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International arbitrage and the extensive margin of trade between rich and poor countries*

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Abstract

Incorporating consumption indivisibilities into the Krugman model, we show that an importer's per capita income becomes a primary determinant of "export zeros". Households in the rich North (poor South) are willing to pay high (low) prices for consumer goods; hence unconstrained monopoly pricing generates arbitrage opportunities for internationally traded products. Export zeros arise because some northern firms abstain from exporting to the South, to avoid international arbitrage. We show that rich countries benefit from a trade liberalization, while poor countries lose. These results hold also under more general preferences with extensive *and* intensive consumption margins. Disaggregated trade data show a robust negative association between export zeros and (potential) importers' per capita income. This evidence is consistent with the predictions of our model.

JEL classification: F10, F12, F19

Keywords: Non-homothetic preferences, parallel imports, arbitrage, extensive margin, export-zeros

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1 Introduction

We study a model of international trade in which an importer's per capita income is a primary determinant of the extensive margin of international trade. Two facts motivate our analysis. *First*, there are huge differences in per capita incomes across the globe and these differences may have important consequences for patterns of international trade via the demand side. *Second*, per capita incomes of destination countries correlate strongly with the extensive margin of trade. In 2007, for example, the probability that the US exports a given HS 6-digit product to a high-income country was 63.4 percent, while the export probabilities to an upper-middle, lower-middle, and low-income destination were only 48.8 percent, 36.6 percent, and 13.6 percent, respectively. Furthermore, also US firm-level data show a positive correlation between export probabilities and destinations' per capita incomes (Bernard, Jensen, and Schott 2009).

Recent research has emphasized the presence of "zeros" in bilateral trade data, see e.g. Helpman, Melitz, and Rubinstein (2007) at the country-pair level; Hummels and Klenow (2005) at the product level; and Bernard, Jensen, Redding, and Schott (2007) at the firm level. However, the literature did not systematically explore the role of per capita incomes. The standard explanation for export zeros relies on heterogeneous firms and fixed export-market entry costs (Melitz 2003, Chaney 2008, Arkolakis, Costinot and Rodriguez-Clare 2012). Export zeros arise if a firm's marginal costs are too high and/or export market size (in terms of aggregate GDP) is too low to cover the fixed export costs.[1] Importantly, there is no separate role for per capita incomes. This is because of the assumption of homothetic preferences: it is irrelevant whether a given aggregate GDP arises from a large population and a low per capita income, or vice versa.

Our paper provides an alternative approach to explain export zeros in which the demand side plays the crucial role. In particular, we elaborate the idea that low per capita incomes are associated with low willingnesses to pay for differentiated products, so that firms abstain from exporting to poor destinations. Our emphasis on the demand channel does not only lead to new predictions on trade patterns. It has also important implications for consumer welfare. Our model predicts that poor countries may lose from a trade liberalization, while rich countries always gain. This is different from standard models where gains from trade are more evenly distributed and all trading partners typically benefit from a trade liberalization.

We start out with a simple model that is identical to the basic Krugman (1980) framework, except that consumer goods are indivisible and households purchase either one unit of a particular product or do not purchase it at all. Such "0-1" preferences generate, in a straightforward way, a situation where a household's willingness to pay for differentiated products depends on household income. However, 0-1 preferences are very stylized, as households can adjust their consumption in response to price and income changes only through the extensive margin.[2] We

[1] This heterogeneous-firm framework has proven to be useful in explaining firm-level evidence on export behavior. For a recent survey, see Bernard, Jensen, Redding, and Schott (2012).

[2] Notice that "0-1" preferences and CES preferences can be considered as two polar cases. With 0-1 preferences, optimal consumption responds only along the extensive margin; with CES-preferences consumption responds only along the intensive margin (because Inada conditions induce households to consume all goods,

then show that the qualitative results of the 0-1 model carry over to more general settings where consumption is allowed to respond both along the extensive and the intensive margin.

Our paper makes two key contributions. The *first* is the recognition that firms from rich countries might not export to a poor country due to a threat of international arbitrage. Consider a US firm that sells its product both in the US and in China. Suppose this firm charges a price in China equal to the Chinese households' (low) willingness to pay and a price in the US equal to the US households' (high) willingness to pay. When price differences are large, arbitrage opportunities emerge: arbitrageurs can purchase the good cheaply on the Chinese market, ship it back to the US, and underbid local US producers. In equilibrium, US firms anticipate the threat of arbitrage and will adjust accordingly. To avoid arbitrage, a US exporter has basically two options: (i) charge a price in the US sufficiently low to eliminate arbitrage incentives; or (ii) abstain from selling the product in China (and other equally poor countries) thus eliminating arbitrage opportunities. These two options involve a trade-off between market size and prices: firms that export globally have a large market but need to charge a low price; firms that sell exclusively on the US market (and in other equally rich countries) can charge a high price but have a small market. In an equilibrium with ex-ante identical firms, the two options yield the same profit.

The *second* key contribution of our paper relates to gains from trade and the welfare effects of trade liberalizations. When per capita income gaps are small, firms are not constrained by arbitrage, and all goods are traded. In such a "full trade equilibrium", lower trade costs increase welfare in both countries. Lower losses during transport provide ressources for production of more varieties from which consumers in both countries benefit. In the more interesting case of large per capita income gaps, firms are constrained by arbitrage, and not all goods are exported to the poor country. In such an "arbitrage equilibrium" lower trade costs increase welfare in the rich country but *decrease* welfare in the poor country. The reason is that lower trade costs tighten the arbitrage constraint. With lower trade costs, globally active firms in the rich country need to reduce prices on their home market. This will induce more firms to abstain from exporting to poor countries, thus avoiding international arbitrage. As a result, fewer varieties are exported to poor countries leading to lower consumption and welfare in these countries.

Our analysis highlights three further points. *First*, we make precise the differential consequences of an increase in aggregate GDP due to a higher per capita income and due to a larger population. A higher *per capita income* in the South raises poor households' willingness to pay, increasing northern firms' incentive to sell their products internationally. In equilibrium, a larger fraction of northern firms export their product to the South. In contrast, a larger *population* in the South leaves southern households' demand for varieties unchanged but allows for the production of more varieties. This increases the world's per capita consumption due to a scale effect; increases the volume of trade; and may or may not increase trade intensity. Moreover, a larger population in the poor country may or may not increase the probability

irrespective of prices and income). Clearly, the realistic scenario is in between these polar cases. We look at this case in Section 5.

that a northern firm exports to the South. In sum, our model predicts that per capita income has a stronger effect than population size on the probability that a northern firm exports to the South.

A *second* point shows that the result of detrimental effects of trade liberalizations (on a poor country's welfare) needs to be qualified in a multi-country setting. When there are many rich and many poor countries, a multilateral trade liberalization still reduces North-South trade due to tighter arbitrage. However, it also stimulates South-South trade because the arbitrage constraint is not binding among trading partners with similar per capita incomes. Hence a multilateral trade liberalization increases the welfare of poor households if the increase in South-South trade overcompensates the fall in North-South trade. The multi-country setting is also useful because it delivers empirical predictions. The main prediction (which we test empirically) is that a northern firm has a high probability to export to other northern countries, while the probability that it exports to a southern country is significantly lower and decreases in the per capita income gap between the North and South.

A *third* point analyzes the conditions under which the basic logic of our 0-1 preferences carries over to general (additive) preferences that allow for both an extensive and intensive margin of consumption. We assume a general, additive subutility function $v(c)$ and make precise the conditions on $v(c)$ under which international arbitrage can emerge. If these conditions are met, there will be export zeros, provided that per capita income differences between the trading partners are sufficiently large. In this sense, the predictions of the simple 0-1 model hold also under more general preferences.

To explore the empirical relevance of the arbitrage channel, we proceed in two steps. We first look at disaggregate trade data for US exports. In particular, we find that the probability that the US exports a HS6-digit product-category to an arbitrarily chosen destination increases in the destination's per capita income, *conditional* on the destination's aggregate GDP (and other commonly used determinants of international trade flows). The impact of a destination's per capita income is highly statistically significant and quantitatively important. We then undertake a simple calibration exercise. We show that the model can match the US export probability to a typical poor country under realistic parameter values. Moreover, the model generates a positive relationship between the export probability and a destination's per capita income. It turns out, however, that the relationship generated by the model is stronger than the one observed in the data. We argue that this an artefact of the symmetry assumption. Adding relevant heterogeneities (unequally productive firms and/or unequally rich consumers) reduces excess sensitivity and brings the predictions of the model closer to the data. We conclude that the arbitrage channel is potentially relevant for explaining the extensive margin of trade between rich and poor countries.

The present paper connects to various strands of the literature. *First*, it is related to the literature on pricing-to-market, which focuses on the cross-country dispersion of prices of tradable goods. Atkeson and Burstein (2008) generate pricing-to-market in a model with Cournot competition and variable mark-ups. However, their focus is on the interaction of market structure and changes in marginal costs rather than on per capita income effects. Hsieh and Klenow (2007), Manova and Zhang (2009), and Alessandria and Kaboski (2011), among others, document that prices of tradable consumer goods show a strong positive correlation with per capita incomes in cross-country data. Simonovska (2011) provides a theoretical framework in which richer consumers are less price-sensitive, so mark-ups and prices are higher in richer countries. A similar mechanism is also at work in the papers by Markusen (2011), Sauré (2010), Behrens and Murata (2012a,b) and Bekkers, Francois, and Manchin (2011). Neary and Mrázová (2013) explore in a comprehensive way how deviations from CES preferences affect equilibrium outcomes in the Krugman model.[3] Variable mark-ups and pricing-to-market driven by per capita income are also a crucial feature in our framework. Our paper extends this literature by showing that export zeros arise from the (threat of) international arbitrage, a feature not considered in previous papers.

Second, the paper is related to the literature on parallel trade (surveyed in Maskus, 2000 and Ganslandt and Maskus, 2007).[4] The key difference lies in our emphasis on the role of general equilibrium effects. In partial equilibrium models, the welfare effects of parallel imports in a rich country are typically ambiguous because there is a tradeoff between reduced innovation incentives on the one side and lower prices for consumers on the other side. To see the contrast, consider for example the recent contribution by Roy and Saggi (2012). They show that in an international duopoly, parallel trade induces the southern firm to charge an above monopoly price in the South in order to be able to charge a high price in the North. Softer competition in the North then induces the northern firm to sell only in its home market at a high price, which harms northern consumers. We show that considering the general equilibrium uncovers an opposing force working through the economy wide resource constraint: It is still true that a subset of northern firms will find it optimal to sell only in their home market at a high price. But this means that less northern resources are used to produce goods for the South, which increases the numbers of available varieties in the North and thus welfare. So the welfare effects of parallel trade rules go in the opposite direction when considering the general equilibrium.

Third, the presence of a trade participation margin links the present paper to a literature that builds on Melitz (2003) and explores demand- and/or market-size effects in the context of heterogeneous firm models. Arkolakis (2010) incorporates marketing costs into that framework, generating an effect of population size on export markets in addition to aggregate income. Eaton, Kortum, and Kramarz (2011) extend this framework, allowing for demand shocks (in

[3] Other papers extending the Krugman-framework and allowing for non-homothetic (or quasi-homothetic) preferences include Fajgelbaum, Grossman, and Helpman (2011), Hummels and Lugovskyy (2009), Desdoigts and Jaramillo (2009), Neary (2009), Melitz and Ottaviano (2008), and Auer, Chaney and Sauré (2014). Many empirical papers found support for non-homotheticities, e.g. Hunter and Markusen (1988), Hunter (1991), Francois and Kaplan (1996), Choi, Hummels, and Xiang (2006), Dalgin, Mitra, and Trindade (2008), Fieler (2011), Hepenstrick (2011), and Bernasconi (2013).

[4] There is compelling evidence that threats of arbitrage affect the pricing decisions of firms in many markets. Pharmaceutical industries are most prominent (WHO 2001, Ganslandt and Maskus 2004, Goldberg 2010). The WHO (2001) report argues that restraints on parallel trade between poor and rich countries would allow companies to supply the former. Consequently, a key WHO recommendation is a more comprehensive implementation of differential pricing strategies. Parallel trade is also relevant in other industries such as cars (Lutz 2004, Yeung and Mok 2013), consumer electronics (Feng 2013), DVDs and cinemas (Burgess and Evans 2005), and other markets, like clothing and cosmetics (NERA 1999).

addition to cost shocks) as further determinants of firms' export behavior. These papers stick to homothetic preferences, hence arbitrage cannot arise. This is different from our paper where non-homotheticities and arbitrage incentives play a central role, and no exogenous firm heterogeneity is required to generate a trade participation margin.

The remainder of the paper is organized as follows. In the next section, we present the basic assumptions and discuss the autarky equilibrium. In Section 3, we use our basic framework to study trade patterns and trade gains in a two-country setting. Section 4 extends the analysis to many rich and poor countries. In Section 5, we introduce general preferences and show that arbitrage equilibria also arise when consumption responds both along the extensive and the intensive margin. Section 6 presents empirical evidence from disaggregated US trade data and calibrates the model to these data. Section 7 concludes.

2 Autarky

We start by presenting the autarky equilibrium. The economy is populated by $\mathcal{P}$ 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 wage is W. Production requires a fixed labor input F to set up a new firm and a variable labor input $1/a$ to produce one unit of output, the same for all firms. Producing good j in quantity $q(j)$ thus requires a total labor input of $F + q(j)/a$.

Consumers. Households spend their income on a continuum of differentiated goods. We 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.[5] Thus consumption is a binary choice: either you buy or you don't buy. Let $x(j)$ denote an indicator that takes value 1 if good j is purchased and value 0 if not. Then utility takes the simple form

$$U = \int_0^\infty x(j)dj, \qquad \text{where } x(j) \in \{0,1\}. \tag{1}$$

Notice that utility is additively separable and that the various goods enter symmetrically. Hence the household's utility is given by the number of consumed goods.

Consider a household with income y who chooses among (a measure of) N goods supplied at prices $\{p(j)\}$.[6] The problem is to choose $\{x(j)\}$ to maximize the objective function (1) subject to the budget constraint $\int_0^N p(j)x(j)dj = y$. Denoting λ as the household's marginal

[5]Preferences of this type were used, inter alia, by Murphy, Shleifer and Vishny (1989) to study demand composition and technology choices, by Matsuyama (2000) to explore non-homotheticities in Ricardian trade, and by Falkinger (1994) and Foellmi and Zweimüller (2006) to analyze inequality and growth.

[6]Notice that the integral in (1) 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.

utility of income, the first order condition can be written as

$$\begin{aligned} x(j) &= 1 \text{ if } 1 \geq \lambda p(j) \\ x(j) &= 0 \text{ if } 1 < \lambda p(j) . \end{aligned}$$

Rewriting this condition as $1/\lambda \geq p(j)$ yields the simple rule that the household will purchase good j if its willingness to pay $1/\lambda$ does not fall short of the price $p(j)$.[7] The resulting demand curve, depicted in Figure 1, is a step function which coincides with the vertical axis for $p(j) > 1/\lambda$ and equals unity for prices $p(j) \leq 1/\lambda$.

Figure 1

By symmetry, the household's willingness to pay is the same for all goods and equal to the inverse of λ, which itself is determined by the household's income and product prices. Intuitively, the demand curve shifts up when the income of the consumer increases (λ falls) and shifts down when the price level of all other goods increases (λ rises).

It is interesting to note the difference between consumption choices under these "0-1" preferences and the standard CES-case. With 0-1 preferences, the household chooses how many goods to buy, while there is no choice about the consumed quantity.[8] In constrast, a household has a choice with CES preferences about the quantities of the supplied goods, but finds it optimal to consume all varieties in positive amounts. This is because Inada conditions imply an infinite reservation price. In other words, 0-1 preferences shift the focus to the *extensive* margin of consumption, while CES preferences focus entirely on the *intensive* margin. It is important to note, however, that our central results below do not depend on the 0-1 assumption. In fact, we will show below that more general preferences – which allow for both the extensive and the intensive margin of consumption – generate results that are qualitatively similar to those derived in the 0-1 case.

Equilibrium. Since both firms and households are identical, the equilibrium is symmetric. Similiar to the standard monopolistic competition model, the information on other firms' prices is summarized in the shadow price λ. Hence, the pricing decision of a monopolistic firm depends only on λ. Moreover, the value of λ is unaffected by the firm's own price because a single firm is of measure zero.

Lemma 1 *There is a single price $p = 1/\lambda$ in all markets and all goods are purchased by all consumers.*

[7] Strictly speaking, the condition $1 \geq \lambda p(j)$ is necessary but not sufficient for $c(j) = 1$ and the condition $1 < \lambda p(j)$ is sufficient but not necessary for $c(j) = 0$. This is because purchasing all goods for which $1 = \lambda p(j)$ may not be feasible given the consumer's budget. For when N different goods are supplied at the same price p but $y < pN$ the consumer randomly selects which particular good will be purchased or not purchased. This case, however, never emerges in the general equilibrium.

[8] The discussion here rules out the case where incomes could be larger than pN, meaning that the consumer is subject to rationing (i.e. he would want to purchase more goods than are actually available at the available prices). While this could be a problem in principle, it will never occur in equilibrium.

Proof. Aggregate demand for good j is a function of λ only. Consequently, the pricing decision of a monopolistic firm depends on the value of λ and not directly on the prices set by competitors in other markets. Thus, it is profit maximising to set $p(j) = 1/\lambda$ as long as $1/\lambda$ exceeds marginal costs. To prove the second part of the Lemma, assume to the contrary that only a fraction ν of consumers purchases the product at price $p(j) = p = 1/\lambda$. However, this cannot be an equilibrium, as the firm could undercut the price slightly and sell to all consumers. ■

Each monopolistic firm faces a demand curve as depicted in Figure 1. It will charge a price equal to the representative consumer's willingness to pay $p = 1/\lambda$ and sell output of quantity 1 to each of the $\mathcal{P}$ households. Without loss of generality, we choose labor as the numéraire, $W = 1$. Two conditions characterize the autarky equilibrium. The *first* is the zero-profit condition, ensuring that operating profits cover the entry costs but do not exceed them to deter further entry. Entry costs are $FW = F$ and operating profits are $[p - W/a]\,\mathcal{P} = [p - 1/a]\,\mathcal{P}$. The zero-profit condition can be written as $p = (aF + \mathcal{P})\,/a\mathcal{P}$. This implies a mark-up μ – a ratio of price over marginal cost – equal to

$$\mu = \frac{aF + \mathcal{P}}{\mathcal{P}}.$$

Notice that technology parameters a and F and the market size parameter $\mathcal{P}$ determine the mark-up.[9] We will show below that the mark-up is a crucial channel through which non-homothetic preferences affect patterns of trade and the international division of labor.

The *second* equilibrium condition is a resource constraint ensuring that there is full employment $\mathcal{P}L = FN + \mathcal{P}N/a$. From this latter equation, equilibrium product diversity (both in production and consumption) in the decentralized equilibrium is given by

$$N = \frac{a\mathcal{P}}{aF + \mathcal{P}}L.$$

3 Trade between a rich and a poor country

Let us now consider a world economy where a rich and a poor country trade with each other. We 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, we let the two countries differ along both dimensions, hence $L^R > L^P$ and

[9] Notice that the determination of mark-ups is quite different between the 0-1 outcome and the standard CES-case. With 0-1 preferences, the mark-up depends on technology and market size parameters. With CES preferences, the mark-up is determined by the elasticity of substitution between differentiated goods, while it is independent of technology and market size. Notice further that, from the zero profit condition of the CES-model, we have $\omega F = (p - \omega/b)x\mathcal{P}$ (where x is the – endogenously determined – quantity of the representative product and $1/b$ is the unit labor requirement). Thus we can write the mark-up as $(b/x)(F/\mathcal{P}) + 1$, which compares to $a(F/\mathcal{P}) + 1$ in the 0-1 case. To achieve realistic mark-ups in empirical applications, the parameter a needs to be normalized appropriately, i.e. it has to assume an order of magnitude similar to the ratio b/x in the CES-model.

$\mathcal{P}^R \gtreqless \mathcal{P}^P$. We assume trade is costly and of the standard iceberg type: for each unit sold to a particular destination, $\tau > 1$ units have to be shipped and $\tau - 1$ units are lost during transport.

3.1 Full trade equilibrium

When the income gap between the two countries is small, all goods are traded internationally. In such a *full trade equilibrium*, a firm's optimal price for a differentiated product in country $i = R, P$ equals the households' willingnesses to pay (see Figure 1), hence we have $p^R = 1/\lambda^R$ and $p^P = 1/\lambda^P$. Since country R is wealthier than country P, we have $\lambda^R < \lambda^P$ and $p^R > p^P$. By symmetry, the prices of imported and home-produced goods are identical within each country.

Solving for the full trade equilibrium is straightforward. Consider the resource constraint in the rich country. $N^R F$ labor units are needed for setting up the N^R firms. Moreover, $N^R \mathcal{P}^R / a$ and $N^R \mathcal{P}^P \tau / a$ labor units are employed in production to serve the home and the foreign market, respectively. Since each of the $\mathcal{P}^R$ households supplies L^R units of labor inelastically, the resource constraint is $\mathcal{P}^R L^R = N^R F + N^R \left(\mathcal{P}^R + \tau \mathcal{P}^P\right)/a$. Similarly, for the poor country. Solving for N^i ($i = R, P$) lets us determine the number of active firms in the two countries

$$N^i = \frac{a\mathcal{P}^i}{aF + (\mathcal{P}^i + \tau \mathcal{P}^{-i})} L^i, \tag{2}$$

(where $-i = P$ if $i = R$ and vice versa).

Now consider the zero-profit conditions in the two countries. An internationally active firm from country i generates total revenues equal to $p^R \mathcal{P}^R + p^P \mathcal{P}^P$ and has total costs $W^i \left[F + (\mathcal{P}^i + \tau \mathcal{P}^{-i})/a\right]$. Using the zero-profit conditions of the two countries lets us calculate relative wages

$$\omega \equiv \frac{W^P}{W^R} = \frac{aF + \tau \mathcal{P}^P + \mathcal{P}^R}{aF + \mathcal{P}^P + \tau \mathcal{P}^R}. \tag{3}$$

When the two countries differ in population size, wages (per efficiency unit of labor) are higher in the larger country.[10] 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 iceberg losses during transportation, which is reflected 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) $\mathcal{P}^P = \mathcal{P}^R$. When the two countries are of equal size, productivity differences vanish because iceberg losses become equally large. Note further that $\tau^{-1} < \omega < \tau$. When the poor country becomes very large, iceberg losses as a percentage of total costs become negligible, $\omega \to \tau$. Similarly, when the rich country becomes large, $\omega \to \tau^{-1}$.

[10] While ω measures relative wages per efficiency unit of labor, $\omega L^P / L^R$ measures relative nominal per capita incomes. In principle, $\omega L^P / L^R > 1$ is possible, so that country P (with the *lower* labor endowment) has the *higher* per capita income. We show below that this can happen only in a full trade equilibrium but not in an arbitrage equilibrium. The latter case is the interesting one in the present context.

Finally, let us calculate prices and mark-ups in the respective export destination. The budget constraint of a household in country i is $W^iL^i = p^i\left(N^R + N^P\right)$. Combining the zero-profit condition with these budget restrictions and the above equation for the number of firms, lets us express the price in country i as

$$p^i = W^iL^i\frac{aF + \mathcal{P}^R + \tau\mathcal{P}^P}{a\mathcal{P}^RL^R + a\omega\mathcal{P}^PL^P}, \; i = R, P. \tag{4}$$

By symmetry, prices for the various goods are identical within each country, irrespective of whether they are produced at home or abroad. Consequently, imported goods generate a lower mark-up than locally produced goods because exporters cannot pass trade costs through to consumers.[11] Marginal costs are W^i/a when the product is sold in the home market and $\tau W^i/a$ when the product is sold in the foreign market. Hence mark-ups (prices over marginal costs) are $\mu_D^i = p^ia/W^i$ in the domestic market and $\mu_X^i = p^ja/(W^i\tau)$ in the export market. Hence a full trade equilibrium is characterized as follows: (i) $N^P/N^R = \omega\mathcal{P}^PL^P/\left(\mathcal{P}^RL^R\right)$, i.e. differences in aggregate GDP lead to proportional differences in produced varieties; (ii) $p^P/p^R = \omega L^P/L^R$, i.e. differences in per capita incomes generate proportional differences in prices; and (iii) $\mu_D^P/\mu_D^R = \mu_X^P/\mu_X^R = L^P/L^R < 1$, i.e. differences in per capita endowments lead to proportional differences in mark-ups.

Patterns of international trade. Let us highlight how the volume and structure of international trade depend on relative per capita endowments L^P/L^R. We define "trade intensity" ϕ as the ratio between the value of world trade and world GDP. In a full trade equlibrium the value of world trade is given by $p^RN^P\mathcal{P}^R + p^PN^R\mathcal{P}^P$ while world income is $L^R\mathcal{P}^R + \omega L^P\mathcal{P}^R$. Trade intensity is given by

$$\phi = \frac{2L^R\mathcal{P}^R \cdot \omega L^P\mathcal{P}^P}{\left(L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P\right)^2}$$

When all goods are traded, the relative size of aggregate GDP matters for trade intensity. When GDP differs strongly across the two countries, trade intensity is small as most world production takes place in the large country and most of this production is also consumed in this country. Trade intensity is maximized when the two countries are of exactly equal size. We can now state the following proposition

Proposition 1 *Assume the two countries are in a full trade equilibrium. a) All goods are traded. b) Trade intensity ϕ increases with both the per capita endowment L^P and population size $\mathcal{P}^P$ if $\omega L^P\mathcal{P}^P < L^R\mathcal{P}^R$. c) The impact on ϕ of $\mathcal{P}^P$ is stronger than the one of L^P. d) A trade liberalization increases trade intensity if $\omega L^P\mathcal{P}^P < L^R\mathcal{P}^R$.*

PROOF. See Appendix A.

[11] This is different from CES preferences, where transportation costs are more than passed through to prices as exporters charge a fixed mark-up on marginal costs (including transportation). Notice that limited cost pass-through has been documented in a large body of empirical evidence.

Trade and welfare. Let us finally consider the gains from trade and the welfare effects of a trade liberalization in a full trade equilibrium. Since all firms sell to all households worldwide, consumption and welfare levels are equalized across rich and poor countries. Gains from trade are higher for the country with lower product variety under autarky. Product variety in autarky is $N^i = a\mathcal{P}^i L^i / \left(aF + \mathcal{P}^i\right)$. The country with a smaller population $\mathcal{P}^i$ and/or lower per capita endowment (lower L^i) gains more from trade. how a trade liberalization affects welfare. Here we are interested in how bilateral trade liberalizations affect welfare and the distribution of trade gains between the two countries. A trade liberalization is modeled as a reduction in iceberg transportation costs τ.

In a full trade equilibrium, households in both countries purchase all goods produced worldwide. Hence the welfare levels are identical in both countries despite their unequal endowment with productive resources

$$U^R = U^P = \frac{aL^R\mathcal{P}^R}{aF + \mathcal{P}^R + \tau\mathcal{P}^P} + \frac{a\omega L^P\mathcal{P}^P}{aF + \mathcal{P}^R + \tau\mathcal{P}^P}.$$

Firms' price setting behavior drives this result. R-consumers are willing to pay higher prices than P-consumers because their income is higher. In the full trade equilibrium, higher nominal incomes translate one-to-one into higher prices, welfare is therefore identical. To see the mechanism by which welfare is equalized, consider mark-ups in the special case when the two countries are equally large. When $\mathcal{P}^P = \mathcal{P}^R$, prices are higher in country R, while costs are the same for each country. In other words, country-R households bear a larger share of total costs. In this case, the poor country's welfare is lower under autarky.[12] We summarize this in the following proposition.

Proposition 2 *In a full trade equilibrium, welfare levels are equalized. A trade liberalization (a lower τ) increases welfare for both countries.*

Proof. In text. ∎

3.2 "Arbitrage" equilibrium with non-traded goods

Full trade ceases to be an equilibrium when per capita income differences $\omega L^P/L^R$ become large. The reason is a threat of arbitrage. Consider a US firm that sells its product both in the US and in China. Suppose the firm charges a price in China that equals the Chinese households' willingness to pay $p^P = 1/\lambda^P$ and a price in the US that equals the US households' willingness to pay $p^R = 1/\lambda^R$. If the difference between $1/\lambda^P$ and $1/\lambda^R$ is large, arbitrage opportunities emerge. Arbitrageurs can purchase the good cheaply on the Chinese market, ship it back to the US, and underbid the producer on the US market. A threat of arbitrage also concerns Chinese firms which both produce for the local market and export to the US. When these firm charge too high prices in the US, arbitrage traders purchase the cheap products in China and parallel export them to the US.

[12] This continues to hold as long as $\mathcal{P}^P$ is not too much larger larger than $\mathcal{P}^R$. When $\mathcal{P}^P \gg \mathcal{P}^R$, so that $\omega L^P > L^R$, prices become higher in country P. In that case, country-P bears the larger share in total costs.

Firms anticipate this arbitrage opportunity and adjust their pricing behavior accordingly. Notice that the threat of parallel trade only constains firms operating on the world market. Firms that abstain from selling the product in the poor country and focus exclusively on the market of the rich country do not face such a threat. Adopting this latter strategy implies a smaller market but lets firms exploit the rich households' high willingness to pay. In equilibrium, firms are indifferent between the two strategies. Notice that concentrating sales exclusively on the rich market country is, in principle, an option both for producers in the rich and in the poor country. In equilibrium, however, only by rich-country producers adopt this strategy. While total revenues are independent of the producer's location, total costs are not. To serve households in the rich country, country-R producers face marginal costs $W^R a$, while country-P exporters face marginal costs $W^R \omega\tau/a$ (they have to bear transportation costs). Since $\omega\tau > 1$, country-P producers have a competitive disadvantage in serving the rich country even when the poor country has lower wages $\omega < 1$.

An *arbitrage equilibrium* looks as follows. 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. To see why this is an equilibrium, 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 induce country-R firms to sell their product only on the home market. Thus, in equilibrium, both types of firms will exist. Notice that all firms are ex-ante identical (i.e. all firms have the same cost- and demand functions). Notice that there is an indeterminacy concerning the selection of firms into export status. Clearly, this is an artefact of the symmtry-assumption, which would disappear once asymmetries (i.e. firm heterogeneities) are added to the model.

We are now ready to solve for the arbitrage equilibrium. Denote the price in the rich country of traded and non-traded goods by p_T^R and p_N^R, respectively. The price of non-traded goods is $p_N^R = 1/\lambda^R$. 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), $p_T^R = \tau/\lambda^P$, in equilibrium. The price of a product in the poor country is still given by $p^P = 1/\lambda^P$. The following lemma proofs that this is a Nash equilibrium.

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

Proof. (i) Assume $1/\lambda^P$ exceeds marginal costs of exporting. In that case, the profit maximization problem of an exporting firm reduces to maximize total revenue $\mathcal{P}^P p^P(j) + \mathcal{P}^R p^R(j)$ 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 $\tau/\lambda^P \geq \lambda^R$ (full trade equilibrium). If $\tau/\lambda^P < \lambda^R$, the arbitrage constraint is binding $\tau p^P(j) = p^R(j) = p_T^R$ 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 zero-profit condition for an internationally active country-i producer is $p_T^R \mathcal{P}^R + p^P \mathcal{P}^P = W^i \left[F + (\mathcal{P}^i + \tau\mathcal{P}^{-i})/a\right]$. These 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. From the zero-profit conditions we see that relative wages ω are still given by equation (3). The zero-profit conditions also let us derive the prices for the various products. Using $p_T^R = \tau p^P$, we get

$$p_T^R = \frac{\tau}{a} \frac{aF + \mathcal{P}^R + \tau\mathcal{P}^P}{\tau\mathcal{P}^R + \mathcal{P}^P} \quad \text{and} \quad p^P = \frac{1}{a} \frac{aF + \mathcal{P}^R + \tau\mathcal{P}^P}{\tau\mathcal{P}^R + \mathcal{P}^P},$$

where we have set $W^R = 1$. (We use this normalization throughout the paper.) The zero-profit condition for an exclusive rich-country producer is $p_N^R \mathcal{P}^R = F + \mathcal{P}^R/a$, from which we calculate the equilibrium price of a non-traded variety

$$p_N^R = \frac{aF + \mathcal{P}^R}{a\mathcal{P}^R}.$$

Notice that, due to the arbitrage constraint on exporters' pricing behavior, prices do not depend on L^P and L^R. This is quite different from the full-trade equilibrium, where price differences reflect differences in per capita endowments.

The resource constraint in country P is the same as that in the full trade equilibrium, so N^P is still given by (2). The resource constraint in country R is now different, however, because there are traded and non-traded products. Denoting the range of traded and non-traded goods produced in the rich country by N_T^R and N_N^R, respectively, the resource constraint of country R is given by $\mathcal{P}^R L^R = N_T^R \left(F + (\mathcal{P}^R + \tau\mathcal{P}^P)/a\right) + N_N^R \left(F + \mathcal{P}^R/a\right)$. Together with the trade balance condition $N_T^R p^P \mathcal{P}^P = N^P p_T^R \mathcal{P}^R$ and the terms of trade $p_T^R/p^P = \tau$ we get

$$N_T^R = \frac{a\mathcal{P}^R}{aF + \tau\mathcal{P}^R + \mathcal{P}^P} \tau L^P, \quad \text{and } N_N^R = \frac{a\mathcal{P}^R}{aF + \mathcal{P}^R} \left(L^R - \tau\omega L^P\right). \tag{5}$$

Patterns of international trade. Let us now describe volume and structure of international trade in an arbitrage equilibrium. The value of traded goods is $p_T^R N^P \mathcal{P}^R + p^P N_T^R \mathcal{P}^P$ (while world income still is $L^R \mathcal{P}^R + \omega L^P \mathcal{P}^R$). Using equations (2) and (5) we calculate the trade intensity in an arbitrage equilibrium.

$$\phi = \frac{2\tau}{\tau + (\mathcal{P}^P/\mathcal{P}^R)} \cdot \frac{\omega L^P \mathcal{P}^P}{L^R \mathcal{P}^R + \omega L^P \mathcal{P}^P} \tag{6}$$

Equation (6) shows that per capita incomes differences and differences in population sizes affect trade intensity in different ways. Consider first the impact of a given change in per capita income of country P. The above expression for ϕ reveals that a higher per capita income of the poor country unambiguously increases the intensity of trade. This is reminiscent of the Linder-hypothesis (Linder 1961) postulating that a higher similarity in per capita incomes is associated higher trade between trading partners. The intution for this result is straightforward. When L^P increases by 10 percent, the range of exported goods increases by 10 percent while prices remain unchanged. Hence the aggregate value of trade $p_T^R N^P \mathcal{P}^R + p^P N_T^R \mathcal{P}^P$ increases by 10 percent as well. In contrast, increasing L^P by 10 percent (while leaving L^R unchanged) increases world GDP by less than 10 percent. Trade intensity, the ratio between world trade and world GDP, thus rises unambiguously.

Now consider a change in population-size of country P. It turns out that a change in $\mathcal{P}^P$ has a smaller effect on trade intensity than an increase in relative per capita incomes that increases GDP by the same magnitude, i.e. we have $\partial \text{log}\phi / \partial \log \mathcal{P}^P < \partial \log \phi / \partial \log L^P$. This can be seen from looking at the volume of world trade which is equal to $2p^P N_T^R \mathcal{P}^P$. An increase in $\mathcal{P}^P$ has a direct and an indirect effect on world trade. The direct effect increases trade in proportion to country P's population. The indirect effect lowers per capita imports. Notice that imports per capita in country-P are equal to $p^P N_T^R = \left[\tau / (\tau + \mathcal{P}^P / \mathcal{P}^R)\right] \omega L^P$. From the point of view of country R, a larger population in country P requires fewer exports to each country-P households to cover a given amount of own imports. Hence country-P imports (and world trade) increase with $\mathcal{P}^P$ less than proportionately.[13]

Proposition 3 *Assume per capita income differences are large, so that the world economy is in an arbitrage equilibrium. a) Some firms in country R do not export. b) An increase in per capita endowment L^P raises trade intensity ϕ, while an increase in population size $\mathcal{P}^P$ may increase or decrease ϕ. c) The impact on ϕ of $\mathcal{P}^P$ is weaker than the one of L^P. d) A trade liberalization decreases trade intensity.*

PROOF. See Appendix B.

Trade and welfare. We proceed by looking at the impact of trade liberalizations. We first consider the case where trade costs are symmetric and explore a bilateral liberalization. (We look at the unilateral case below). In an arbitrage equilibrium, a bilateral trade liberalization lets consumers' welfare levels in the two countries diverge. Country-P households' welfare equals $N_T^R + N^P$, while country-R households' welfare equals $N^P + N_T^R + N_N^R$. Using (2) and (5), these welfare levels are given by

$$U^P = \frac{aL^P(\mathcal{P}^P + \tau\mathcal{P}^R)}{aF + \tau\mathcal{P}^R + \mathcal{P}^P} \quad \text{and} \quad U^R = \frac{aL^P(\mathcal{P}^P + \tau\mathcal{P}^R)}{aF + \tau\mathcal{P}^R + \mathcal{P}^P} + \frac{a\mathcal{P}^R\left(L^R - \tau L^P\right)}{aF + \mathcal{P}^R}.$$

It is straightforward to verify, that $\partial U^P / \partial \tau > 0$ while $\partial U^R / \partial \tau < 0$. We are now able to state the following proposition.

[13]Notice that an increase in $\mathcal{P}^P$ also increases ω. It is shown in the proof of proposition 2 (see Appendix) that taking the impact of $\mathcal{P}^P$ on ω into account, an increase in $\mathcal{P}^P$ still reduces per capita imports.

Proposition 4 *In an arbitrage equilibrium, a trade liberalization increases the welfare of country-R households, but decreases it for country-P households.*

Proof. In text. ■

Proposition 4 shows the crucial role of trade costs for welfare. Unequal countries have different preferred trade barriers (or different preferred degrees of trade liberalizations). Consumers in the rich country are essentially free-traders, whereas consumers in the poor country are harmed by liberalizations. What is the intuition behind this result? The reason is country-R firms' pricing behavior. As higher trade costs imply a less tight arbitrage constraint, country-R firms can charge higher prices for traded goods relative to non-traded goods. This induces country-R firms to export rather than sell exclusively to domestic customers. The result is an increase in trade intensity which benefits the poor country. Put differently, poor country households are against a trade liberalization because a lower τ decreases trade and welfare in country P.

Unilateral trade liberalization. Up to now we have assumed symmetric trade costs across countries. However, policy makers can influence trade costs through tariffs and regulations. This is interesting in the present context because, in an arbitrage equilibrium, the poor country has an incentive to increase trade barriers and relax the arbitrage constraint. This increases the supply or northern varieties and hence may raise welfare in the South. It is therefore interesting to look at an unilateral trade liberalization. Assume that trade costs differ between countries, with τ^i denoting iceberg costs for imports into country i. While total revenues of exporters are still $p_T^R \mathcal{P}^R + p^P \mathcal{P}^P$, now total costs do not only vary as a result of unequally large populations but also because of differences in transportation costs, $W^i \left[F + (\mathcal{P}^i + \tau^{-i}\mathcal{P}^{-i})/a\right]$. From the zero-profit condition we derive relative wages ω as

$$\omega \equiv \frac{W^P}{W^R} = \frac{aF + \tau^P \mathcal{P}^P + \mathcal{P}^R}{aF + \mathcal{P}^P + \tau^R \mathcal{P}^R},$$

which implies that $\left(\tau^R\right)^{-1} < \omega < \tau^P$. Assume that income differences are sufficiently large, $\omega L^P / L^R < \tau^R$, so that an arbitrage equilibrium prevails. To prevent arbitrage, the price of traded goods in the rich country may not exceed the price in the poor country plus transportation costs, hence firms will charge $p_T^R = \tau^R p^P$ in the rich country.[14]

Using zero-profit conditions and resource constraints is it is straightforward to calculate welfare in the two countries as

$$U^P = \frac{a\mathcal{P}^P + a\tau^R \mathcal{P}^R}{aF + \tau^R \mathcal{P}^R + \mathcal{P}^P} L^P \quad \text{and} \quad U^R = U^P + \frac{a\mathcal{P}^R}{aF + \mathcal{P}^R}\left(L^R - \tau^R \omega L^P\right).$$

Interestingly, a unilateral trade liberalization by the poor country (a fall in τ^P) does not have any effect on poor households, but affects rich households through a fall in ω. Lower costs

[14]To make sure that such an equilibrium exists, we also assume that country-R exporters can charge a price in country P that covers (production plus transportation) costs, $p^P > \tau^P/a$. This implies $\tau^P \tau^R < aF/\mathcal{P}^R + 1$. If this condition is satisfied also country-P exporters will export, $p_T^R > \tau^R/a$ because $p_T^R = \tau^R p^P$.

of exporting to the poor country makes producers in country R more productive, improving their terms of trade while leaving the arbitrage constraint unaffected. This saves resources for country R which are employed to produce non-traded goods. This raises welfare of rich consumers. In contrast, an unilateral increase in trade barriers into the rich country (a larger τ^R) harms country-R but benefits country-P households. Hence, our model predicts that a poor country has an incentive to levy an export tax. This relaxes the arbitrage constraint and increases the supplied varieties and hence welfare in country P.

3.3 Existence of equilibria

The conditions under which the threat of parallel trade becomes binding and the economy switches from a full trade to a partical trade equilibrium are straighforward. In a full trade equilibrium, relative prices equal relative per capita incomes $p^P/p^R = \omega L^P/L^R$. In that case, differences in willingnesses to pay must be small enough, $\lambda^P/\lambda^R \leq \tau$, so that the threat of parallel trade is not binding. In constrast, when differences in willingnesses to pay become large, $\lambda^P/\lambda^R > \tau$, the parallel trade constraint kicks in. This happens when

$$\frac{\omega L^P}{L^R} > \tau^{-1}. \tag{7}$$

In other words, a full trade equilibrium emerges when per capita incomes are similar, while an arbitrage equilibrium emerges when the gap in per capita incomes is large.

Up to now we have implicitely assumed that trade costs are sufficiently low so that the two countries will engage in trade. The following proposition proves existence of a general equilibrium with trade.

Proposition 5 *When $\tau \leq \tau^* \equiv \sqrt{aF/\mathcal{P}^R + 1}$, the two countries will trade with each other for all $L^P/L^R \in (0, 1]$.*

PROOF. See Appendix C.

The trade condition in the proposition makes sure prices in country P are sufficiently high to induce country-R firms to export their product. Notice that, with $\tau \leq \tau^*$, country-P firms are also willing to export since they can charge a price $p_T^R > p^P < \tau/a$. The trade condition is quite intuitive. Trade is more valuable when fixed costs are high, as these costs are spread out over a larger market. For the same reason, trade is more valuable if the local market is small. Hence the critical value of iceberg costs τ^* is increasing in F and falling in $\mathcal{P}^R$. Notice also that the trade condition makes a statement about the relative size of trade costs and the square root of the mark-up. One could argue that empirically observed mark-ups are often lower than observed trade costs, thus contradicting the trade condition. Notice, however, that $aF/\mathcal{P}^R + 1$ is the mark-up of a (northern) firm that sells its product exclusively on the home market, while the average mark-up in the economy is a weighted average of these non-exporting firms (with high mark-ups) and exporting firms (with low mark-ups). Hence, our simple model can accommodate a situation where there is trade, even though the economy-wide mark-up falls short of trade costs.

Figure 2 shows the relevant equilibria in $(L^P/L^R, \tau)$ space. There is full trade in region **F** which emerges at high values of L^P/L^R and intermediate values of τ. An arbitrage equilibrium prevails in region **A** which arises at low trade costs and high income differences. Figure 2 also shows what happens when population size in the poor country increases. In that case, the downward-sloping branch that separates regions **F** and **A** shifts to the left. When the poor country is larger, τ^* is unaffected and there are more parameter constellations $(L^P/L^R, \tau)$ under which a full trade equilibrium emerges. In this sense, a larger population in the poor country fosters trade.[15]

Figure 2

Figure 3 shows the welfare responses of changes in τ across the various regimes graphically. Panel a) is drawn for relatively low per capita income differences $\omega L^P/L^R > \tau^*$. In that case, an arbitrage equilibrium emerges with low trade costs, while a full trade equilibrium emerges with moderate trade costs. Panel b) is drawn for higher per capita income differences $\omega L^P/L^R \leq \tau^*$ so that a full trade equilibrium is not feasible. Country-R welfare (the bold graph) is monotonically decreasing in τ in both panels of Figure 3. Hence the R-consumer reaches his maximum welfare when trade costs are at their lowest possible level $\tau = 1$. In contrast, the impact of τ on country-P welfare (the dotted graph) interacts with per capita income differences. When these differences are low (panel a), country-P welfare increases in τ when $\tau < \left(\omega L^P/L^R\right)^{-1}$ and decreases in τ when $\tau \geq \left(\omega L^P/L^R\right)^{-1}$. Welfare is maximized at $\tau = \left(\omega L^P/L^R\right)^{-1}$ (when the equilibrium switches from a full-trade to an arbitrage equilibrium). When per capita income differences are large (panel b), country-P welfare decreases monotonically in τ (full trade is not feasible) and welfare is maximized at $\tau = \tau^*$.

Figure 3

4 Many rich and poor countries

In an arbitrage equilibrium with two countries, all firms in the poor country are exporters while only a subset of firms in the rich country exports. Moreover, a trade liberalization that relaxes the arbitrage constraint always hurts poor consumers. We now show that these predictions need to be qualified in a multi-country world. The effect of moving from two to many countries can be most easily shown when there are n identical rich countries and m identical poor countries, i.e. a world with a fragmented rich North and a fragmented poor South. As before, we assume that countries differ in per capita endowments (and population size) but are identical in all other respects.

[15]Notice that there is international trade even when income differences become extremely large and L^P/L^R becomes very small. The range of traded goods approaches zero, however, when L^P/L^R goes to zero.

The general equilibrium has a structure very similar to that of the two-country case. From the zero-profit conditions for internationally active firms, it is straightforward to show that relative wages are now given by

$$\omega \equiv \frac{W^R}{W^P} = \frac{aF + \tau\mathcal{P}^{-R} + \mathcal{P}^R}{aF + \tau\mathcal{P}^{-P} + \mathcal{P}^P},$$

where $\mathcal{P}^{-R} = (n-1)\mathcal{P}^R + m\mathcal{P}^P$ and $\mathcal{P}^{-P} = n\mathcal{P}^R + (m-1)\mathcal{P}^P$ are rest-of-the-world populations from the perspective of country R and country P, respectively. In full world trade equilibrium, relative prices of southern relative to northern markets are determined by relative per capita incomes, $p^P/p^R = \omega L^P/L^R$, and the ratio of produced varieties still reflects differences in aggregate GDP, $N^P/N^R = \omega L^P\mathcal{P}^P/L^R\mathcal{P}^R$.

The interesting case is when income differences sufficiently large, so that $\omega L^P/L^R > \tau^{-1}$. In that case, the arbitrage constraint is binding, limiting trade between the rich North and the poor South. A northern firm now has two options: either export worldwide or export only to other northern countries. Notice that, unlike in the two-country case, all northern firms are now exporters. Firms that export exclusively to the North have a smaller market but can charge higher prices. Firms that export to all countries worldwide set low prices but have the large world market. While large differences in per capita incomes limit trade *across* regions, there is full trade *within* regions. As there are no income differences within a region, all goods produced in that region are also sold to other countries in that region.

The arbitrage equilibrium can now be solved in a straightforward way (for details see Appendix E). We first study how differences in per capita incomes and population sizes affect trade intensity. It is straightforward to calculate

$$\phi = 2\frac{m\omega L^P\mathcal{P}^P}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}\frac{(m-1)\mathcal{P}^P + \tau\mathcal{P}^R}{m\mathcal{P}^P + n\tau\mathcal{P}^R} + 2\frac{(n-1)L^R\mathcal{P}^R}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}.$$

which readily reduces to the expression derived in the last section when $n = m = 1$. An increase in L^P increases world trade intensity (and reduces North-North trade with exclusive goods). It can also be shown that a larger population in the South has a weaker effect on trade intensity than a larger per capita income. Hence with respect to per capita incomes and populations sizes, the results of the two-country case carry over to the multi-country framework.

In contrast to the two-country case, the effect of a trade liberalization on welfare is now ambiguous. There are two effects. On the one hand, a lower τ implies a tighter arbitrage constraint for globally active producers. Lower prices for globally traded products (relative to products exclusively sold in the North) induce former northern world-market producers to concentrate their sales on northern markets only. This reduces trade intensity between the North and the South. On the other hand, a reduction in τ stimulates trade within regions. While South-South trade increases less than North-South trade falls (first term of above equation increases in τ), North-North trade unambiguously increases (second term decreases in τ). A trade liberalization is more likely to stimulate trade if there are more countries with a region. Within-regional trade is more strongly affected in this case and dominates the reduction in

North-South trade. A trade liberalization is also more likely to stimulate North-South trade, the larger is the North relative to the South. In that case, North-North trade (which is positively affected) comprises the bulk of world trade. When the North is much larger than the South, positive effects on North-North trade of a trade liberalization dominate negative effects on North-South trade flows.

It turns out that the welfare level of a country-P household is given by

$$U^P = mN^P + nN_N^R = \frac{aL^P(m\mathcal{P}^P + \tau n\mathcal{P}^R)}{aF + \tau\mathcal{P}^{-P} + \mathcal{P}^P}.$$

It is straightforward to see that $\partial U^P/\partial\tau < 0$ if $aF < (m-1)\mathcal{P}^P(1 + (m/n)(\mathcal{P}^P/\mathcal{P}^R))$. This means that a trade liberalization may raise welfare in country P and is more likely to do so the higher is $m\mathcal{P}^P$. A reduction in τ has two opposing effects. The arbitrage channel is still at work and induces northern firms to abstain from selling to southern households. This is harmful for southern welfare. However, a lower τ stimlates South-South trade, which has a beneficial effect on southern welfare. Households in the poor country gain from a trade liberalization when there are many poor countries and when poor countries are large. In such a situation, there is a lot to gain from South-South trade because there are many trade barriers and because the southern markets are large.

We summarize the above discussion in the following

Proposition 6 *Assume there are m identical poor countries and n identical rich countries, with $L^P/L^R < (\omega\tau)^{-1}$. a) All northern firms export, but some of them export only to other northern countries; b) A trade liberalization (a lower τ) unambiguously increases welfare of rich households. It increases welfare of poor households if $aF < (m-1)\mathcal{P}^P(1 + (m/n)(\mathcal{P}^P/\mathcal{P}^R))$ and decreases it otherwise. The increase in welfare is larger in the North than in the South.*

Proof. In text. ■

Notice that the multi-country model generates an empirically testable hypothesis. The model predicts a positive correlation between the export probability of a northern firm and the per-capita income of a potential destination. In our simple model, the probability that a firm from a rich country exports to another rich country is 100 percent. (The prediction that 100 percent of all firms export is clearly an artefact arising from the assumed absence of firm heterogeneity.) In contrast, the probability that a nothern firms exports to a poor country is less than 100 percent and is lower the poorer a potential destination. Below, we will test this prediction by investigating whether and to wich extent US export probabilities of HS6-digit product categories are indeed positively related to potential destinations' per capita incomes.

5 General preferences

The assumption of 0-1 preferences yields a tractable framework with closed-form solutions. However, the focus is entirely on the extensive margin of consumption. This contrasts with the standard CES case where all adjustments happen along the intensive margin. We go beyond these two polar cases in this section by studying general preferences. We show that the qualitative characteristics of the equilibria under 0-1 preferences carry over to general preferences featuring non-trivial intensive *and* extensive margins of consumption. In particular, we precisely define the conditions under which an arbitrage equilibrium with non-traded goods exists and also provide a simple calibration exercise showing that arbitrage equilibria emerge under reasonable parameter values and that there is a quantitatively strong relationship between per capita incomes on the extensive margin of trade.

5.1 Utility and prices

Let us go back to the setup of Section 5 with two countries that differ in per capita income and population size. However, let household welfare take the general form

$$U = \int_0^\infty v(c(j))dj,$$

where $c(j)$ denotes the consumed quantity of good j. It is assumed that the subutility $v()$ satisfies $v' > 0$, $v'' < 0$ and $v(0) = 0$. Beyond these standard assumptions, we make two further assumptions on the function $v()$: (i) $v'(0) < \infty$, (ii) $v''(0) > -\infty$, and (iii) $-v'(c)/[v''(c)c]$ is decreasing in c. The first assumption implies that reservation prices are finite, generating a non-trivial extensive margin of consumption; the second ensures that an arbitrage equilibrium exists when per capita income differences are sufficiently high (see below); and the third implies a price elasticity of demand decreasing along the demand curve. Monopolistic pricing leads to $p = (1 + v''(c)c/v'(c))^{-1}b$, where b denotes marginal cost. To simplify notation, we denote the mark-up by $\mu(c) \equiv (1 + v''(c)c/v'(c))^{-1}$. Assumptions (i)-(iii) imply that $\mu(0) = 1$ and $\mu'(c) > 0$.[16]

How does firms' price setting behavior change when there are consumer responses along the intensive margin? With 0-1 preferences, the monopoly price equals the representative household's willingness to pay and does not depend on marginal production costs. With general preferences, however, firms solve the standard profit maximization problem: the price equals marginal costs times a mark-up that depends on the price elasticity of demand. This implies an important difference to the case of 0-1 preferences. With general preferences, there are price differences between imported and domestically produced goods. While symmetric utility implies that importers and local producers within a given location face the same demand curve, marginal costs differ since importers have to bear transportionation costs and since wages vary by location. To allow for such differences, we denote by p_j^i, c_j^i and b_j^i, respectively, the price, quantity and marginal cost of a good produced in country j and consumed in country i. Unconstrained monopoly pricing implies $p_j^i = \mu(c_j^i)b_j^i$.

[16] $\mu'(c) > 0$ follows directly from assumption (iii). To see why $\mu(0) = 1$ we use l'Hopital's rule $\lim_{c\to 0} v'(c)c/v(c) = \lim_{c\to 0}(1 + v''(c)c/v'(c))$. However, $\lim_{c\to 0} v'(c)c/v(c) = v'(0) \cdot \lim_{c\to 0} c/v(c) = v'(0)/v'(0) = 1$. This implies $\lim_{c\to 0} v''(c)c/v'(c) = 0$ and hence $\lim_{c\to 0}\mu(c) = 1$. Since the monopolist optimally chooses a price along the elastic part of the demand curve, no further restrictions on the $\mu(c)$-function are needed.

5.2 The arbitrage equilibrium

The arbitrage equilibrium features a situation in which (i) only a subset of country-R producers sell their product worldwide at sufficiently low prices to avoid arbitrage; (ii) the remaining country-R firms sell their product exclusively in the rich country at the unconstrained monopoly price; (iii) all poor-country producers export their products, also at prices that avoid arbitrage. The discussion in this section focuses on the conditions under which an arbitrage equilibrium exists. (Appendix E provides the full system of equations that characterize such an equilibrium.)

The arbitrage constraints for country-R and country-P producers, respectively, are now given by

$$1/\tau \leq p_R^R/p_R^P \leq \tau \text{ and } 1/\tau \leq p_P^P/p_P^R \leq \tau.$$

A necessary condition for the existence of an arbitrage equilibrium is that these constraints are binding, so that $p_R^R/p_R^P = p_P^R/p_P^P = \tau$. This happens to be the case if the gap in per capita incomes becomes sufficiently large. As L^R/L^P, and hence c_R^R/c_R^P, get large the ratio of (unconstrained) monopoly prices eventually exceeds trade costs, or $\mu(c_R^R)/\mu(c_R^P) > \tau^2$. (Recall that $\mu'(c) > 0$.) Notice, however, that a binding arbitrage constraint does not necessarily imply that there are non-traded goods. The reason is that adjustment now does not only occur at the extensive margin but also at the intensive margin. Hence there are full trade equilibria where the arbitrage constraint binds.

To verify the existence of an arbitrage equilibrium with non-traded goods, we look at incentives of country-R firms to sell exclusively on the home market rather than selling their products worldwide. A country-R producer's profit is given by (to ease notation we write $p_R^R \equiv \tau p$ and $p_R^P \equiv p$)

$$\pi = \mathcal{P}^R \left(\tau p - 1/a\right) c_R^R + \mathcal{P}^P \left(p - \tau/a\right) c_R^P.$$

The corresponding demand curves are given by the first order conditions $v'(c_R^R) = \lambda^R \tau p$ and $v'(c_R^P) = \lambda^P p$ for households in country-R and and country-P, respectively. This yields $dc_R^R/dp = (1/p)v'(c_R^R)/v''(c_R^R)$ and $dc_R^P/dp = (1/p)v'(c_R^P)/v''(c_R^P)$. The first order condition of the monopolistic firm's price setting choice is given by

$$\frac{\tau p - 1/a}{p}\left(-\frac{v'(c_R^R)}{v''(c_R^R)}\right) + \frac{p - \tau/a}{p}\left(-\frac{v'(c_R^P)}{v''(c_R^P)}\right)\frac{\mathcal{P}^P}{\mathcal{P}^R} = \tau c_R^R + c_R^P\frac{\mathcal{P}^P}{\mathcal{P}^R}.$$

To examine whether an arbitrage equilibrium exists, let L^P and therefore c_R^P approach zero, all other exogenous variables (including $\mathcal{P}^P/\mathcal{P}^R$) remain fixed. The first order condition then becomes

$$\frac{\tau p - 1/a}{\tau p}\left(-\frac{v'(c_R^R)}{v''(c_R^R)c_R^R}\right) + \frac{p - \tau/a}{\tau p c_R^R}\left(-\lim_{c_R^P \to 0}\frac{v'(c_R^P)}{v''(c_R^P)}\right)\frac{\mathcal{P}^P}{\mathcal{P}^R} = 1.$$

Now consider the optimal decision of a country-R firm whether to produce exclusively for the home market. Denoting by p^N and c_R^N price and quantity of non-traded goods, the first order condition for exclusive producers is

$$\frac{p^N - 1/a}{p^N}\left(-\frac{v'(c_R^N)}{v''(c_R^N)c_R^N}\right) = 1.$$

When τ is sufficiently low, so that $p > \tau/a$, comparing the last two equations shows that the price of a non-exporting firm p^N is strictly larger than the price of an exporting firm τp. (This is because, by assumption, $-v'(0)/v''(0) > 0$.) Since $c_R^P \to 0$ when $L^P \to 0$, export revenues are zero. Hence non-exporters charge higher prices and their profits are larger than those of exporters. This implies that an outcome where all firms export cannot be an equilibrium. We summarize our discussion in

Proposition 7 *There is a critical income gap Δ such that, for all $L^P/L^R < \Delta$, an equilibrium emerges in which only a subset of goods is traded.*

Proof. In text. ■

The above proposition implicitely assumes an equilibrium where the two countries trade with each other. This is not a priori clear because the countries may also remain in autarky. The following proposition shows that transportation costs need to fall short of a certain limit to make sure that trade will take place in equilibrium.

Proposition 8 *Denote by c_a^R consumption per variety under autarky in the rich country. There will be trade in equilibrium, if $\tau < \mu(c_a^R)v'(0)/v'(c_a^R)$ where $aF/\mathcal{P}^R = c_a^R(\mu(c_a^R) - 1)$.*

Proof. See Appendix F. ■

An important result we derived under 0-1 preferences holds that population size has a weaker effect than per capita incomes in determining trade patterns. We now demonstrate that this is also true with general preferences. The previous proposition showed that, starting from a full trade equilibrium, increasing the gap in per capita incomes will eventually generate an arbitrage equilibrium with non-traded goods. We now show this is *not* necessarily the case, when we increase relative population size.

To make this point, we proceed as follows. We first observe that, starting from a full trade equilibrium, an increase in L^P/L^R beyond unity eventually leads to a "reversed" arbitrage equilibrium, in which some country-P producers sell only on the domestic market while all country-R producers export. We now show that such a reversed arbitrage equilibrium *cannot* emerge from a successive increase in $\mathcal{P}^P/\mathcal{P}^R$ (keeping $L^P/L^R < 1$ constant), because this does *not* generate price differences sufficiently large to escape a full trade equilibrium. In other words, increasing $\mathcal{P}^P/\mathcal{P}^R$, we cannot reach a situation where both arbitrage constraints are violated, $\mu(c_R^P) \geq \mu(c_R^R)$ and $\mu(c_P^P) \geq \mu(c_P^R)\tau^2$. To see this, consider the households' budget constraints

$$\begin{aligned} aL^R &= N_P\mu(c_P^R)c_P^R\tau\omega + N_R\mu(c_R^R)c_R^R \\ aL^P &= N_P\mu(c_P^P)c_P^P + N_R\mu(c_R^P)c_R^P\tau/\omega, \end{aligned}$$

and take the difference between the two equations. If both arbitrage conditions are violated, the budget constraints can only hold if $\omega > \tau$. However, if $\omega > \tau$ the zero-profit condition is violated in at least one country in a full trade equilibrium (where firms charge the unconstrained monopoly price). In such an equilibrium, the zero-profit condition in country j is given by

$$\mathcal{P}^R c_j^R(\mu(c_j^R) - 1)/a + \mathcal{P}^P c_j^P(\mu(c_j^P) - 1)\tau/a = F,$$

where $p_P^i > p_R^i$ and $c_P^i < c_R^i$, since country P has higher marginal cost than country R, both on the domestic and the export market. However, this implies $c_P^i(\mu(c_P^i) - 1) < c_R^i(\mu(c_R^i) - 1)$ for both $i = P$ *and* $i = R$, i.e. country R-producers make strictly larger profits on both markets. It follows that, when the zero-profit condition holds in country R, it must be violated in country P, and vice versa, if country P is the low-wage country. In the latter case, we must have $\omega > 1/\tau$ to ensure that both zero-profit conditions can hold simultaneously. Hence we have $\omega \in (1/\tau, \tau)$ in a full trade equilibrium with unconstrained price setting. In sum, we always have $\omega < \tau$ in a full trade equilibrium. But this implies that households' budget constraints continue to hold simultaneously when $\mathcal{P}^P/\mathcal{P}^R$ gets very large. Thus, unlike a successive increase in L^P/L^R (beyond unity), it is not possible to reach a "reversed" arbitrage equilibrium with a successive increase in $\mathcal{P}^P/\mathcal{P}^R$. In this sense, the difference in population sizes has a weaker effect on trade patterns than the difference in per capita endowments. We summarize our discussion in the following

Proposition 9 *Per capita endowments are more important for trade patterns than population sizes. Starting from a full trade equilibrium with unconstrained price setting, successive increases in L^P/L^R (beyond unity) lead to a "reversed" arbitrage equilibrium, while successive increases in $\mathcal{P}^P/\mathcal{P}^R$ cannot generate a reversed arbitrage equilibrium.*

Proof. In text. ■

6 Empirical evidence

In this section we assess whether our model leads to quantiative predictions consistent with empirical facts in disaggregated trade data. We proceed in three steps. First, we test the prediction (developed at the end of section 4) of a positive relationship between a rich country's export probability and a destination's per capita income, looking at US export data for 1,263 HS6-digit product categories to 135 potential export destinations. Second, we use the model developed in section 5 and undertake a calibration exercise to study whether our framework can match (i) the US export probability to a "typical" poor country and (ii) the gradient of the US export probability with respect to destinations' per capita incomes. Finally, we provide a discussion contrasting the model's predictions with the empirical evidence.

6.1 Evidence from disaggregated trade data

We analyze the following baseline regression

$$D(i,k) = \alpha_0 + \alpha_1 \ln GDP(k) + \alpha_2 \ln y(k) + X(i,k)\beta + \phi(i) + e(i,k),$$

where $D(i,k)$ indicates whether the US exports product i to country k, $GDP(k)$ is aggregate GDP of country k, and $y(k)$ denotes per capita income of country k. $X(i,k)$ is a vector of controls,[17] $\phi(i)$ is a product-fixed effect, and $e(i,k)$ is an error term.

We use UN Comtrade data complied by Gaulier and Zignago (2010) containing yearly unidirected bilateral trade flows at the 6-digit-level of the Harmonized System (1992) for the year 2007. We observe 5,018 product categories at the 6-digit level. We look only at consumer goods (according the BEC classification). This leaves us with 1,263 product categories from which we exclude those 11 categories the US did not export in 2007. Our data set includes 135 potential export destinations. Information on per capita incomes (2005 PPP-adjusted USD) and population sizes are taken from Heston et al. (2006). We exclude all bilateral trade flows with negative quantities and set $D(i,k) = 0$ when the observed quantity falls short of USD 2,000. We end up with 169,020 potential export flows (1,252 products $\times$ 135 potential importers). 39.1 percent of these potential export flows actually materialized in 2007.

Empirical results. A crucial prediction of our model is $\alpha_2 > 0$: a destination's per capita income is a significant determinant for the export probability, conditional on the destiantion's aggregate GDP. In the standard homothetic model we should have $\alpha_2 = 0$, since there is no extra role for a destination's per capita income once aggregate GDP is controlled for. The estimates of Table 1, column 1, clearly indicate that α_2 is positive, statistically significant, and quantatively large: doubling a destination's per capita income, holding its aggregate GDP constant, increases the US export probability of a HS6 digit product category by 8.5 percentage points. The estimates of column 1 also imply that a destination's per capita income is more important than its population size. To see this, denote by $Pop(k)$ destination k's population size, so that $\ln Pop(k) = \ln GDP(k) - \ln y(k)$. This lets us rewrite the empirical model as $D(i,k) = \alpha_0 + (\alpha_1 + \alpha_2) \ln y(k) + \alpha_1 \ln Pop(k) + ...$ Hence doubling the per capita income (holding population size constant) increases the export probability by 14.9 (= 8.5 + 6.4) percentage points, while doubling population size (holding per capita income constant) increases it by only 6.4 percentage points. We conclude that the empirical evidence is consistent with the predictions of our model, according to which per capita income play a more important role than populations size to explain the extensive margin of international trade (see Propositions 3 and 9).

Table 1

[17] Control variables include: log of distance between exporter's and importer's capital, dummy for a common border, dummy for importer being an island, dummy for importer being landlocked, dummy for importer and exporter ever having had colonial ties, dummy for currency union between importer and exporter, dummy for importer and exporter sharing a common legal system, dummy for religious similarity, dummy for importer and exporter having a free trade agreement, and dummy for importer and exporter sharing a common language.

To check the robustness of our estimates, columns 2-6 of Table 1 replace the regressor $\ln y(k)$ by a set of dummy variables to allow for a more flexible impact of per capita incomes on export probabilities.[18] In column 2, we use the same sample as in the log specification of column 1; column 3 excludes very small destination (with population size less than 1 million); and column 4 and 5 aggregate export proabilities to HS4 and HS2 digit levels, respectively. Results indicate a monotonic impact of per capita income, which is robust across specifications.[19]

Explaining the evidence with previous approaches. We first note that the per capita income effect of Table 1 cannot be explained by standard heterogeneous-firm models à la Melitz (2003). Because of CES preferences, there is no extra role for a destination's per capita income once the destination's aggregate GDP is controlled for. In this sense, our model is able to explain an empirical fact that cannot be explained by standard heterogeneous firm models. In principle, standard models could accomodate the results by assuming that market-entry costs are decreasing in destinations' per capita incomes. However, such an assumption is ad hoc and influential recent work by Arkolakis (2010) argues in the opposite direction. In the Arkolakis model, market entry (i.e. advertising) costs decrease in population size. Holding aggregate GDP constant, this implies a positive relationship between market entry costs and the destination's per capita income.

Moreover, simple specifications of non-homothetic preferences frequently used in the literature (e.g. Markusen 1986, Bergstrand 1990, Mitra/Trindade 2005) can also not account for the per capita income effects of Table 1. In these specifications, a CES-index for differentiated products is linked with a homogenous good, assuming the latter is a necessity and the former are luxuries.[20] Such specifications of non-homotheticities generate a bang-bang solution: as long as subsistence needs are not covered, consumers' willingness to pay for differentiated products – the "reservation price" – is zero; when subsistence needs are covered, reservation prices for differentiated products jump to infinity and all goods are traded. This means that further assumptions are needed to generate export zeros.

More recent approaches of non-homothetic preferences allow for variable elasticities of substitution (VES). In such specifications, non-negativity constraints may become binding as reservation prices may become finite. Simonovska (2012), Markusen (2012), Behrens and Murata (2012a,b), Sauré (2012), and Mrazova and Neary (2013) provide such models. In these

[18]The estimated model is $D(i,k) = \tilde{\alpha}_0 + \tilde{\alpha}_1 \ln GDP(k) + \sum_{n=1}^{6} \tilde{\alpha}_{2n} D_y(k,n) + X(i,k)\tilde{\beta} + \tilde{\phi}(i) + \tilde{e}(i,k)$, where $D_y(k,n)$ indicates whether of not destination k falls into per capita income category n. We classify countries into 7 per capita income groups: (i) lower than USD 1000; (ii) USD 1000-1999; (iii) USD 2000-3999; (iv) USD 4000-7999; (v) USD 8000-15999; (vi) USD 16000-31999; and (vii) USD 32000 or larger. The group with per capita income larger than USD 32,000 serves as the reference group.

[19]In Tables A1 and A2 of the Appendix, we provide further robustness checks. In Table A1, we show that the US results for 2007 shown in Table 1 are very similar in each single year since 1997. In Table A2 we look at the 14 largest consumer goods exporters (rather than only the US). For all these large exporting countries we find a significant effect of destinations' per capita income, holding destinations' GDP constant (the only exception being Mexico where the effect is barely significant and quantitatively small). These results are also in line with the evidence in Baldwin and Harrigan (2011) and Bernasconi and Wuergler (2012) where, respectively, output per worker and income per capita are included as control variables in extensive margin regressions.

[20]A frequently adpoted functional form with the property is $\alpha \log(x - \bar{x}) + (1-\alpha)\log C$ where x is the quantity of the homogenous good, $\bar{x}$ is the subsistence level, and C is a CES aggregator for differentiated products.

papers, export zeros emerge under supply heterogeneities, when a destination's reservation price falls short of the marginal (production plus transportation) costs of serving that market. Notice, however, that the above papers do not consider arbitrage. Clearly, the empirical evidence in Table 1 cannot discriminate between export zeros arising from the reservation price falling short of the marginal production costs and export zeros arising from international arbitrage. To explore the quantitative relevance of the arbitrage channel further, we now provide a simple calibration exercise.

6.2 Calibrating the model

The aim of this section is to investigate the quantitative relevance of arbitrage constraints predicted by our model. To check whether and which extent arbitrage constraints can account for the empirically observed positive relationship between export probabilities and per capita incomes, we want to match two moments of the data: (i) the US export probability to a "poor" trading partner and (ii) the profit shares in the two countries. A poor county is defined as country with a per capita income lower than USD 8,000. (76 out of the 135 countries used in the above empirical analysis belong to this subsample.) Taking the coefficients of our baseline regression in Table 1, column 2, the predicted export probability to the typical poor country is 0.326, which we try to match exactly in the calibration. Moreover, we look for parameters such that the implied profit shares in the rich and the poor country are close to 0.333, a benchmark frequently usually in quantitative applications.[21]

The starting point of our calibration is the model developed in section 5. We assume that the subutility $v(c)$ belongs to the HARA (hyperbolic absolute risk aversion) class, which takes the form $v'(c) = (s - c\sigma)^{1/\sigma}$. Imposing the restriction $s > 0$ implies $v'(0) = s^{1/\sigma} < \infty$; $v''(0) = -v'(0)/s > -\infty$; and $-v'(c)/[v''(c)c] = s/c - \sigma$ is decreasing in c. This satisfies our initial assumptions on the form of $v(c)$ adopted in section 5. This specification encompasses the Stone-Geary for $\sigma = -1$, the quadratic utility for $\sigma = 1$, and the 0-1 utility when $\sigma \to \infty$. For our calibration exercise we make the further parameter restriction $s = \sigma$ (which precludes the Stone-Geary).

To match the income of the average trade partner we need to measure real income. Relative real incomes cannot be simply calculated by taking the ratio of nominal incomes. With non-homothetic preferences, the rich and poor country have different price indices. To be as close as possible to a calibration exercise with CES preferences, we need to transform the utility indices U_P and U_R such that the index is homogenous of degree one in quantities. We define the ratio of real per capita incomes as $y_P/y_R = v^{-1}(U_P)/v^{-1}(U_R)$.[22]

[21] Notice that the target of our calibration exercise is the profit share rather than the markup. The reason is that, in our model, there is no intermediate sector. Hence it is more reasonable to focus on the profit share so that the implied price-cost ratio is a "gross" markup. Obviously, profit share and markup are closely related. For instance, in the autarky equilibrium with 0-1 preferences, aggregate income is $\mathcal{P}L$, while profits are $FN = aFL/(aF/\mathcal{P} + 1)$. The profit share reads therefore $(aF/\mathcal{P})/(aF/\mathcal{P} + 1)$, while the gross markup equals $\mu = aF/\mathcal{P} + 1$. Thus, a profit share of 1/3 corresponds to the gross markup of 1/2.

[22] The functional form of $v(\cdot)$ has a bliss point, which implies that the value of the argument in $v^{-1}(\cdot)$ could exceed $v(s/\sigma) = v(1)$, the utility at the bliss point. To avoid this, we need to normalize welfare levels such that the adjusted ratio of real per capita incomes is $y_P/y_R = v^{-1}(kU_P)/v^{-1}(kU_R)$, where k is a normalization factor.

We now turn to the calibration exercise. The simulations show that the results depend on the ratio $aF/\mathcal{P}^R L^R$. Hence, we can normalize $\mathcal{P}^R = L^R = F = 1$ and vary a. This leaves us with five parameters: the productivity parameter a, the preference parameter σ, population $\mathcal{P}^P$ and per capita endowment L^P of the poor country, and trade costs τ. Since we want to match the extensive margin of trade with typical poor US trading partner, $\mathcal{P}^P$ and L^P are determined by the ratio of per capita GDP y_P/y_R, which equals 0.083. This ratio pins down the labor endowment L^P using the above formula for y_P/y_R. The ratio of aggregate GDP $\mathcal{P}^P y_P/\mathcal{P}^R y_R$ determines $\mathcal{P}^P$ (recall that $\mathcal{P}^R$ was set to unity). In 2007, the (unweighted) aggreate GDP of trading partners with per capita income below 8,000 USD was equal to 287 billion USD, whereas aggregate GDP of the US was equal to 13,027 billion USD. Finally, trade costs are set to 1.2, which is somewhat larger than 1.1 chosen for missing country pairs in the standard DOTS IMF database.[23]

We are left with our free choice parameters a and σ. We set $a = 0.475$ and $\sigma = 50$. We chose a high value of σ to come close to the 0-1 specification. Under this parameter constellation the model predicts an export probability of 0.328, which matches exactly the US export probability to the average poor destination observed in the data. The calibrated profit shares for the rich and poor country equal 0.328 and 0.262, respectively which are not too far off the benchmark of 0.333. (Clearly, when σ is varied, we need to adjust a to match the extensive trade margin exactly.) We conclude that our model can match the observed US export probability to a typical poor destination under reasonable parameter values.[24]

Figure 4

We can take our simple calibration exercise one step further by matching not only the US export probability to a typical poor destination, but also its gradient with respect destinations' per capita incomes. Figure 4 constrasts the predictions of the model to the per capita income effects estimated in the regression in Table 1, column 2 (holding all characteristics other than per capita income indicators constant, at the sample means of countries poorer than USD 8,000). Figure 4 reveals that the model predicts a very steep gradient: the export probability is 0.030 to destinations with a per capita income below USD 1,000 (class mean USD 750); 0.527 to destinations with incomes between USD 4,000 and 8,000 (class mean 6,000); and more than 90 percent to destinations with a per capita income above USD 8,000. In contrast, the

(It turns out that alternative values of k have only a very small effect on the calibration outcomes.) Note also, that a similar normalization would not change the results in the CES case, since $v^{-1}(\cdot)$ is a power function. In that case, $v^{-1}(a)/v^{-1}(b) = v^{-1}(a/b)$, and we have $v^{-1}(kU_P)/v^{-1}(kU_R) = v^{-1}(U_P/U_R)$. In other words, the correction parameter k is irrelevant in the case of homothetic preferences.

[23] Estimates of trade costs vary according to the particular definition. Anderson and van Wincoop (2004) argue that trade costs (broadly defined) are large. In the context of parallel trade, where an arbitrageur exploits price differentials for an existing product, the relevant trade costs should be defined more narrowly, consisting mainly tariffs and direct transport costs. Hummels (2007) reports 4 percent of ad valorem transport costs for US imports and 7 percent for New Zealand. Including tariffs and accounting for higher transport costs with poor countries, it seems reasonable to set trade costs at a somewhat higher level in the calibration.

[24] Alternative combinations of σ and a that match the export probability to the typical poor country of 0.328 exactly, and lead to a very similar gradient as in Figure 4 below. However, for lower values of σ, the implied profits share become unrealistically large.

gradient of export probabilities observed in the data is much flatter. It ranges from an export probability of 0.268 for destinations with incomes below USD 1,000; 0.416 to destination with incomes between 4,000 and 8,000; and 0.533 for destinations with incomes above 8,000.

6.3 Discussion

While our model can match the US export probability to a typical poor destination, it predicts a gradient substantially steeper than the one observed in the data. We argue that there are two main reasons for this discrepancy.

First, the model assumes perfect symmetry across products and identical households within each country. In reality, of course, asymmetries are pervasive: firms differ in productivity and households are unequally rich (or have different tastes). Arguably, introducing asymmetries would generate a flatter gradient. Figure 4 reveals that our model *overestimates* the US export probability to other rich destinations. The model predicts an export probability of unity, while the regression analysis reveals a US HS6-digit export probability to other rich countries which is substantially lower. The model prediction is clearly an artefact of the assumption that firms work with identical technologies. Once we allow for productivity differences, firms with too high costs who will have to abstain from exporting to other rich destinations. This generates an export probability below 1, bringing the prediction of the model closer to the data.[25]

On the other hand, the model *underestimates* the export probabilities to low-income countries. This is most easy to see when the poor country consists of wealthy and less wealthy households. In that case, firms of the rich country have a higher incentive to export, since there is the additional option to charge somewhat higher prices and sell to wealthy consumers in the export destination. This softens the arbitrage constraint and leads to higher export probabilities to poor destinations, thus bringing the predictions of the model closer to the data. A similar outcome may arise from heterogeneities on the supply side. There will be price differences across products which let consumers in a poor destination purchase only the low-priced goods. This relaxes their budget constraint, allowing them to spread out expenditures over a larger set of imported products.

In sum, introducing relevant demand and supply heterogeneities arguably decreases (increase) the export probability of rich-country firms to rich (poor) destinations. While the model predicts a too steep gradient of export probabilities with respect to destinations' per capita incomes, we argue that our calibraton exercise is consistent with the idea that arbitrage is important. Suppose, to the contrary, that the model had predicted a too weak effect of per capita incomes on export probabilities. Since adding relevant heterogeneities would have made the gradient even flatter, the model predictions would have been even more at odds with the data, leading to the conclusion that arbitrage is of limited relevance. While allowing for heterogeneous firms and consumers is beyond the scope of this paper, we conclude that our

[25] Notice that this argument does not rely on fixed export costs. To see this, consider a firm that can charge the same price in the home and in the export market (because consumers in both countries have identical willingnesses to pay). Such a firm may break even in the home market but not in the export market when the price is high enough to cover the marginal cost of production but too low to cover also the transportation costs.

calibration exercise points to the potential importance of arbitrage for explaining the extensive margin of international trade.

A *second* reason for the difference between the model's predictions and the observed data may be due to aggregation bias. In the model, the export probability refers to a single product, while in the empirical analysis the export probability refers to a product group (HS6 digit). Aggregation may increase measured export probabilitie, because it suffices to have positive exports of one single product, to measure positive exports for a HS6 product category. If per capita income effects materialize mainly within (rather than between) HS6 product categories, export probabilities will be strongly overestimated for poor countries, while less so in richer countries. Getting rid of the aggregation bias would therefore generate lower export probabilities to poor destinations and a steeper gradient in export probabilities, bringing the gradient of the empirical estimates closer to the one predicted by the model.

7 Conclusions

This paper studies a model of international trade in which an importer's per capita income is a primary determinant of export zeros. This is due to a demand effect: consumers in poor countries have lower willingnesses to pay for differentiated products than consumers in rich countries. As a result, northern firms have a low incentive to export to a southern destination. Our model generates export zeros from non-homothetic preferences and does not rely on firm heterogeneity and/or fixed export-market entry costs. Hence our analysis is complementary to standard heterogeneous-firm approaches which focus on the supply side.

A key insight of our analysis is that export zeros arise from a threat of international arbitrage. Globally active firms cannot simultaneously set low prices in the South and high prices in the North because this triggers arbitrage opportunities. Northern firms have two options to avoid arbitrage: (i) set a sufficiently low price in the North; or (ii) abstain from exporting to the South. These two options involve a trade-off between market size and price: firms that export globally have a large market but need to charge a low price; firms that sell exclusively to northern markets can charge a high price but have a smaller market. The equilibrium of our model is characterized by Linder-effects, a situation where similarity in per capita incomes increases trade intensity between two countries. The model also generates interesting welfare effects. While rich countries always gain from a trade liberalization, poor countries may lose. Lower trade costs tighten the arbitrage constraint and this induces northern firms *not* to export to poor destinations, thus reducing the menu of supplied goods and harming welfare of households in the South.

The patterns of trade predicted by our model are qualitatively in line with empirical evidence from disaggregate US trade data. We document that the US export probability of a HS6-digit product to a particular destination decreases significantly in that destination's per capita income. This result holds after controlling for the destination's aggregate GDP and is very robust. To assess whether our model can match these empirical observations also quantitatively, we present a calibration exercise. We show that our model can match the US export probability to a typical poor destination under reasonable parameter values. We also show, that the model predicts a quantiatively strong relation between export probabilities and importers' per capita incomes. However, the gradient predicted by the model is substantially steeper than the one observed in the data. We argue that the model's excess sensitivity is an artefact of the symmetry assumption. Adding empirically relevant heterogeneities (unequally productive firms, within-country income inequality or unequal tastes) is likely to generate a substantially flatter gradient, thus bringing the predictions of the model closer to empirically observed data. We conclude that the predictions of our model are consistent with the hypothesis that arbitrage is quantitatively important.

While a full-fletched analysis of supply and demand heterogeneities is clearly beyond the scope of this paper, extending our basic framework to account for these (empirically highly relevant) features is an interesting direction for future research. The challenge is to appropriately disentangle supply and demand effects and assess their relative importance. This seems particularly relevant for a better understanding of how the emerging markets of China and India (and other emerging markets) and their rapidly growing per capita incomes affect trade patterns and the international division of labor.

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A Proof of Proposition 1

Part b). This follows from calculating the derivatives of ϕ with respect to L^P

$$\frac{\partial \phi}{\partial L^P} = \frac{2L^R\mathcal{P}^R\omega\mathcal{P}^P}{(L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P)^2} - \frac{4L^R\mathcal{P}^R\omega L^P\mathcal{P}^P}{(L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P)^3}\omega\mathcal{P}^P = \frac{\phi}{L^P}\left(1 - \frac{2\omega L^P\mathcal{P}^P}{L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P}\right),$$

and with respect to $\mathcal{P}^P$

$$\frac{\partial \phi}{\partial \mathcal{P}^P} = \frac{\phi\left(1 + \frac{\partial\omega}{\partial\mathcal{P}^P}\frac{\mathcal{P}^P}{\omega}\right)}{\mathcal{P}^P}\left(1 - \frac{2\omega L^P\mathcal{P}^P}{L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P}\right),$$

where $\frac{\partial\omega}{\partial\mathcal{P}^P}\frac{\mathcal{P}^P}{\omega} > 0$.

Part c). A given increase in $L^P\mathcal{P}^P$ has a stronger impact on ϕ if it comes from $\mathcal{P}^P$ rather than from L^P if $\partial\phi/\partial\log L^P = \left(\partial\phi/\partial L^P\right)L^P < \partial\phi/\partial\log\mathcal{P}^P = \left(\partial\phi/\partial\mathcal{P}^P\right)\mathcal{P}^P$. This is true since $\frac{\partial\omega}{\partial\mathcal{P}^P}\frac{\mathcal{P}^P}{\omega} > 0$.

Part d). This follows from the derivative of ϕ with respect to τ

$$\frac{\partial \phi}{\partial \tau} = \frac{\phi\frac{\partial\omega}{\partial\tau}}{\omega}\left(1 - \frac{2\omega L^P\mathcal{P}^P}{L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P}\right).$$

B Proof of Proposition 2

Part b) follows from the derivatives of ϕ with respect to L^P and $\mathcal{P}^P$. It is straightforward to see that $\partial\phi/\partial L^P > 0$. To calculate $\partial\phi/\partial\mathcal{P}^P$ we need to take into account that ω depends on $\mathcal{P}^P$

$$\frac{\partial \phi}{\partial \mathcal{P}^P} = \frac{-1}{\mathcal{P}^R\left(\tau + \mathcal{P}^P/\mathcal{P}^R\right)}\phi + \frac{1 + \frac{\partial\omega}{\partial\mathcal{P}^P}\frac{\mathcal{P}^P}{\omega}}{\mathcal{P}^P}\frac{L^R\mathcal{P}^R}{L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P}\phi,$$

hence an increase in $\mathcal{P}^P$ increases trade intensity ϕ when $\mathcal{P}^P$ is small and vice versa.

Part c). We need to show that the volume of trade increases with $\mathcal{P}^P$ less than proportionally. The argument in the text was made without considering that $\mathcal{P}^P$ increases ω. It remains to show that, taking account of the impact of $\mathcal{P}^P$ on ω, an increase in $\mathcal{P}^P$ reduces per capita imports. We sign$\partial p^P N_T^R/\partial\mathcal{P}^P = \text{sign}\partial\text{log}(p^P N_T^R)/\partial\mathcal{P}^P < 0$. Calculating $p^P N_T^R$, taking logs and the derivate with respect to $\mathcal{P}^P$ reveals that $\partial p^P N_T^R/\partial\mathcal{P}^P < 0$ if

$$-\frac{1}{\tau\mathcal{P}^R + \mathcal{P}^P} + \frac{\tau}{aF + \mathcal{P}^R + \tau\mathcal{P}^P} - \frac{1}{aF + \tau\mathcal{P}^R + \mathcal{P}^P} < 0.$$

Multiplying by $aF + \mathcal{P}^R + \tau\mathcal{P}^P$ yields

$$-\frac{aF + \mathcal{P}^R + \tau\mathcal{P}^P}{\tau\mathcal{P}^R + \mathcal{P}^P} + \frac{\tau(aF + \mathcal{P}^R + \tau\mathcal{P}^P)}{aF + \mathcal{P}^R + \tau\mathcal{P}^P} - \frac{aF + \mathcal{P}^R + \tau\mathcal{P}^P}{aF + \tau\mathcal{P}^R + \mathcal{P}^P} < 0 \Longleftrightarrow -p^P + \frac{\tau - \omega}{a} < 0,$$

which holds true because $p^P > \tau/a$.

Part d). We note that $\text{sign}(\partial\phi/\partial\tau) = \text{sign}(\partial\log\phi/\partial\tau)$. Taking logs of the expression for ϕ

and the derivative with respect to τ yields

$$\text{sign}(\partial\phi/\partial\tau) = \text{sign}\left(\frac{1}{\tau} - \frac{1}{\tau + \frac{\mathcal{P}^R}{\mathcal{P}^P}} + \frac{\omega'(\tau)}{\omega(\tau)} - \frac{\omega'(\tau)}{\omega(\tau)} \cdot \frac{\frac{\omega(\tau)L^P}{L^R}}{\frac{\omega(\tau)L^P}{L^R} + \frac{\mathcal{P}^R}{\mathcal{P}^P}}\right) > 0,$$

which, using $\omega(\tau)L^P/L^R < \tau$ and $\frac{\omega'(\tau)\tau}{\omega(\tau)} > -1$, implies

$$\text{sign}(\partial\phi/\partial\tau) = \text{sign}\left[\left(1 + \frac{\omega'(\tau)\tau}{\omega(\tau)}\right)\left(1 - \frac{\tau}{\tau + \frac{\mathcal{P}^R}{\mathcal{P}^P}}\right)\right] > 0.$$

C Proof of Proposition 3

Part a). In an arbitrage equilibrium we have $p^P = \left(aF + \mathcal{P}^R + \tau\mathcal{P}^P\right) / \left(a\tau\mathcal{P}^R + a\mathcal{P}^P\right)$. Country-$R$ firms export if $p^P \geq \tau/a$ or, equivalently, $\left(aF + \mathcal{P}^R + \tau\mathcal{P}^P\right)\left(\tau\mathcal{P}^R + \mathcal{P}^P\right)^{-1} \geq \tau$. Solving that latter equation for τ yields the trade condition. (Notice that, if the trade conditions holds for country-R firms, it also holds for country-P firms, as we have $p_T^R = \tau p^P > p^P$.)

Part b). Under full trade we have $p^P = \omega L^P\left(aF + \mathcal{P}^R + \tau\mathcal{P}^P\right)\left(a\mathcal{P}^R L^R + a\omega\mathcal{P}^P L^P\right)^{-1} \geq \tau/a$ or $\left(\omega L^P/L^R\right)\left(aF/\mathcal{P}^R + 1\right) \geq \tau$. But since full trade occurs only when $\omega L^P/L^R \geq 1/\tau$, the trade condition follows.

D Two regions: n rich and m poor countries

In an arbitrage equilibrium, the price of globally traded goods is $p_T^R = \tau p^P$ in the North. Zero profit constraints of globally traded goods are

$$p^P m\mathcal{P}^P + \tau p^P n\mathcal{P}^R = \left(F + \frac{\mathcal{P}^i + \tau\mathcal{P}^{-i}}{a}\right) W^i, \quad i = R, P.$$

where where $\mathcal{P}^{-R} = (n-1)\mathcal{P}^R + m\mathcal{P}^P$ and $\mathcal{P}^{-P} = n\mathcal{P}^R + (m-1)\mathcal{P}^P$. The prices of globally traded goods can be directly calculated $p^P = (aF + \mathcal{P}^R + \tau\mathcal{P}^{-R})/(am\mathcal{P}^P + a\tau n\mathcal{P}^R)$ and $p_T^R = \tau p^P$. The zero profit conditions for goods exclusively traded in the North are

$$p_N^R n\mathcal{P}^R = \left(F + \frac{\mathcal{P}^R + \tau(n-1)\mathcal{P}^R}{a}\right) W^R,$$

and the price of these goods follows immediately $p_N^R = W^R(aF + \mathcal{P}^R + \tau(n-1)\mathcal{P}^R)/(an\mathcal{P}^R)$. From the zero profit conditions of globally traded goods we can calculate relative wages between North and South

$$\omega \equiv \frac{W^P}{W^R} = \frac{aF + \tau\mathcal{P}^{-R} + \mathcal{P}^R}{aF + \mathcal{P}^P + \tau\mathcal{P}^{-P}}.$$

The resource constraints are

$$
\begin{aligned}
L^P \mathcal{P}^P &= N^P \left(F + \frac{\mathcal{P}^P + \tau \mathcal{P}^{-P}}{a} \right) \qquad \text{for a poor country, and} \\
L^R \mathcal{P}^R &= N_T^R \left(F + \frac{\mathcal{P}^R + \tau \mathcal{P}^{-R}}{a} \right) + N_N^R \left(F + \frac{\mathcal{P}^R + \tau (n-1) \mathcal{P}^R}{a} \right) \qquad \text{for a rich country.}
\end{aligned}
$$

Each R-country imports all goods produced worldwide, while each P-country imports only a subset of these goods. Hence the aggregate trade balance between the North and the South has to be balanced in equilibrium.[26] This implies

$$
\tau N^P \mathcal{P}^R = N_T^R \mathcal{P}^P.
$$

From the resource constraints and the trade balance condition we get closed-form solutions for N_P, N_R^T, and N_N^R. This gives welfare of rich and poor households

$$
U^R(\tau) = mN^P + nN_T^R + nN_N^R = \frac{aL^P \left(m\mathcal{P}^P + \tau n \mathcal{P}^R \right)}{aF + \mathcal{P}^P + \tau \mathcal{P}^{-P}} + \frac{a \left(L^R - \tau \omega L^P \right) n \mathcal{P}^R}{aF + \mathcal{P}^R + \tau (n-1) \mathcal{P}^R},
$$

and

$$
U^P(\tau) = mN^P + nN_T^R = \frac{aL^P \left(m\mathcal{P}^P + \tau n \mathcal{P}^R \right)}{aF + \mathcal{P}^P + \tau \mathcal{P}^{-P}}.
$$

We see that that $\partial U^R(\tau)/\partial \tau < 0$ and $\partial U^S(\tau)/\partial \tau \leq 0$ when $aF < (m-1)\mathcal{P}^P(1 + m\mathcal{P}^P/(n\mathcal{P}^R))$. It also follows that $\partial U^R(\tau)/\partial \tau < \partial U^S(\tau)/\partial \tau$, i.e. a trade liberalization benefits the rich country more.

Finally, let us calculate trade intensity. The value of North-North trade is given by

$$
2(n-1) \left(p_N^R N_N^R + p_T^R N_T^R \right) n \mathcal{P}^R = 2(n-1) \left(L^R - \omega \tau L^P \frac{m\mathcal{P}^P}{m\mathcal{P}^P + \tau n \mathcal{P}^R} \right) \mathcal{P}^R.
$$

The value of South-South trade is

$$
2(m-1) p^P N^P m \mathcal{P}^P = 2(m-1) \frac{m\mathcal{P}^P}{m\mathcal{P}^P + \tau n \mathcal{P}^R} \omega L^P \mathcal{P}^P
$$

and the value of North-South trade is

$$
2mp^P N^P n \mathcal{P}^R = 2m \frac{n \tau \mathcal{P}^R}{m\mathcal{P}^P + \tau n \mathcal{P}^R} \omega L^P \mathcal{P}^P
$$

[26] Due to the symmetry of our set-up, the volume of bilateral trade is undetermined. One of the Northern countries could produce predominantly (or exclusively) goods that are consumed only in the North, while the other Northern country produces mainly (or exclusively) goods that are consumed worldwide. In that case, the first Northern country runs a trade surplus with the other Northern country and a trade deficit with both Southern countries taken together. Such trade imbalances cannot occur between the Southern countries, since each Southern country consumes all goods the other Southern country produce, meaning that the South-South trade flows are of the same magnitude in either direction. However, each Southern country may run a surplus with one of the Northern countries that is balanced by a deficit with the other Northern country. Notice further that all bilateral trade flows are equalized in a full trade equilibrium since all households in each country consume all goods that are produced worldwide.

This allows us to calculate trade intensity ϕ, the value of world trade relative to world GDP as

$$\phi = 2\frac{(n-1)\left(p_N^R N_N^R + p_T^R N_T^R\right) n\mathcal{P}^R + (m-1)p^P N^P m\mathcal{P}^P + mp^P N^P n\mathcal{P}^R}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}$$

which, using the above formulas, can be expressed as

$$\phi = 2\frac{m\omega L^P\mathcal{P}^P}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}\left(\frac{(m-1)\mathcal{P}^P + n\tau\mathcal{P}^R}{m\mathcal{P}^P + n\tau\mathcal{P}^R}\right) + 2\frac{(n-1)\left(L^R - \tau\omega L^P \frac{m\mathcal{P}^P}{m\mathcal{P}^P + \tau n\mathcal{P}^R}\right)\mathcal{P}^R}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}.$$

$$\phi = 2\frac{m\omega L^P\mathcal{P}^P}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}\left(\frac{(m-1)\mathcal{P}^P + n\tau\mathcal{P}^R}{m\mathcal{P}^P + n\tau\mathcal{P}^R}\right) - 2\frac{(n-1)\tau\omega L^P \frac{m\mathcal{P}^P}{m\mathcal{P}^P + \tau n\mathcal{P}^R}\mathcal{P}^R}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P} + 2\frac{(n-1)L^R\mathcal{P}^R}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}.$$

$$\phi = 2\frac{m\omega L^P\mathcal{P}^P}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}\frac{(m-1)\mathcal{P}^P + \tau\mathcal{P}^R}{m\mathcal{P}^P + n\tau\mathcal{P}^R} + 2\frac{(n-1)L^R\mathcal{P}^R}{nL^R\mathcal{P}^R + m\omega L^P\mathcal{P}^P}.$$

When $m = 1$ and $n = 1$ we get

$$\phi = 2\frac{\omega L^P\mathcal{P}^P}{L^R\mathcal{P}^R + \omega L^P\mathcal{P}^P}\frac{\tau\mathcal{P}^R}{\tau\mathcal{P}^R + \mathcal{P}^P}.$$

Unlike in the arbitrage equilibrium of the two-county case, trade intensity may decrease in τ. This is when a reduction in τ increases South-South and North-North trade more strongly than it reduces North-South trade.

E Equilibrium with general preferences

The arbitrage equilibrium. Here we state the full system of equations that characterize an arbitrage equilibrium with non-traded goods. *Households* choose consumption levels to maximize utility. This implies marginal rates of substitution

$$\frac{v'(c_R^R)}{v'(c_P^R)} = \frac{p_R^R}{p_P^R}, \qquad \frac{v'(c_R^P)}{v'(c_P^P)} = \frac{p_R^P}{p_P^P}, \qquad \frac{v'(c_R^R)}{v'(c_R^N)} = \frac{p_R^R}{p_R^N}.$$

Firms set prices to maximize profits. Firms that sell exclusively on the home market set the unconstrained monopoly price

$$p_R^N = \mu(c_R^N)\frac{1}{a}.$$

Exporting firms set prices to avoid arbitrage

$$p_P^R = \tau p_P^P, \qquad p_R^R = \tau p_R^P.$$

which leads to first-order conditions[27]

$$\tau \frac{p_P^P - \omega/a}{p_P^P} \left(-\frac{v'(c_P^R)}{v''(c_P^R)} \right) + \frac{p_P^P - \omega/a}{p_P^P} \left(-\frac{v'(c_P^P)}{v''(c_P^P)} \right) \frac{\mathcal{P}^P}{\mathcal{P}^R} = \tau c_P^R + c_P^P \frac{\mathcal{P}^P}{\mathcal{P}^R},$$

$$\frac{\tau p_R^P - 1/a}{\tau p_R^P} \left(-\frac{v'(c_R^R)}{v''(c_R^R)} \right) + \frac{p_R^P - \tau/a}{p_R^P} \left(-\frac{v'(c_R^P)}{v''(c_R^P)} \right) \frac{\mathcal{P}^P}{\mathcal{P}^R} = c_R^R + \tau c_R^P \frac{\mathcal{P}^P}{\mathcal{P}^R}.$$

The *resource constraints* are

$$L^P = N_P \left(F + \mathcal{P}^R \tau c_P^R/a + \mathcal{P}^P c_P^P/a \right),$$

$$L^R = N_R^T \left(F + \mathcal{P}^R c_R^R/a + \mathcal{P}^P \tau c_R^P/a \right) + N_R^N \left(F + \mathcal{P}^R c_R^N/a \right),$$

the *trade balance* condition is

$$p_R^P N_R^T \mathcal{P}^P c_R^P = p_P^R N_P \mathcal{P}^R c_P^R,$$

and the *zero-profit conditions* are

$$\mathcal{P}^P c_P^P \left(p_P^P - \omega/a \right) + \mathcal{P}^R c_P^R \left(p_P^R - \tau\omega/a \right) = \omega F.$$

$$\mathcal{P}^R c_R^R \left(p_R^R - 1/a \right) + \mathcal{P}^P c_R^P \left(p_R^P - \tau/a \right) = F,$$

$$\mathcal{P}^R c_R^N \left(p_R^N - 1/a \right) = F,$$

In sum, the arbitrage equilibrium has 14 equations in 14 unkowns: quantities (c_P^P, c_R^P, c_R^R, c_P^R, c_R^N), prices (p_P^P, p_R^P, p_R^R, p_P^R, p_R^N), firm measures (N_P, N_R^T, N_R^N), and the relative wage ω.

Full trade equilibria. As mentioned in the main text, a binding arbitrage constraint is a neccessary though not sufficient condition for an arbitrage equilibrium with non-traded goods since consumers can now respond also along the intensive margin. There are three types of full trade equilibria: (i) both P- and R-firms are price-constrained; (ii) P-firms are price-constrained while R-firms set the monopoly price; and (iii) firms in both countries set the monopoly price.[28]

ad (i). When both firms are price-constrained but all goods are traded, all equations are identical except that $N_R^N = c_R^N = 0$ and p_R^N do not exist. The system reduces to 11 equations.

ad (ii). When P-firms are price constrained but R-firms are not, we have $p_R^R = \mu(c_R^R)/a$

[27] These conditions derive from maximizing the profit functions for country-P and country-R producers, i.e. $\mathcal{P}^P c_P^P \left(p_P^P - \omega/a \right) + \mathcal{P}^R c_P^R \left(p_P^R - \tau\omega/a \right)$ and $\mathcal{P}^R c_R^R \left(p_R^R - 1/a \right) + \mathcal{P}^P c_R^P \left(p_R^P - \tau/a \right)$, subject to the above arbitrage constraints. Moreover, we use the fact that households' demand functions derive from $v(c) = \lambda p$ which implies $\partial c/\partial p = (1/p) v'(c)/v''(c)$.

[28] Notice that the (unconstrained) price gap of country-P firms between market P and market R is higher than the corresponding price gap for country-R firms. This is because country-P firms have low (high) costs and low (high) demand on the home (foreign) market. This is different from the situation of country-R firms. They have high (low) costs and low (high) demand on the foreign (home) market. This implies that country-P firms get price-constrained first, and an equilibrium, where country-R firms are price-constrained - but country-P firms are not - cannot exist.

and $p_R^P = \mu(c_R^P)\tau/a$ while p_P^R and p_P^P are still determined as above.

ad (iii). When firms in both countries are unconstrained, also P-firms set the monopoly price $p_P^P = \mu(c_P^P)\omega/a$ and $p_P^R = \mu(c_P^R)\omega\tau/a$.

F Proof of Proposition 7

We determine the autarky equilibrium and ask under which conditions an entrepreneur has incentives to sell his products abroad. Setting $W = 1$, optimal monopolistic pricing implies $p = \mu(c)/a$. With free entry, profits $\mathcal{P}^R(p_a^R - 1/a)c_a^R$ must equal set up costs F

$$aF/\mathcal{P}^R = \left(\mu(c_a^R) - 1\right) c_a^R$$

The equilibrium is symmetric for all firms, hence the resource constraint reads

$$L^R = N_a^R \left(F + \mathcal{P}^R c_a^R/a\right)$$

Solving for c_a^R and N_a^R, we see that c_a^R does not depend on L^R. Hence when the two countries differ only in L^i but have equal populations, intensive consumption levels under autarky are identical between the two countries, $c_a^R = c_a^P$. Selling one marginal unit abroad at price $v'(0)/\lambda_a^P$, allows the purchase of $v'(0)/(\lambda_a^P p_a^P)$ foreign goods. Since $\lambda_a^P = v'(c_a^P)/p_a^P$ and $c_a^R = c_a^P$ this is equal to $v'(0)/v'(c_a^R) > 1$. Reselling this (new) product at home, yields a price $v'(0)p_a^R/v'(c_a^R)$ minus trade costs. Hence, this strategy is profitable if $\left[v'(0)p_a^R/v'(c_a^R)\right] \cdot \left[v'(0)/v'(c_a^R)\right] > \tau^2$. Expressing p_a^R in terms of c_a^R, we get the condition of the Proposition.

Table 1: Extensive margin of U.S. exports, 2007

	(1) All HS6	(2) All HS6	(3) Pop>1m HS6	(4) All HS4	(5) All HS2
Mean dependent variable	0.391	0.391	0.399	0.576	0.731
Log importer GDP	0.064***	0.070***	0.089***	0.076***	0.061***
	(0.011)	(0.010)	(0.010)	(0.011)	(0.009)
Log importer GDP per capita	0.085***				
	(0.014)				
Per capita income USD 385–999		-0.265***	-0.205***	-0.270***	-0.178***
		(0.064)	(0.066)	(0.067)	(0.065)
Per capita income USD 1,000–1,999		-0.262***	-0.226***	-0.249***	-0.145**
		(0.067)	(0.068)	(0.071)	(0.060)
Per capita income USD 2,000–3,999		-0.237***	-0.233***	-0.232***	-0.163***
		(0.065)	(0.063)	(0.066)	(0.049)
Per capita income USD 4,000–7,999		-0.116*	-0.146**	-0.076	-0.035
		(0.069)	(0.066)	(0.068)	(0.047)
Per capita income USD 8,000–15,999		-0.128*	-0.149**	-0.104	-0.089*
		(0.068)	(0.064)	(0.067)	(0.051)
Per capita income USD 16,000–31,999		-0.034	-0.030	-0.017	-0.008
		(0.064)	(0.061)	(0.060)	(0.041)
Per capita income USD 32,000–		ref	ref	ref	ref
Trade cost indicators	Yes	Yes	Yes	Yes	Yes
HS fixed effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.424	0.423	0.442	0.431	0.417
N	169,020	169,020	147,736	42,255	9,045

Notes: Estimates based on a linear probability model, *, **, *** denotes statistical significance at the 10%, 5%, 1% level, respectively. Standard errors are clustered on importer level. Year is 2007. Omitted category of income per capita groups is above USD 32,000. Trade cost indicators include log of distance between exporter's and importer's capital, dummy for a common border, dummy for importer being an island, dummy for importer being landlocked, dummy for importer and exporter ever having had colonial ties, dummy for currency union between importer and exporter, dummy for importer and exporter sharing a common legal system, dummy for religious similarity, dummy for importer and exporter having a free trade agreement, and dummy for importer and exporter sharing a common language.

Table A.1: Extensive margin of exports of the 14 largest consumer-goods exporters, 2007

	(1)	(2)	(3)	(4)
	All	Pop>1m	All	All
	HS6	HS6	HS4	HS2
Mean dependent variable	0.226	0.240	0.362	0.540
Log importer GDP	0.048***	0.055***	0.062***	0.063***
	(0.005)	(0.007)	(0.006)	(0.006)
Log importer GDP per capita	0.047***	0.048***	0.057***	0.051***
	(0.008)	(0.011)	(0.011)	(0.012)
Trade cost indicators	Yes	Yes	Yes	Yes
HS fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.355	0.365	0.407	0.465
N	1,978,095	1,726,513	508,082	109,590

Notes: Sample is based on exports from countries with consumer goods exports larger than 50 billion USD in 2007: China, Germany, USA, France, Japan, Italy, UK, Spain, Netherlands, Belgium-Luxembourg, Canada, Mexiko, Switzerland, Korea. Estimates based on a linear probability model, *, **, *** denotes statistical significance at the 10%, 5%, 1% level, respectively. Standard errors in paranthesis are clustered on importer level; standard errors in brackets are clustered on the importer-exporter pair level. Sample includes all potential export flows to countries with GDP per capita lower than the exporter under consideration. Year is 2007.

Table A.2: Extensive margin of U.S. exports, 1997-2007

Year	Mean of dep. var.	log importer GDP per capita		log importer GDP		Adj R^2	N
		coeff.	std.dev.	coeff.	std.dev.		
1997	0.389	0.103***	(0.016)	0.078***	(0.011)	0.452	173,031
1998	0.387	0.102***	(0.016)	0.075***	(0.011)	0.445	172,894
1999	0.384	0.099***	(0.014)	0.075***	(0.011)	0.440	175,140
2000	0.386	0.094***	(0.014)	0.074***	(0.011)	0.430	176,400
2001	0.382	0.093***	(0.015)	0.074***	(0.011)	0.430	173,880
2002	0.373	0.087***	(0.015)	0.074***	(0.011)	0.419	173,466
2003	0.375	0.090***	(0.014)	0.071***	(0.010)	0.420	173,742
2004	0.378	0.091***	(0.014)	0.070***	(0.010)	0.423	173,466
2005	0.391	0.091***	(0.014)	0.069***	(0.010)	0.424	173,052
2006	0.396	0.092***	(0.013)	0.067***	(0.010)	0.430	172,914
2007	0.391	0.085***	(0.014)	0.064***	(0.011)	0.424	169,020

Notes: Estimates based on the same specification as in Table 2, column 2 above. Number of observations vary over time because the number of countries poorer than the US and the number of HS6 consumer goods categories exported by US firms may change over time. Estimates are from a linear probability model, *, **, *** denote statistical significance at the 10%, 5%, 1% level, respectively. Controls are the same as in Table 1. Standard errors are clustered on importer level.

Table A.3: Extensive margin of exports of the 14 largest consumer-goods exporters, 2007

Country	Mean of dep. var.	log importer GDP per capita		log importer GDP		Adj R^2	N
		coeff.	std.dev.	coeff.	std.dev.		
Belgium-Lux.	0.197	0.039***	(0.011)	0.034***	(0.007)	0.414	155,067
Canada	0.126	0.042***	(0.008)	0.033***	(0.005)	0.263	154,800
China	0.370	0.060**	(0.026)	0.068***	(0.012)	0.428	93,525
France	0.289	0.071***	(0.015)	0.045***	(0.009)	0.375	146,674
Germany	0.286	0.058***	(0.013)	0.059***	(0.007)	0.440	149,160
Italy	0.283	0.059***	(0.012)	0.056***	(0.008)	0.430	145,314
Japan	0.129	0.026***	(0.008)	0.045***	(0.006)	0.360	140,301
Korea Rp (South)	0.111	0.022***	(0.007)	0.043***	(0.005)	0.297	121,608
Mexico	0.056	0.010*	(0.006)	0.010***	(0.003)	0.246	101,282
Netherlands	0.228	0.052***	(0.012)	0.038***	(0.007)	0.421	153,846
Spain	0.238	0.061***	(0.012)	0.046***	(0.007)	0.397	148,346
Switzerland	0.176	0.045***	(0.009)	0.046***	(0.005)	0.401	147,506
United Kingdom	0.247	0.051***	(0.012)	0.060***	(0.007)	0.398	151,646
USA	0.391	0.085***	(0.014)	0.064***	(0.011)	0.424	169,020

Notes: Includes countries with consumer goods exports larger than 50 billion USD in 2007. Estimates are based on a linear probability model, specification is identical to the one in Table 2, column 2. *, **, *** denote statistical significance at the 10%, 5%, 1% level, respectively. Standard errors in paranthesis are clustered on importer level. Only potential exports flows to countries with GDP per capita lower than the exporter under consideration are included in the sample. Controls are the same as in Table 1. Year is 2007.

Figure 1: Demand function

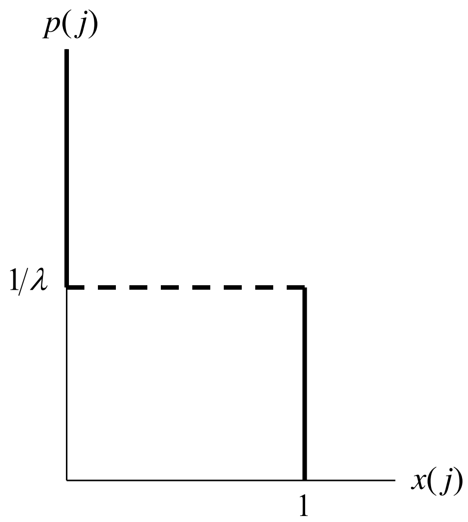


Figure 2: Full trade and arbitrage equilibrium

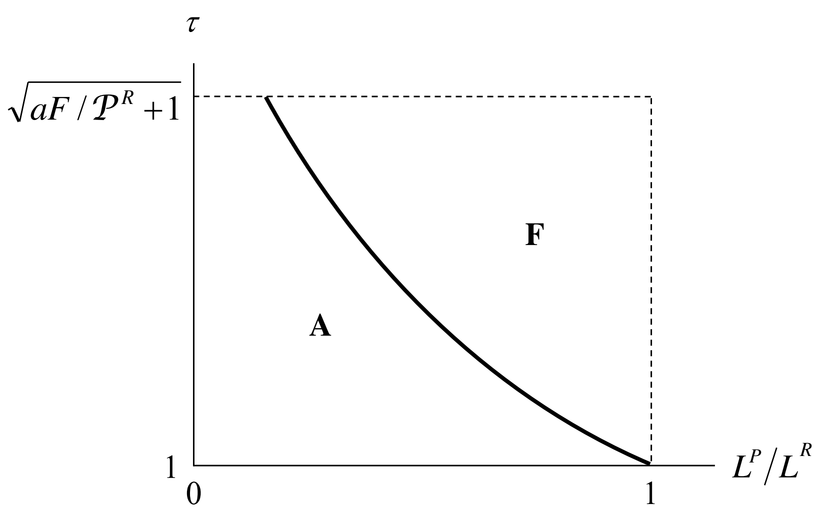
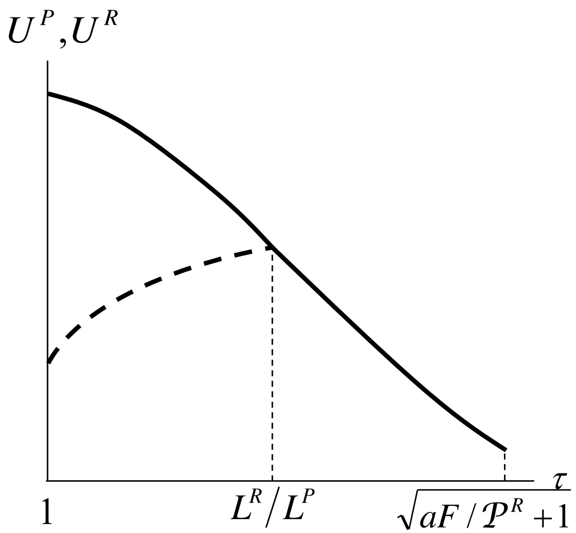
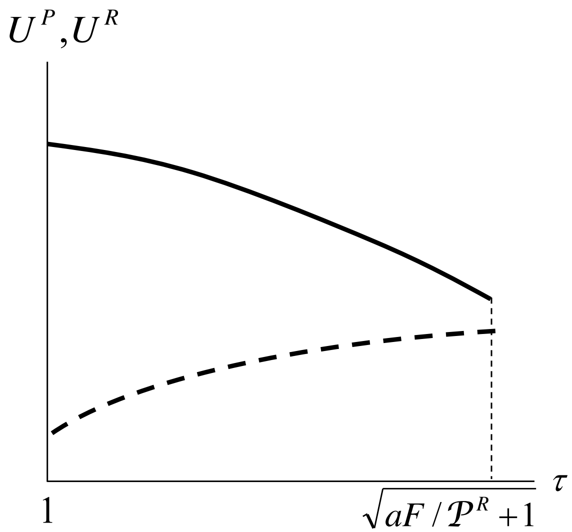


Figure 3: Welfare and trade costs

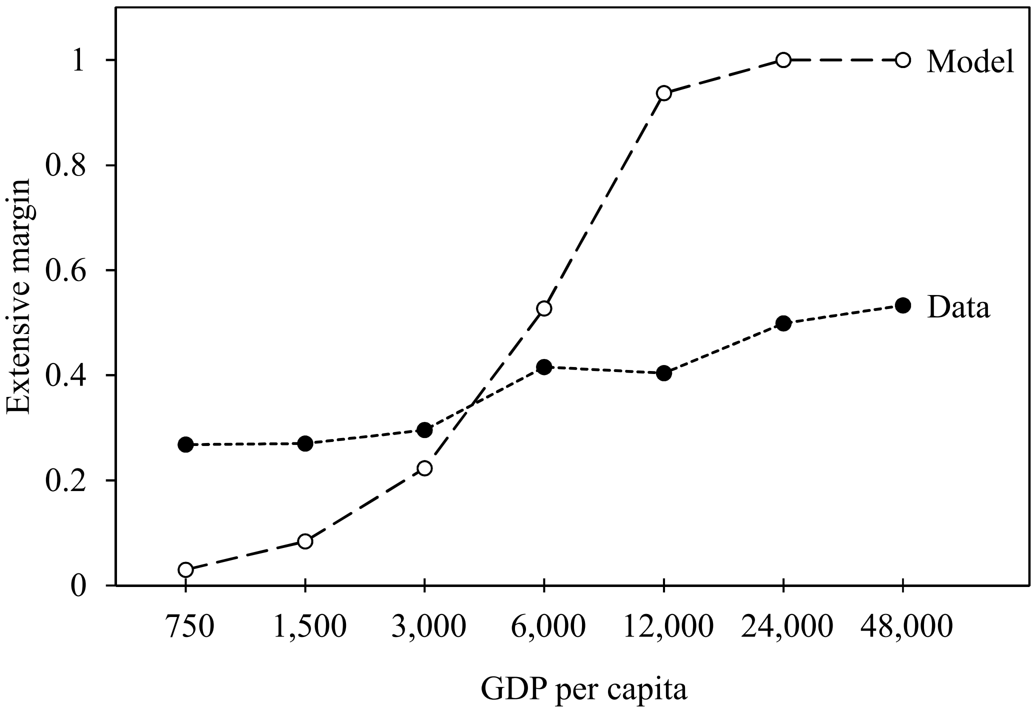


(a)



(b)

Figure 4: Calibration



Note: The figure depicts the export probability on the vertical axis and the destinations per capita income on the horizontal axis. The graph "Data" is based on the regression of Table 1, column 2. It depicts the estimated export probabilities based on the coefficients of the per-capita income dummies and sets control variables to the mean of countries with per capita income lower than USD 8,000. Per capita income levels 750, 1,500, 3,000, 6,000, 12,000, 24,000, and 48,000 refer to (class means of) per capita income categories 385-999, 1,000-1,999, 2,000-3,999, 4,000-7,999, 8,000-15,999, 16,000-31,999, and 32,000+, respectively. The graph "Model" reports the predictions of our theoretical model, based on the calibration procedure described in the main text.