}$, I get $\omega = \frac{q(F+P^R+\tau P^P)}{F+G+a(\tau P^R+P^P)}$ and $p_R^P = \frac{F+P^R+\tau P^P}{\tau P^R+P^P}$.

A country-R exporters deviates to a low quality pooling strategy if $\tau q p_R^P P^R + q p_R^P - [F + G + a(P^R + \tau P^R)] > 0$, or if $q > q_3^R = \frac{F+G+a(P^R+\tau P^R)}{F+P^R+\tau P^P}$. A country-$R$ exporter deviates to a separating strategy if $(\tau q p_R^P + (1-q)p_N^R)P^R + q p_R^P P^P - [F + G + P^R + \tau a P^P] > 0$, or if $q > q_1^R = \frac{G+\tau a P^P}{\tau P^P}$. A country-$P$ exporter deviates to a high quality pooling strategy if $\tau p_R^P P^R + p_R^P P^P - \omega[F + \tau P^R + P^P] > 0$, or if $q < q_3^P = \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P}$.

Finally, assume a regime where country-P producers set prices $p_P^P = 1/\lambda^P$ and $p_{T,P}^R = \tau 1/\lambda^P$ (high quality pooling), and country-R producers set $p_R^P = q/\lambda^P$ and $p_{T,R}^R = \tau q/\lambda^P$ (low quality pooling). I have $p_R^P = q p_P^P$ and, together with the zero-profit conditions and $p_N^R = 1/\lambda^R = \frac{F+P^R}{P^R}$, I get $\omega = \frac{F+G+a(P^R+\tau P^P)}{q(F+\tau P^R+P^P)}$ and $p_R^P = \frac{F+G+a(P^R+\tau P^P)}{\tau P^R+P^P}$.

A country-R exporters deviates to a high quality pooling strategy if $\tau(1/q)p_R^P P^R + (1/q)p_R^P P^P - [F + P^R + \tau P^P] > 0$, or if $q < q_3^R = \frac{F+G+a(P^R+\tau P^R)}{F+P^R+\tau P^P}$. A country-$R$ exporter deviates to a separating strategy if $(\tau p_R^P + (1-q)p_N^R)P^R + p_R^P P^P - [F + G + P^R + \tau a P^P] > 0$, or if $q < q_2^R = \frac{F+aP^R}{F+P^R}$. A country-$P$ exporter deviates to a low quality pooling strategy if $\tau p_R^P P^R + p_R^P P^P - \omega[F + G + a(\tau P^R + P^P)] > 0$, or if $q > q_3^P = \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P}$.

By the above critical values for q and Proposition 2, it follows directly that a country-R exporter adopt: (a) a high quality pooling strategy for $q < q_1^R = \frac{G+\tau a P^P}{\tau P^P}$ and $q < q_3^R = \frac{F+G+a(P^R+\tau P^R)}{F+P^R+\tau P^P}$; (b) a low quality pooling strategy for $q > q_2^R = \frac{F+aP^R}{F+P^R}$ and $q > q_3^R = \frac{F+G+a(P^R+\tau P^R)}{F+P^R+\tau P^P}$; (c) a separating strategy for $q > q_1^R = \frac{G+\tau a P^P}{\tau P^P}$ and $q < q_2^R = \frac{F+aP^R}{F+P^R}$.

A country-P exporter adopt: (a) a high quality pooling strategy for $q < q_1^P = \frac{G+(1+(\tau-1)\theta)aP^P}{(1+a(\tau-1)\theta)P^P}$ and $q < q_3^P = \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P}$; (b) a low quality pooling strategy for $q > q_2^P = \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R}$ and $q > q_3^P = \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P}$; (c) a separating strategy for $q > \frac{G+(1+(\tau-1)\theta)aP^P}{(1+a(\tau-1)\theta)P^P}$ and $q < q_2^P = \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R}$.

Appendix D: Proof of Proposition 5

An exporter selling the low quality to the rich country and the high quality to the poor country faces the following profit maximization problem:

$$\max_{p_T^R, p^P} \left[P^R(p_T^R - a) + P^P(p^P - \tau) \right],$$

s.t. (i) $p_T^R \leq q/\lambda_R$, (ii) $p^P \leq 1/\lambda_P$,

(iii) $q/\lambda_R - p_T^R \geq 1/\lambda_R - \tau p^P$, and (iv) $1/\lambda_P - p^P \geq q/\lambda_P - \tau p_T^R$.

Assume that constraints (ii) and (iii) are binding, while (i) and (iv) are not. I have $p^P = 1/\lambda_P$ and $p_T^R = \tau/\lambda_P - (1-q)/\lambda_R$. Constraint (i) is inactive if $q/\lambda_R > \tau/\lambda_P - (1-q)/\lambda_R$, or if $\frac{1/\lambda_R}{1/\lambda_P} > \tau$, which holds by the full trade condition. Constraint (iv) is inactive if $q/\lambda_P - \tau p_T^R < 0$, of if $\frac{1/\lambda_R}{1/\lambda_P} < \frac{\tau - \frac{q}{\tau}}{1-q}$. Conversely, if

$$\frac{1/\lambda_R}{1/\lambda_P} > \frac{\tau - \frac{q}{\tau}}{1-q},$$

constraint (iv) becomes active and constraint (ii) cannot simultaneously be active.

Appendix E: Proof of Proposition 6

In a partial trade regime where q_h is sold globally (A1) I have $p^p = (F + P^R + \tau P^P)/(\tau P^R + P^P)$. Country-$R$ firms export as long as the margin of traded goods is positive: $p^P \geq \tau$, or $(F + P^R + \tau P^P)/(\tau P^R + P^P) \geq \tau$. Solving the latter equation for τ yields the trade condition. If the trade condition holds for country-R firms, it also holds for country-P firms, since $p_T^R = \tau p^P \geq \omega_h \tau$ and $\omega_h < \tau$. Under full trade I have $p^p = \omega_h L^P(F + P^R + \tau P^P)/(L^R P^R + \omega_h L^P P^P) \geq \tau$ or $(\omega_h L^P/L^R)(F/P^R + 1) \geq \tau$. But since full trade occurs $\omega_h L^P/L^R \geq 1/\tau$, the trade condition follows.

In a partial trade regime where q_h is sold to the rich and q_l to the poor (S), $p^p = (q(F + P^R) + G + \tau a P^P)/(\tau P^R + P^P)$. Country-$R$ firms export as long as the margin of traded goods is positive: $p^P \geq \tau a$, or $(q(F + P^R) + G + \tau a P^P)/(\tau P^R + P^P) \geq \tau a$. Solving the latter equation for τ yields $\tau_{h,l}^* \equiv \sqrt{(qF + G)/aP^R + q/a}$. It is straightforward to verify that $\tau^* < \tau_{h,l}^*$. If the trade condition holds for country-R firms, it also holds for country-P firms, since $p_T^R = \tau p^P + (1-q)p_N^R \geq \omega_{h,l}\tau$ and $\omega_h < \tau$. Under full trade, $p^p = \omega_{h,l} L^P(F + G + P^R + \tau a P^P)/(L^R P^R + \omega_{h,l} L^P P^P) \geq \tau a$ or $(\omega_{h,l} L^P/L^R)((F+G)/P^R + 1) \geq \tau a$. By (3), full trade occurs if $\omega_{h,l} L^P/L^R \geq q/\tau$. Even if (3) would hold with equality, the trade condition is satisfied because $p \leq \sqrt{q((F+G)/aP^R + 1)} > \tau^*$.

Finally, in a partial trade regime where exporters sell q_l globally (A2 & A3) I have $p^p = (F + G + a(P^R + \tau P^P))/(\tau P^R + P^P)$. Country-$R$ firms export as long as the margin of traded goods is positive: $p^P \geq \tau a$, or $(F+G+a(P^R+\tau P^P))/(\tau P^R+P^P) \geq \tau a$. Solving the latter equation for τ yields $\tau_l^* \equiv \sqrt{(F+G)/aP^R+1}$. Since $\tau^* < \tau_l^*$, the trade conditions holds. If the trade condition holds for country-R firms, it also holds for country-P firms, since $p_T^R = \tau p^P \geq \omega_l \tau a$ and $\omega_l < \tau$. Under full trade, $p^p = \omega_l L^P(F+G+a(P^R+\tau a P^P))/(L^R P^R + \omega_l L^P P^P) \geq \tau a$ or $(\omega_l L^P/L^R)((F+G)/P^R+1) \geq \tau a$. Since full trade only occurs if $\omega_l L^P/L^R \geq 1/\tau$, the trade condition follows.

Calculations

Separating Equilibrium (3.2) Prices.

$$
\begin{aligned}
p_N^R &= \frac{F+P^R}{P^R} \\
p_T^R &= \tau p^P + (1-q)p_N^R \\
p_T^R P^R + p^P P^P &= F + P^R + G + \tau a P^P \\
\left(\tau p_l^P + (1-q)\frac{F+P^R}{P^R}\right) P^R + p_l^P P^P &= F + P^R + G + \tau a P^P \\
p^P &= \frac{q(F+P^R) + G + \tau a P^P}{\tau P^R + P^P} \\
p_T^R &= \tau \frac{q(F+P^R) + G + \tau a P^P}{\tau P^R + P^P} + (1-q)\frac{F+P^R}{P^R} \\
&= \frac{\left[\tau + (1-q)\frac{P^P}{P^R}\right](F+P^R) + \tau(G+\tau a P^P)}{\tau P^R + P^P}
\end{aligned}
$$

Proof of Proposition 2. (a) Separating regime **S**: A country-R exporter deviates to a *high quality pooling* strategy if

$$
\begin{aligned}
\tau(1/q)p^P P^R + (1/q)p^P P^P - (F + P^R + \tau P^P) &> 0 \\
p^P(\tau P^R + P^P) - q(F + P^R + \tau P^P) &> 0 \\
q(F+P^R) + G + \tau a P^P - q(F + P^R + \tau P^P) &> 0 \\
q < \frac{G + \tau a P^P}{\tau P^P} &= q_1^R.
\end{aligned}
$$

A country-P exporter deviates to a *high quality pooling* strategy if

$$
\begin{aligned}
(1/q)p^P P^R + (1/q)p^P P^P - \omega_{h,l}(F + \tau P^R + P^P) &> 0 \\
q(F+P^R) + G + \tau a P^P - q\omega_{h,l}(F + \tau P^R + P^P) &> 0 \\
(q-1)(F+P^R) + F + P^R + G + \tau a P^P - q\omega_{h,l}(F + \tau P^R + P^P) &> 0 \\
(q-1)(F+P^R)\frac{1}{\omega_{h,l}} + F + \tau P^R + G + a P^P - q(F + \tau P^R + P^P) &> 0 \\
(1-q)\left[F + \tau P^R - (F+P^R)\frac{1}{\omega_{h,l}}\right] + G + aP^P - qP^P &> 0 \\
(1-q)\frac{(\tau-1)aP^P F + (\tau-1)GP^R + (\tau^2-1)aP^P P^R}{F + G + P^R + \tau a P^P} + G + aP^P - qP^P &> 0 \\
(1-q)a(\tau-1)P^P \frac{F + G\frac{P^R}{aP^P} + (1+\tau)P^R}{F + G + P^R + \tau a P^P} + G + aP^P - qP^P &> 0 \\
q < \frac{G + (1 + (\tau-1)\theta)aP^P}{(1 + a(\tau-1)\theta)P^P} = q_1^P \text{ , where } \theta &= \frac{F + G\frac{P^R}{aP^P} + (1+\tau)P^R}{F + G + P^R + \tau a P^P}
\end{aligned}
$$

Show that $q_1^P \geq q_1^R$:

$$\begin{aligned}
\frac{G+(1+(\tau-1)\theta)aP^P}{(1+a(\tau-1)\theta)P^P} &\geq \frac{G+\tau aP^P}{\tau P^P} \\
G(\tau-1-a(\tau-1)\theta) &\geq \tau aP^P(1+a(\tau-1)\theta-1-(\tau-1)\theta) \\
G(1-a\theta) &\geq -\tau aP^P(1-a)\theta \\
G &\geq \theta a(G-(1-a)\tau P^P),
\end{aligned}$$

which tivially holds, because $G < (1-a)\tau P^P$ for $q_1^R < 1$.

A country-R exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}
\tau p^P P^R + p^P P^P - (F+G+a(P^R+\tau P^P)) > 0 \\
p^P(\tau P^R + P^P) - (F+G+a(P^R+\tau P^P)) > 0 \\
q(F+P^R) + G + \tau aP^P - (F+G+a(P^R+\tau P^P)) > 0 \\
q > \frac{F+aP^R}{F+P^R} = q_2^R.
\end{aligned}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}
\tau p^P P^R + p^P P^P - \omega_{h,l}(F+G+a(\tau P^R+P^P)) > 0 \\
q(F+P^R) + G + \tau aP^P - \omega_{h,l}(F+G+a(\tau P^R+P^P)) > 0 \\
(q-1)(F+P^R) + F + P^R + G + \tau aP^P - \omega_{h,l}(F+G+a(\tau P^R+P^P)) > 0 \\
(q-1)(F+P^R)\frac{1}{\omega_{h,l}} + (1-a)\tau P^R > 0 \\
q > \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R} = q_2^P.
\end{aligned}$$

Show that $q_2^R \geq q_2^P$:

$$\begin{aligned}
\frac{F+aP^R}{F+P^R} &\geq \frac{F+P^R-\omega_{h,l}(1-a)\tau P^R}{F+P^R} \\
P^R(\omega_{h,l}\tau-1) &\geq aP^R(\omega_{h,l}\tau-1)
\end{aligned}$$

which holds, since $\omega_{h,l} \in (\tau^{-1}, \tau)$.

A country-R exclusive producer deviates to selling the *low quality* if

$$\begin{aligned}
qp_N^R P^R - (F+G+aP^R) > 0 \\
q(F+P^R) - (F+G+aP^R) > 0 \\
q > \frac{F+G+aP^R}{F+P^R} = q^E.
\end{aligned}$$

(b) Arbitrage regime **A1**: A country-R exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}
\tau qp^P P^R + qp^P P^P - (F+G+a(P^R+\tau P^P)) > 0 \\
q(F+P^R+\tau P^P) - (F+G+a(P^R+\tau P^P)) > 0 \\
q > \frac{F+G+a(P^R+\tau P^P)}{F+P^R+\tau P^P} = q_3^R.
\end{aligned}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}\tau q p^P P^R + q p^P P^P - \omega_h(F+G+a(\tau P^R+P^P)) &> 0\\ q(F+\tau P^R+P^P) - (F+G+a(\tau P^R+P^P)) &> 0\\ q > \frac{F+G+a(\tau P^R+P^P)}{F+\tau P^R+P^P} &= q_3^P.\end{aligned}$$

A country-R exporter deviates to a *separating* strategy if

$$\begin{aligned}(\tau q p^P + (1-q)p_N^R)P^R + q p^P P^P - (F+G+P^R+\tau a P^P) &> 0\\ q p^P(\tau P^R + P^P) + (1-q)p_N^R P^R - (F+G+P^R+\tau a P^P) &> 0\\ q(F+P^R+\tau P^P) + (1-q)(F+P^R) - (F+G+P^R+\tau a P^P) &> 0\\ q > \frac{G+\tau a P^P}{\tau P^P} &= q_1^R.\end{aligned}$$

A country-P exporter deviates to a *separating* strategy if

$$\begin{aligned}(\tau q p^P + (1-q)p_N^R)P^R + q p^P P^P - \omega_h(F+G+\tau P^R+aP^P) &> 0\\ q(F+P^R+\tau P^P) + (1-q)(F+P^R) - \omega_h(F+G+\tau P^R+aP^P) &> 0\\ (1-q)\left[(F+P^R)\frac{1}{\omega_h} - (F+\tau P^R)\right] - G + qP^P - aP^P &> 0\\ -(1-q)P^P\frac{(\tau-1)F+(\tau^2-1)P^R}{F+P^R+\tau P^P} - G + qP^P - aP^P &> 0\\ -(1-q)(\tau-1)P^P\frac{F+(1+\tau)P^R}{F+P^R+\tau P^P} - G + qP^P - aP^P &> 0\\ q > \frac{G+(a+(\tau-1)\phi)P^P}{(1+(\tau-1)\phi)P^P} &= q_{1'}^P\text{ , where }\phi = \frac{F+P^R+\tau P^R}{F+P^R+\tau P^P}.\end{aligned}$$

Show that $q_{1'}^P \geq q_1^R$:

$$\begin{aligned}\frac{G+(a+(\tau-1)\phi)P^P}{(1+(\tau-1)\phi)P^P} &\geq \frac{G+\tau a P^P}{\tau P^P}\\ G(\tau-1) + \tau a P^P + \tau(\tau-1)\phi P^P &\geq G(\tau-1)\phi + \tau a P^P + \tau a(\tau-1)\phi P^P\\ G &\geq (G-(1-a)\tau P^P)\phi\end{aligned}$$

which tivially holds, because $G < (1-a)\tau P^P$ for $q_1^R < 1$.

(c) Arbitrage regime **A2**: A country-R exporter deviates to a *high quality pooling* strategy if

$$\begin{aligned}\tau(1/q)p^P P^R + (1/q)p^P P^P - (F+P^R+\tau P^P) &> 0\\ F+G+a(P^R+\tau P^P) - q(F+P^R+\tau P^P) &> 0\\ q < \frac{F+G+a(P^R+\tau P^P)}{F+P^R+\tau P^P} &= q_3^R.\end{aligned}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}\tau(1/q)p^P P^R + (1/q)p^P P^P - \omega_l(F + \tau P^R + P^P) &> 0\\ F + G + a(\tau P^R + P^P) - q(F + \tau P^R + P^P) &> 0\\ q < \frac{F + G + a(\tau P^R + P^P)}{F + \tau P^R + P^P} &= q_3^P.\end{aligned}$$

A country-R exporter deviates to a *separating* strategy if

$$\begin{aligned}(\tau p^P + (1-q)p_N^R)P^R + p^P P^P - (F + G + P^R + \tau a P^P) &> 0\\ F + G + a(P^R + \tau P^P) + (1-q)(F + P^R) - (F + G + P^R + \tau a P^P) &> 0\\ q < \frac{F + aP^R}{F + P^R} &= q_2^R.\end{aligned}$$

A country-P exporter deviates to a *separating* strategy if

$$\begin{aligned}(\tau p^P + (1-q)p_N^R)P^R + p^P P^P - \omega_l(F + G + \tau P^R + aP^P) &> 0\\ F + G + a(P^R + \tau P^P) + (1-q)(F + P^R) - \omega_l(F + G + \tau P^R + aP^P) &> 0\\ (1-q)(F + P^R)\frac{1}{\omega_l} - (1-a)\tau P^R &> 0\\ q < \frac{F + P^R - \omega_l(1-a)\tau P^R}{F + P^R} &= q_{2'}^P.\end{aligned}$$

Show that $q_2^R \geq q_{2'}^P$:

$$\begin{aligned}\frac{F + aP^R}{F + P^R} &\geq \frac{F + P^R - \omega_l(1-a)\tau P^R}{F + P^R}\\ P^R(\omega_l\tau - 1) &\geq aP^R(\omega_l\tau - 1)\end{aligned}$$

which holds, since $\omega_l \in (\tau^{-1}, \tau)$.

(d) Arbitrage regime **A3**: A country-R exclusive producer deviates to the *high quality* if

$$\begin{aligned}(1/q)p_N^R P^R - (F + P^R) &> 0\\ (F + G + aP^R) - q(F + P^R) &> 0\\ q < \frac{F + G + aP^R}{F + P^R} &= q^E.\end{aligned}$$

Proof of Proposition 3. Assume a regime where country-P exporters adopt a high quality pooling strategy and country-R producer adopt a separating strategy: A country-R exporter deviates to a *high quality pooling* strategy if

$$\begin{aligned}
\tau(1/q)p_R^P P^R + (1/q)p_R^P P^P - (F + P^R + \tau P^P) &> 0 \\
p_R^P(\tau P^R + P^P) - q(F + P^R + \tau P^P) &> 0 \\
q(F + P^R) + G + \tau a P^P - q(F + P^R + \tau P^P) &> 0 \\
q < \frac{G + \tau a P^P}{\tau P^P} &= q_1^R.
\end{aligned}$$

A country-P exporter deviates to a *separating* strategy if

$$\begin{aligned}
(\tau p_R^P + (1-q)p_N^R)P^R + p_R^P P^P - \omega(F + G + \tau P^R + aP^P) &> 0 \\
q(F + P^R) + G + \tau a P^P + (1-q)(F + P^R) - \omega(F + G + \tau P^R + aP^P) &> 0 \\
F + G + P^R + \tau a P^P - \frac{q(F + P^R) + G + \tau a P^P}{q(F + \tau P^R + P^P)}(F + G + \tau P^R + aP^P) &> 0 \\
q\omega_{h,l}(F + \tau P^R + P^P) - (q(F + P^R) + G + \tau a P^P) &> 0
\end{aligned}$$

(see the following steps in Proposition 2)

$$q > \frac{G + (1 + (\tau - 1)\theta)aP^P}{(1 + a(\tau - 1)\theta)P^P} = q_1^P \text{ , where } \theta = \frac{F + G\frac{P^R}{aP^P} + (1+\tau)P^R}{F + G + P^R + \tau a P^P}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}
\tau p_R^P P^R + p_R^P P^P - \omega(F + G + a(\tau P^R + P^P)) &> 0 \\
p_R^P(\tau P^R + P^P) - \omega(F + G + a(\tau P^R + P^P)) &> 0 \\
q(F + P^R) + G + \tau a P^P - \omega(F + G + a(\tau P^R + P^P)) &> 0 \\
q > \frac{F + G + a(\tau P^R + P^P)}{F + \tau P^R + P^P} &= q_3^P.
\end{aligned}$$

Assume a regime where country-P exporters adopt a low quality pooling strategy and country-R producer adopt a separating strategy: A country-R exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}
\tau p_R^P P^R + p_R^P P^P - (F + G + a(P^R + \tau P^R)) &> 0 \\
q(F + P^R) + G + \tau a P^P - (F + G + a(P^R + \tau P^R)) &> 0 \\
q > \frac{F + aP^R}{F + P^R} &= q_2^R.
\end{aligned}$$

A country-P exporter deviates to a *separating* strategy if

$$\begin{aligned}
(\tau p_R^P + (1-q)p_N^R)P^R + p_R^P P^P - \omega(F + G + \tau P^R + aP^P) &> 0 \\
q(F + P^R) + G + \tau a P^P + (1-q)(F + P^R) - \omega(F + G + \tau P^R + aP^P) &> 0 \\
F + G + P^R + \tau a P^P - \frac{q(F + P^R) + G + \tau a P^P}{F + G + a(\tau P^R + P^P)}(F + G + \tau P^R + aP^P) &> 0 \\
\omega_{h,l}(F + G + a(\tau P^R + P^P)) - (q(F + P^R) + G + \tau a P^P) &> 0 \\
\text{(see the following steps in Proposition 2)} \\
q < \frac{F + P^R - \omega_{h,l}(1-a)\tau P^R}{F + P^R} &= q_2^P.
\end{aligned}$$

A country-P exporter deviates to a *high quality pooling* strategy if

$$\begin{aligned}
\tau(1/q)p_R^P P^R + (1/q)p_R^P P^P - \omega(F + \tau P^R + P^P) &> 0 \\
q(F + P^R) + G + \tau a P^P - q\omega(F + \tau P^R + P^P) &> 0 \\
q < \frac{F + G + a(\tau P^R + P^P)}{F + \tau P^R + P^P} &= q_3^P.
\end{aligned}$$

Assume a regime where country-P exporters adopt a low quality pooling strategy and country-R producer adopt a high quality pooling strategy: A country-R exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}
\tau q p_R^P P^R + q p_R^P P^P - (F + G + a(P^R + \tau P^R)) &> 0 \\
q(F + P^R + \tau P^P) - (F + G + a(P^R + \tau P^R)) &> 0 \\
q > \frac{F + G + a(P^R + \tau P^P)}{F + P^R + \tau P^P} &= q_3^R.
\end{aligned}$$

A country-R exporter deviates to a *separating* strategy if

$$\begin{aligned}
(\tau p_R^P + (1-q)p_N^R)P^R + p_R^P P^P - (F + G + P^R + \tau a P^P) &> 0 \\
F + P^R + \tau P^P + (1-q)(F + P^R) - (F + G + P^R + \tau a P^P) &> 0 \\
q > \frac{G + \tau a P^P}{\tau P^P} &= q_1^R.
\end{aligned}$$

A country-P exporter deviates to a *high quality pooling* strategy if

$$\begin{aligned}
\tau p_R^P P^R + p_R^P P^P - \omega(F + \tau P^R + P^P) &> 0 \\
F + P^R + \tau P^P - \omega(F + \tau P^R + P^P) &> 0 \\
F + P^R + \tau P^P - \frac{q(F + P^R + \tau P^P)}{F + G + a(\tau P^R + P^P)}(F + \tau P^R + P^P) &> 0 \\
q < \frac{F + G + a(\tau P^R + P^P)}{F + \tau P^R + P^P} &= q_3^P.
\end{aligned}$$

Assume a regime where country-P exporters adopt a high quality pooling strategy and country-R producer adopt a low quality pooling strategy: A country-R exporter deviates to a *high quality pooling* strategy if

$$\begin{aligned}\tau(1/q)p_R^P P^R + (1/q)p_R^P P^P - (F + P^R + \tau P^P) &> 0 \\ F + G + a(P^R + \tau P^P) - q(F + P^R + \tau P^P) &> 0 \\ q < \frac{F + G + a(P^R + \tau P^P)}{F + P^R + \tau P^P} &= q_3^R.\end{aligned}$$

A country-R exporter deviates to a *separating* strategy if

$$\begin{aligned}(\tau p_R^P + (1-q)p_N^R)P^R + p_R^P P^P - (F + G + P^R + \tau a P^P) &> 0 \\ F + G + a(P^R + \tau P^P) + (1-q)(F + P^R) - (F + G + P^R + \tau a P^P) &> 0 \\ q < \frac{F + aP^R}{F + P^R} &= q_2^R.\end{aligned}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}\tau p_R^P P^R + p_R^P P^P - \omega(F + G + a(\tau P^R + P^P)) &> 0 \\ F + P^R + G + \tau a P^P - \omega(F + G + a(\tau P^R + P^P)) &> 0 \\ q > \frac{F + G + a(\tau P^R + P^P)}{F + \tau P^R + P^P} &= q_3^P.\end{aligned}$$

Per-unit trade costs (5.1).

Prices. Arbitrage regime **A1**:

$$\begin{aligned}p_N^R P^R + p^P P^P - (F + P^R + (1+t)P^P) &= 0 \\ (p^P + t)P^R + p^P P^P - (F + P^R + (1+t)P^P) &= 0 \\ p^P(P^R + P^P) - (F + P^R + P^P + t(P^P - P^R)) &= 0 \\ p^P &= \frac{F + P^R + P^P + t(P^P - P^R)}{P^R + P^P} \\ p_T^R &= p^P + t \\ p_T^R &= \frac{F + (1+t)(P^R + P^P) + t(P^P - P^R)}{P^R + P^P} \\ p_N^R &= \frac{F + P^R}{P^R}\end{aligned}$$

Arbitrage regime **A2**:

$$p_N^R P^R + p^P P^P - (F + G + aP^R + (a+t)P^P) = 0$$
$$(p^P + t)P^R + p^P P^P - (F + G + aP^R + (a+t)P^P) = 0$$
$$p^P(P^R + P^P) - (F + a(P^R + P^P) + t(P^P - P^R)) = 0$$
$$p^P = \frac{F + G + a(P^R + P^P) + t(P^P - P^R)}{P^R + P^P}$$
$$p_T^R = p^P + t$$
$$p_T^R = \frac{F + G + (a+t)(P^R + P^P) + t(P^P - P^R)}{P^R + P^P}$$
$$p_N^R = \frac{F + P^R}{P^R}$$

Arbitrage regime **A3**:

$$p^P = \frac{F + G + a(P^R + P^P) + t(P^P - P^R)}{P^R + P^P}$$
$$p_T^R = p^P + t$$
$$p_T^R = \frac{F + G + (a+t)(P^R + P^P) + t(P^P - P^R)}{P^R + P^P}$$
$$p_N^R = \frac{F + G + aP^R}{P^R}$$

Separating regime **S**:

$$p_N^R P^R + p^P P^P - (F + G + P^R + (a+t)P^P) = 0$$
$$(p^P + t + (1-q)p_N^R)P^R + p^P P^P - (F + G + P^R + (a+t)P^P) = 0$$
$$p^P(P^R + P^P) + (1-q)(F + P^R) - (F + G + P^R + aP^P + t(P^P - P^R)) = 0$$
$$p^P = \frac{q(F + P^R) + G + aP^P + t(P^P - P^R)}{P^R + P^P}$$
$$p_T^R = p^P + t + (1-q)p_N^R$$
$$p_N^R = \frac{F + P^R}{P^R}$$

Varieties. Arbitrage regime **A1**:

$$P^P L^P = N^P(F + (1+t)P^R + P^P) = 0$$
$$N^P = \frac{P^P L^P}{F + (1+t)P^R + P^P} = \omega_h L^P \frac{P^P}{F + P^R + (1+t)P^P}$$
$$N_T^R p^P P^P = N^P p_T^R P^R$$
$$N_T^R = N^P \left(\frac{p^P + t}{p^P}\right) \frac{P^R}{P^P}$$
$$N_T^R = \omega_h L^P \frac{P^R}{F + P^R + (1+t)P^P} \left(1 + \frac{t}{p^P}\right)$$
$$P^R L^R = N_N^R(F + P^R) + N_T^R(F + P^R + (1+t)P^P)$$
$$N_N^R = \frac{P^R}{F + P^R}\left[L^R - \omega_h L^P \left(1 + \frac{t}{p^P}\right)\right]$$

Arbitrage regime **A2**:

$$P^P L^P = N^P(F + G + (a+t)P^R + aP^P) = 0$$
$$N^P = \frac{P^P L^P}{F + G + (a+t)P^R + aP^P} = \omega_l L^P \frac{P^P}{F + G + aP^R + (a+t)P^P}$$
$$N_T^R p^P P^P = N^P p_T^R P^R$$
$$N_T^R = N^P \left(\frac{p^P + t}{p^P}\right) \frac{P^R}{P^P}$$
$$N_T^R = \omega_l L^P \frac{P^R}{F + G + aP^R + (a+t)P^P} \left(1 + \frac{t}{p^P}\right)$$
$$P^R L^R = N_N^R(F + P^R) + N_T^R(F + G + aP^R + (a+t)P^P)$$
$$N_N^R = \frac{P^R}{F + P^R}\left[L^R - \omega_l L^P \left(1 + \frac{t}{p^P}\right)\right]$$

Arbitrage regime **A3**:

$$N^P = \frac{P^P L^P}{F + G + (a+t)P^R + aP^P} = \omega_l L^P \frac{P^P}{F + G + aP^R + (a+t)P^P}$$
$$N_T^R = \omega_l L^P \frac{P^R}{F + G + aP^R + (a+t)P^P} \left(1 + \frac{t}{p^P}\right)$$
$$P^R L^R = N_N^R(F + G + aP^R) + N_T^R(F + G + aP^R + (a+t)P^P)$$
$$N_N^R = \frac{P^R}{F + G + aP^R}\left[L^R - \omega_l L^P \left(1 + \frac{t}{p^P}\right)\right]$$

Separating regime **S**:

$$P^P L^P = N^P(F + G + (1+t)P^R + aP^P) = 0$$
$$N^P = \frac{P^P L^P}{F + G + (1+t)P^R + aP^P} = \omega_{h,l} L^P \frac{P^P}{F + G + P^R + (a+t)P^P}$$
$$N_T^R p^P P^P = N^P p_T^R P^R$$
$$N_T^R = N^P \left(\frac{p^P + t + (1-q)p_N^R}{p^P}\right) \frac{P^R}{P^P}$$
$$N_T^R = \omega_{h,l} L^P \frac{P^R}{F + P^R + (1+t)P^P} \left(1 + \frac{t + (1-q)p_N^R}{p^P}\right)$$
$$P^R L^R = N_N^R(F + P^R) + N_T^R(F + G + P^R + (a+t)P^P)$$
$$N_N^R = \frac{P^R}{F + P^R}\left[L^R - \omega_{h,l} L^P \left(1 + \frac{t}{p^P}\right)\right] - \frac{1-q}{p^P}$$
$$N_N^R = \frac{1}{p_N^R}\left[L^R - \omega_{h,l} L^P \left(\frac{p_T^R}{p^P}\right)\right]$$

Borders of regimes. Separating regime **S**: Country-R exporter deviates to a *high quality pooling* strategy if

$$
\begin{aligned}
(p^P/q+t)P^R+(p^P/q)P^P-(F+P^R+(1+t)P^P) &> 0\\
p^P(P^R+P^P)+qtP^R-q(F+P^R+(1+t)P^P) &> 0\\
q(F+P^R)+G+aP^P+t(P^P-P^R)+qtP^R-q(F+P^R+(1+t)P^P) &> 0\\
q<\frac{G+aP^P+t(P^P-P^R)}{P^P+t(P^P-P^R)} &= q_1^R.
\end{aligned}
$$

Country-P exporter deviates to a *high quality pooling* strategy if

$$
\begin{aligned}
(p^P/q+t)P^R+(p^P/q)P^P-\omega_{h,l}(F+(1+t)P^R+P^P) &> 0\\
q(F+P^R)+G+aP^P+t(P^P-P^R)+qtP^R-q\omega_{h,l}(F+(1+t)P^R+P^P) &> 0\\
(q-1)(F+(1+t)P^R)+F+P^R+G+(a+t)P^P-q\omega_{h,l}(F+(1+t)P^R+P^P) &> 0\\
(q-1)(F+(1+t))\frac{1}{\omega_{h,l}}+F+(1+t)P^R+G+aP^P-q(F+(1+t)P^R+P^P) &> 0\\
(1-q)(F+(1+t)P^R)\left[1-\frac{1}{\omega_{h,l}}\right]+G+aP^P-qP^P &> 0\\
(1-q)t(P^P-P^R)\frac{F+(1+t)P^R}{F+G+P^R+(a+t)P^P}+G+aP^P-qP^P &> 0\\
q<\frac{G+aP^P+t(P^P-P^R)\theta}{P^P+t(P^P-P^R)\theta}=q_1^P \text{ , where } \theta &= \frac{F+(1+t)P^R}{F+G+P^R+(a+t)P^P}
\end{aligned}
$$

Clearly, $q_1^R=q_1^P$ for $P^P=P^R$.

Country-R exporter deviates to a *low quality pooling* strategy if

$$
\begin{aligned}
(p^P+t)P^R+p^PP^P-(F+G+aP^R+(a+t)P^P)) &> 0\\
p^P(P^R+P^P)+tP^R-(F+G+aP^R+(a+t)P^P)) &> 0\\
q(F+P^R)+G+aP^P+t(P^P-P^R)+tP^R-(F+G+aP^R+(a+t)P^P)) &> 0\\
q>\frac{F+aP^R}{F+P^R} &= q_2^R.
\end{aligned}
$$

Country-P exporter deviates to a *low quality pooling* strategy if

$$
\begin{aligned}
(p^P+t)P^R+p^PP^P-\omega_{h,l}(F+G+(a+t)P^R+aP^P) &> 0\\
q(F+P^R)+G+aP^P+t(P^P-P^R)+tP^R-\omega_{h,l}(F+G+(a+t)P^R+aP^P) &> 0\\
(q-1)(F+P^R)+F+P^R+G+(a+t)P^P-\omega_{h,l}(F+G+(a+t)P^R+aP^P) &> 0\\
(q-1)(F+P^R)\frac{1}{\omega_{h,l}}+(1-a)P^R &> 0\\
q>\frac{F+P^R-\omega_{h,l}(1-a)P^R}{F+P^R} &= q_2^P.
\end{aligned}
$$

Clearly, $q_2^R=q_2^P$ for $P^P=P^R$, because $\omega_{h,l}=1$.

Arbitrage regime **A1**: A country-R exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}(qp^P+t)P^R+qp^PP^P-(F+G+aP^R+(a+tP^P)&>0\\ q(F+P^R+P^P+t(P^P-P^R))+tP^R-(F+G+aP^R+(a+t)P^P)&>0\\ q>\frac{F+G+a(P^R+P^P)+t(P^P-P^R)}{F+P^R+P^P+t(P^P-P^R)}&=q_3^R.\end{aligned}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$\begin{aligned}(qp^P+t)P^R+qp^PP^P-\omega_h(F+G+(a+t)P^R+aP^P)&>0\\ q(F+P^R+P^P+t(P^P-P^R))+tP^R-\frac{\omega_l}{\omega_h}(F+G+aP^R+(a+t)P^P)&>0\\ q>\frac{\omega_h}{\omega_l}\frac{F+G+a(P^R+P^P)+t(P^P-\frac{\omega_h}{\omega_l}P^R)}{F+P^R+P^P+t(P^P-P^R)}&=q_3^P.\end{aligned}$$

Clearly, $q_3^R=q_3^P$ for $P^P=P^R$, because $\omega_h=\omega_l=1$.

A country-R exporter deviates to a *separating* strategy if

$$\begin{aligned}(qp^P+t+(1-q)p_N^R)P^R+qp^PP^P-(F+G+P^R+(a+t)P^P)&>0\\ qp^P(P^R+P^P)+tP^R+(1-q)p_N^RP^R-(F+G+P^R+(a+t)P^P)&>0\\ q(F+P^R+P^P+t(P^P-P^R))+tP^R+(1-q)(F+P^R)-(F+G+P^R+(a+t)P^P)&>0\\ \frac{G+aP^P+t(P^P-P^R)}{P^P+t(P^P-P^R)}&=q_1^R\end{aligned}$$

A country-P exporter deviates to a *separating* strategy if

$$\begin{aligned}(qp^P+t+(1-q)p_N^R)P^R+qp^PP^P-\omega_h(F+G+(1+t)P^R+aP^P)&>0\\ q(F+P^R+(1+t)P^P)-qtP^R+tP^R+(1-q)(F+P^R)-\omega_h(F+G+(1+t)P^R+aP^P)&>0\\ q(F+P^R+(1+t)P^P)+(1-q)(F+(1+t)P^R)-\omega_h(F+G+(1+t)P^R+aP^P)&>0\\ (1-q)(F+(1+t)P^R)\left[\frac{1}{\omega_h}-1\right]+G+aP^P-qP^P&>0\\ -(1-q)t(P^P-P^R)\frac{F+(1+t)P^R}{F+P^R+(1+t)P^P}-G-aP^P+qP^P&>0\\ q>\frac{G+aP^P+t(P^P-P^R)\phi}{P^P+t(P^P-P^R)\phi}=q_{1'}^P\text{ , where }\phi&=\frac{F+(1+t)P^R}{F+P^R+(1+t)P^P}\end{aligned}$$

Clearly, $q_1^R=q_{1'}^P$ for $P^P=P^R$.

Arbitrage regime **A2**: A country-R exporter deviates to a *high quality pooling* strategy if

$$\begin{aligned}(p^P/q+t)P^R+(p^P/q)P^P-(F+P^R+(1+t)P^P)&>0\\ F+G+a(P^R+P^P)+t(P^P-P^R)+qtP^R-q(F+P^R+(1+t)P^P)&>0\\ q<\frac{F+G+a(P^R+P^P)+t(P^P-P^R)}{F+P^R+P^P+t(P^P-P^R)}&=q_3^R.\end{aligned}$$

A country-P exporter deviates to a *low quality pooling* strategy if

$$
\begin{aligned}
(p^P/q+t)P^R+(p^P/q)P^P-\omega_l(F+(1+t)P^R+P^P) &> 0\\
F+G+a(P^R+P^P)+t(P^P-P^R)+qtP^R-q\frac{\omega_l}{\omega_h}(F+P^R+(1+t)P^P) &> 0\\
q < \frac{\omega_l}{\omega_h}\frac{F+G+a(P^R+P^P)+t(P^P-P^R)}{F+P^R+P^P+t(P^P-\frac{\omega_h}{\omega_l}P^R)} &= q^P_{3'}.
\end{aligned}
$$

Clearly, $q^R_3 = q^P_{3'}$ for $P^P = P^R$, because $\omega_h = \omega_l = 1$.

A country-R exporter deviates to a *separating* strategy if

$$
\begin{aligned}
(p^P+t+(1-q)p^R_N)P^R+p^PP^P-(F+G+P^R+(a+t)P^P) &> 0\\
F+G+a(P^R+P^P)+t(P^P-P^R)+tP^R+(1-q)(F+P^R)-(F+G+P^R+(a+t)P^P) &> 0\\
q < \frac{F+aP^R}{F+P^R} &= q^R_2.
\end{aligned}
$$

A country-P exporter deviates to a *separating* strategy if

$$
\begin{aligned}
(p^P+t+(1-q)p^R_N)P^R+p^PP^P-\omega_l(F+G+(1+t)P^R+aP^P) &> 0\\
F+G+a(P^R+P^P)+t(P^P-P^R)+tP^R+(1-q)(F+P^R)-\omega_l(F+G+tP^R+aP^P) &> 0\\
(1-q)(F+P^R)\frac{1}{\omega_l}-(1-a)P^R &> 0\\
q < \frac{F+P^R-\omega_l(1-a)P^R}{F+P^R} &= q^P_{2'}.
\end{aligned}
$$

Clearly, $q^R_2 = q^P_2$ for $P^P = P^R$, because $\omega_l = 1$.

Arbitrage regime **A3**: A country-R exclusive producer deviates to the *high quality* if

$$
\begin{aligned}
(1/q)p^R_NP^R-(F+P^R) &> 0\\
(F+G+aP^R)-q(F+P^R) &> 0\\
q < \frac{F+G+aP^R}{F+P^R} &= q^E.
\end{aligned}
$$

Welfare effects of a trade liberalization (5.2).

Iceberg trade costs: Assume the prevailing regime to be A1. Welfare in the poor country is given by

$$
U^P = N^R_T + N^P = L^P\frac{\tau P^R+P^P}{F+\tau P^R+P^P}
$$

Taking the first derivative with respect to τ yields

$$
\frac{\partial U_P}{\partial \tau} = \frac{L^PP^RF}{(F+\tau P^R+P^P)^2} > 0.
$$

Similarly, for regimes A2 or A3, the derivative is given by

$$\frac{\partial U_P}{\partial \tau} = \frac{qL^P P^R (F+G)}{(F+G+(\tau P^R + P^P)a)^2} > 0.$$

Clearly, $\frac{\partial U_R}{\partial \tau} = \frac{\partial (N_N^R + N_T^R + N^P)}{\partial \tau} < 0$ must holds since less resources are available when trade costs increase.

In the separating regime, I have $U_P = q(N_{h,l}^P + N_{h,l}^R)$.

$$\frac{\partial U_P}{\partial \tau} = \frac{\partial}{\partial \tau}\left[qL^P \frac{\omega_{h,l}}{p_l^P}\right] = qL^P \frac{\omega_{h,l}}{p_l^P}\left[\frac{\frac{\partial}{\partial \tau}\omega_{h,l}}{\omega_{h,l}} - \frac{\frac{\partial}{\partial \tau}p_l^P}{p_l^P}\right]$$

The derivative is positive if $\frac{\frac{\partial}{\partial \tau}\omega_{h,l}}{\omega_{h,l}} - \frac{\frac{\partial}{\partial \tau}p_l^P}{p_l^P} =$

$$P^R\left[\frac{1}{\tau P^R + P^P} - \frac{1}{F+G+\tau P^R + P^P a}\right]$$

$$-P^P a\left[\frac{1}{q(F+P^R)+G+\tau P^P a} - \frac{1}{F+P^R+G+\tau P^P a}\right] \geq 0$$

$$P^R\left[(F+P^R+G+\tau P^P a)(q(F+P^R)+G+\tau P^P a)[(1-a)P^P - (F+G)]\right] -$$

$$P^P a\left[(\tau P^R + P^P)(F+G+\tau P^R + P^P a)(1-q)(F+P^R)\right] \geq 0$$

$$P^P \leq -[(1-a)P^P - (F+G)]\frac{\omega_{h,l}p^P}{a(1-q)p_N^R}$$

If the population of the poor country is sufficiently large i.e. $P^P \geq \frac{F+G}{1-a}$ the poor country profits from a trade liberalization with certainty.

Per-unit trade costs: Assume the prevailing regime to be A1. Welfare in the poor country is given by $U^P = (\omega_h L^P)/p^P$. $\frac{\partial U_P}{\partial t} \geq 0$ if $\frac{\frac{\partial}{\partial t}\omega_h}{\omega_h} - \frac{\frac{\partial}{\partial t}p^P}{p^P} \geq 0$, where $\omega_h = \frac{F+P^R+P^P+tP^P}{F+P^R+P^P+tP^R}$ and $p^P = \frac{F+P^R+P^P+t(P^P-P^R)}{P^R+P^P}$.

$$\frac{\frac{\partial}{\partial t}\omega_h}{\omega_h} - \frac{\frac{\partial}{\partial t}p^P}{p^P} = (P^P - P^R)\left[\frac{F+P^R+P^P}{F+(1+t)P^R+P^P} - \frac{F+P^R+(1+t)P^P}{F+P^R+P^P+t(P^P-P^R)}\right] \geq 0.$$

Easy to see that

$$\frac{F+P^R+P^P}{F+(1+t)P^R+P^P} < \frac{F+P^R+(1+t)P^P}{F+P^R+P^P+t(P^P-P^R)},$$

and thus $\frac{\partial U_P}{\partial t} \geq 0$ if $P^R \geq P^P$, and vice versa.

Similarly, for regimes A2 or A3, I have $\frac{\partial U_P}{\partial t} \geq 0$ if $\frac{\frac{\partial}{\partial t}\omega_l}{\omega_l} - \frac{\frac{\partial}{\partial t}p^P}{p^P} \geq 0$, where $\omega_l = \frac{F+G+a(P^R+P^P)+tP^P}{F+G+a(P^R+P^P)+tP^R}$ and $p^P = \frac{F+G+a(P^R+P^P)+t(P^P-P^R)}{P^R+P^P}$. $\frac{\frac{\partial}{\partial t}\omega_l}{\omega_l} - \frac{\frac{\partial}{\partial t}p^P}{p^P} =$

$$(P^P - P^R)\left[\frac{F+G+a(P^R+P^P)}{F+G+(a+t)P^R+aP^P} - \frac{F+G+aP^R+(a+t)P^P}{F+G+a(P^R+P^P)+t(P^P-P^R)}\right] \geq 0,$$

and thus $\frac{\partial U_P}{\partial t} \geq 0$ if $P^R \geq P^P$, and vice versa.

In the separating regime, where $\omega_{h,l} = \frac{F+G+P^R+aP^P+tP^P}{F+G+P^R+aP^P+tP^R}$ and $p^P = \frac{q(F+P^R)+G+aP^P+t(P^P-P^R)}{P^R+P^P}$, the derivative is positive if $\frac{\frac{\partial}{\partial t}\omega_{h,l}}{\omega_{h,l}} - \frac{\frac{\partial}{\partial t}p_l^P}{p_l^P} =$

$$(P^P - P^R)\left[\frac{F+G+P^R+aP^P}{F+G+(1+t)P^R+aP^P} - \frac{F+G+P^R+(a+t)P^P}{q(F+P^R)+G+aP^P+t(P^P-P^R)}\right] \geq 0,$$

Easy to see that

$$\frac{F+G+P^R+aP^P}{F+G+(1+t)P^R+aP^P} < \frac{F+G+P^R+(a+t)P^P}{q(F+P^R)+G+aP^P+t(P^P-P^R)},$$

and thus $\frac{\partial U_P}{\partial t} \geq 0$ if $P^R \geq P^P$, and vice versa.

Statutory Declaration / Affidavit

I hereby declare that the thesis with title

The Extensive Margin and the Quality Margin of International Trade

has been composed by myself autonomously and that no means other than those declared were used. In every single case, I have marked parts that were taken out of published or unpublished work, either verbatim or in a paraphrased manner, as such through a quotation. All contents and ideas stemming from "The macroeconomics of model T" by Föllmi et al. (2014) and "International Arbitrage and the Extensive Margin of Trade between Rich and Poor Countries" by Föllmi et al. (2013) are *not cited* in text. This is authorized by Prof. Dr. Josef Zweimüller, co-author of the above contributions.

This thesis has not been handed in or published before in the same or similar form.

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