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ABSTRACT

We develop a general equilibrium model of monopolistic competition and trade based on indirectly additive preferences and heterogenous firms. It generates markups independent from destination population but increasing in destination per capita income, as documented empirically. Trade liberalization delivers an increase in consumed variety and incomplete cost pass-through. This leads to welfare gains that can be much lower than those predicted by comparable models with different preferences. We introduce a tractable utility function that further predicts that small firms grow more during trade liberalization and pass through cost changes more than do large firms. Once we estimate the model to match moments from cross-firm and cross-country data we (i) find quantitatively large differences in the welfare gains from trade relative to models based on homothetic preferences, and (ii) evaluate the gains and losses from the Transatlantic Trade and Investment Partnership agreement.

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1 Introduction

Gains from intra-industry trade derive largely from the consumption of new and cheaper imported varieties (Broda and Weinstein, 2006). These gains have been the focus of international trade theory at least since Krugman (1980) and the subsequent large literature based on CES preferences. Summarizing this literature, Arkolakis *et al.* (2012, ACR) have shown that: i) the gains from trade liberalization can be simply captured by a formula featuring only the change in the domestic expenditure share and a "trade elasticity", namely the elasticity of the relative imports with respect to variable trade costs; ii) for heterogeneous firm models with an untruncated Pareto distribution of productivities (including the celebrated Melitz-Chaney model: see Melitz, 2003 and Chaney, 2008), the trade elasticity depends only on the shape parameter of the productivity distribution. Arkolakis *et al.* (2015, ACDR) have proved that the same welfare formula applies to general homothetic preferences, noticing that in this case liberalization does not produce gains from variety (see also Feenstra, 2014). Finally, ACDR have shown that the welfare gains from trade are only marginally smaller in comparable models based on the class of directly additive preferences (*à la* Dixit and Stiglitz, 1977). These surprising results appear to suggest that not only the supply side dimensions, but also consumer preferences, have a limited role in shaping the gains from trade.

We reconsider the role of preferences in affecting trade and its gains. We introduce to the international trade literature a class of preferences which generates variable demand elasticities (encompassing models with isoelastic, linear and more general demand functions) and show that they are crucial in shaping pricing, trade patterns and the gains from trade. Our preferences are indirectly additive (IA), which means that they are represented by an indirect utility which is additive in prices (Houthakker, 1960). The class includes CES preferences as the only case in common with the classes of directly additive and homothetic preferences. In addition, it contains an entire family of well-behaved non-homothetic preferences with the unique property that the elasticity of demand for each good depends on its own price and on income, but not on other prices (Bertoletti and Etro, 2016a,b). Such IA preferences are represented by the following indirect utility:

$$V = \int_{\Omega} v\left(\frac{p(\omega)}{E}\right) d\omega,$$

where Ω is the variety space and the subutility v for each variety ω is decreasing in the ratio between its price $p(\omega)$ and income E. Our assumptions on the supply side are standard. Each variety is produced by a firm after paying an entry cost with a productivity drawn from a known distribution. Monopolistic competition reigns.

We initially analyze the equilibrium in autarky for general IA preferences and cost distributions. Firms adopt markups that can be variable in their marginal cost and in the income of consumers, but that are always independent of the size of the market. Therefore, opening up to costless trade induces gains from variety that are qualitatively *à la* Krugman (1980). However, except for the CES case, the equilibrium is inefficient: too many goods are consumed (relative to the mass of created goods) and low-cost firms produce too little. In the case of costly trade between identical countries, firms set lower markups for exports and selection effects *à la* Melitz (2003) arise as long as production involves fixed costs.

To make headway in a multi-country framework with costly trade, we abstract from overhead production costs as in Melitz and Ottaviano (2008) and ACDR, and we adopt a Pareto distribution of productivity. Our model predicts that firms extract higher mark-ups from richer destinations, but that they do not set different mark-ups in countries of different population size. These predictions are in line with the empirical results obtained by Simonovska (2015) from cross-country price data of identical products sold via the Internet. In particular, controlling for the cost to deliver products to a destination, the author finds that a typical monopolistically-competitive apparel producer charges higher prices for identical goods in richer destinations, but she does not find evidence that prices vary with the population size of the market. Dingel (2015) obtains similar results using data on unit values for individual US producers across many destinations. We confirm these findings using prices for 110 products with identical characteristics sold in retail locations in 71 countries. Notice that traditional models of monopolistic competition cannot account for prices increasing in destination income when they are based on quasilinear preferences (Melitz and Ottaviano, 2008) or homothetic preferences (Feenstra, 2014), and generate prices that are decreasing in destination population when they are based on directly additive or homothetic preferences (for instance, see Behrens *et al.*, 2014, Simonovska, 2015, and ACDR).[1]

The model generates further firm-level predictions that are consistent with data. First, more productive firms enjoy higher mark-ups, in line with the evidence in De Loecker and Warzynski (2012). Second, when trade costs are large, exporters are more productive and represent a minority of the active firms, as documented in Bernard *et al.* (2003), yet they may sell tiny amounts per export market, as documented in Eaton *et al.* (2011). New implications emerge for the margins of trade. The extensive margin is increasing in destination per-capita income, neutral in destination population, and falling in the trade cost to the destination. Hence, the model predicts that the extensive margin is falling in the distance to the destination (to the

[1]Our theoretical results are also in line with empirical findings by Handbury and Weinstein (2014) for U.S. cities. Identifying varieties with barcode data, and controlling for all retail heterogeneity and purchasers' characteristics, the authors provide convincing evidence that larger cities do not feature different prices of individual varieties, but have more varieties available, which yields lower price indices there. Using the same data source, Broda *et al.* (2009) document that richer consumers pay more for identical products even after controlling for average income in the zip code in which they live, where the latter aims to capture local costs to operate the store.

extent that trade costs are increasing in distance) and potentially rising in overall GDP of the destination country (the product of per-capita income and population), which is in line with Bernard *et al.* (2007) who document that the US extensive margin is falling in the distance to the destination and rising in the destination's GDP.[2] Finally, the intensive margin of trade is increasing in a destination's overall GDP and decreasing in the destination's per-capita income, which is in line with exploratory findings by Eaton *et al.* (2011) for several exporting countries across their export destinations.

As in Melitz (2003) and Melitz and Ottaviano (2008), trade liberalization reallocates production across exporting and non-exporting firms and across countries. A qualitative difference is that trade liberalization expands the set of exporters but does not affect the set of domestic producers (unless fixed costs are introduced).[3] Consumers exploit the reductions in the price of imports by expanding the number of imported varieties and consuming the same set of domestic goods (but in lower amounts). We obtain an exact quantitative measure of the welfare gains from trade liberalization for the IA class. Its approximation (valid for small trade cost changes) is:

$$d\ln W = -(1-\bar{\epsilon}^E)\frac{d\ln\lambda}{\kappa},$$

where $\bar{\epsilon}^E \in (0,1)$ is a sales-weighted average across firms of the elasticity of price with respect to per-capita income, κ is the shape of the Pareto distribution of productivity, which can be interpreted as the trade elasticity, and λ is the share of domestic expenditure. For reference, recall that the gains calculated by ACR and ACDR for a variety of models based on homothetic preferences are given by $d\ln W = -\frac{d\ln\lambda}{\kappa}$.[4] The differences between the two classes of models are very stark. Not only do IA models yield strictly lower welfare gains than homothetic ones, but the magnitude of the difference falls within a very wide range. In fact, the more firms price

[2]The evidence on the relationship between the extensive margin and the components of destination GDP, per-capita income and population size, is mixed. Hummels and Klenow (2002) find that the number of product categories is increasing with respect to the importer's per-capita income with a larger elasticity than with respect to its population across a large number of exporting countries. Recently, Macedoni (2015) confirms these predictions using firm- and product-level data for a number of exporting countries featured in the Exporter Dynamics Database. When the author focuses on large firms that sell their products online, he finds that firms offer more varieties in richer destinations, but not in larger countries. The different findings in the literature point to the heterogeneity in fixed costs across countries, industries, and modes of operation (brick-and-mortar versus electronic sales). Our baseline theory abstracts from fixed costs of production, but the extension *à la* Melitz described in Section 2.2 would restore the standard role that destination size plays in driving export market entry patterns, without affecting the model's desirable pricing predictions.

[3]It should be noted that the selection effects of Melitz and Ottaviano (2008) and ACDR are not due to a supply-side increase of competition (they cannot be due to strategic interactions in models with a continuum of competitors). Namely, domestic firms exit during a liberalization because there is a demand-side change of substitutability among goods which reduces the domestic choke price: see Bertoletti and Epifani (2014) and Bertoletti and Etro (2016b) for a discussion.

[4]ACDR also consider directly additive preferences and obtain gains that are marginally smaller than the case of homothetic preferences: their lower bound is given by $d\ln W = -\frac{d\ln\lambda}{\kappa+1}$.

to market (the less elastic is demand) the lower are the welfare gains from trade liberalization because a smaller portion of the cost reduction is translated into lower prices for the consumers. Thus, preferences, which govern the degree to which firms can price to market in monopolistic competition models, are critical in understanding the magnitude of the welfare gains from trade.

To obtain further predictions and to quantify the welfare gains from trade liberalization, we introduce a convenient "addilog" specification of preferences, with $v(s) = \frac{(a-s)^{1+\gamma}}{1+\gamma}$, where a represents the maximum willingness to pay for each variety in terms of its normalized price $s = p/E$, and the parameter $\gamma > 0$ governs demand, which is perfectly rigid for $\gamma \to 0$, linear in prices for $\gamma = 1$ and perfectly elastic for $\gamma \to \infty$. This yields closed form solutions of firm-level and aggregate variables as well as the welfare gains, and delivers two additional predictions in line with the data. First, trade liberalization increases sales more for smaller firms, as documented by Eaton *et al.* (2008) and Arkolakis (2015). Together with the fact that trade liberalization induces entry of foreign varieties, this implies that adjustments on the extensive margin (changes to new and least traded varieties) are critical in understanding the welfare gains from trade (as argued by Broda and Weinstein, 2006, and Kehoe and Ruhl, 2013). Second, the degree of cost pass-through is falling in firm productivity, as documented by Berman *et al.* (2014). This implies that larger firms change prices less with changes in costs and more with changes in income, and it is precisely this behavior that directly impacts the measured welfare gains in the formula above.

We estimate the addilog model and directly compare the welfare cost of autarky predicted by the ACR framework based on CES preferences and our framework with IA preferences. In particular, we obtain data on λ for 123 countries in year 2004 and fix the supply-side (trade elasticity) parameter κ to 5 - in line with ACR, ACDR and estimates in Caliendo and Parro (2015). An estimate for $\bar{\epsilon}^E$, the sales-weighted average elasticity of price with respect to per-capita income, is not readily available, but the addilog specification implies that the sales-weighted average elasticity of price with respect to income is a constant that depends on the supply-side parameter κ and the demand-side parameter γ. Therefore, given κ, we identify γ from the following two moments: (i) the average elasticity of price with respect to income from micro-level data, as reported in Simonovska (2015); and (ii) the domestic sales advantage of exporters over non-exporters for the US, as reported in Bernard *et al.* (2003). We choose these moments for the following reasons. First, our model differs from existing alternatives precisely along the pricing dimension, therefore, targeting the price elasticity with respect to income seems to be a natural choice. Second, it is the price elasticity with respect to income, weighted by each firm's relative sales, that constitutes $\bar{\epsilon}^E$ - the object that governs the welfare gains in our model. Therefore, the distribution of firm sales and the price elasticity with respect to income are crucial elements in determining the magnitude of the welfare gains from trade.

We follow Eaton *et al.* (2011) and we estimate all the parameters that are necessary in order to simulate micro- and macro-level predictions from bilateral trade data for 123 countries via the gravity equation that holds for a large class of models, including ours, and, conditional on these parameters as well as on κ, we pin down γ using the simulated method of moments (SMM) estimator. This strategy obtains a value for $\gamma \approx 1$, which implies that, when $\kappa = 5$, the IA specification that best fits the data is approximately the case of linear demand. Using the welfare formula that is applicable for large changes in trade costs in the IA model, the mean welfare cost of moving from the trade equilibrium in year 2004 to autarky is 6%. The corresponding statistic for the ACR class of models based on CES preferences is 14%, which is more than double that of IA.[5] Hence, the mismeasurement of welfare is both quantitatively and economically large, which leads us to conclude that the demand side is crucial in understanding the welfare gains from trade.

Given the unique set of predictions that our theoretical framework yields and the novelty of the parametric preference specification to the international trade literature, we engage in an additional quantitative exercise that aims to test the ability of the model to account for micro- and macro-level facts in the data. In particular, rather than imposing restrictions on the model's parameters, κ and γ, we estimate both via SMM targeting the moments (i) and (ii) above as well as (iii) the measured productivity advantage of exporters over non-exporters for the US, as reported in Bernard *et al.* (2003). On the micro-level, the estimated model predicts that 16% of US manufacturing firms export, which compares favorably to the 18-21% statistic reported by Bernard *et al.* (2003) and Bernard *et al.* (2012) from U.S. data over the past couple of decades, and the export intensity is highly concentrated suggesting that firms export very tiny amounts. On the macro-level, the model yields an average mark-up among U.S. manufacturing firms of 19%, which falls within the middle of the range of 5-40% reported by Jaimovich and Floetotto (2008). Mean cost pass-through amounts to 0.57, which is in the range of estimates obtained by De Loecker *et al.* (2015) and others. The average elasticity of price with respect to per-capita income amounts to 0.43, while the average plus one standard deviation is 0.51; hence, more productive firms price to market more, though these values exceed estimates in the literature.

Given the model's favorable quantitative performance with respect to data, we use it to evaluate the welfare gains from a bilateral reduction in trade costs between the US and the European countries that are currently involved in the negotiation of the Transatlantic Trade and Investment Partnership. We find an average gain in welfare of 0.3% to the potential

[5] To relate our finding to ACR's, consider their reported US domestic expenditure share of 0.93 and their preferred value for κ of 5. In this case, the welfare cost of autarky for the US is 1.4% according to the CES model and 0.6% according to the (IA) linear demand model.

members, with the US enjoying roughly 0.7% GDP increase and small open economies like Ireland and Belgium (together with Luxembourg and the Netherlands) enjoying roughly 2% and 0.8% income improvement, respectively. While non-TTIP members, and especially USA's major trade parters Canada and Mexico, suffer losses, there are positive gains in world welfare.

The remainder of the paper proceeds as follows. In Section 2, we present the general theory. In Section 3, we study trade between heterogenous countries. In Section 4, we describe the estimation procedure. In Section 5, we present the quantitative results. We conclude in Section 6.

2 The Framework

Consider a market populated by L identical agents, each one with labor endowment e. Firms can produce a good from a set Ω at a constant marginal cost after paying a sunk entry cost $F_e > 0$. Upon entry, the "intrinsic" marginal cost c of each firm is independently and identically drawn from a distribution $G(c)$ with support $[0, \overline{c}]$ for a large, and possibly infinite, $\overline{c} > 0$. All costs are in (efficiency) units of labor and the labor market is perfectly competitive: in this section we normalize the wage to unity so that c is marginal cost and, given zero expected profits, *per capita* income E just equals the labor endowment.

The indirect utility of each agent depends (exploiting homogeneity of degree zero) on the normalized prices $s(\omega) = p(\omega)/E$, for $\omega \in \Omega$, according to the following additive specification:

$$V = \int_{\Omega} v(s(\omega))d\omega, \tag{1}$$

where v is a decreasing and convex function up to a (possibly infinite) choke value $a \equiv v^{-1}(0)$, so that aE is the maximum willingness to pay for each variety, with $v(s) = 0$ for all $s \geq a$. With the exception of CES preferences that it encompasses (with an infinite choke price), (1) represents a class of preferences that are neither homothetic nor directly additive (see Bertoletti and Etro, 2016a). By Roy identity, the individual demand for each variety ω that is actually consumed is given by:

$$x(\omega) = \frac{v'(s(\omega))}{\mu}, \tag{2}$$

where $\mu = \int_{\Omega} v'(s(\omega))s(\omega)d\omega = -E(\partial V/\partial E)$ is simply related to the marginal utility of income, and thus depends on all prices and on the measure of consumed varieties. Accordingly, demand faced by a producer of variety ω is decreasing in its own price $p(\omega)$ and vanishes if this is above the choke level:

$$\widehat{p} = aE, \tag{3}$$

which depends linearly on income.[6]

2.1 Autarkic equilibrium

Let N be the measure of firms paying the entry cost: we analyze monopolistic competition among a measure n of active firms producing different varieties for a given distribution of costs. The profits of a firm with marginal cost c choosing a price $p(c)$ can then be written as:

$$\pi(c) = \frac{(p(c) - c)v'\left(\frac{p(c)}{E}\right)L}{\mu}, \tag{4}$$

where μ is unaffected by a single firm which faces a demand whose elasticity is just the elasticity of $v'(s)$, namely $\theta(s) \equiv -sv''(s)/v'(s)$. The optimal pricing rule is:

$$p(c) = c\left(\frac{\theta\left(p(c)/E\right)}{\theta\left(p(c)/E\right) - 1}\right), \tag{5}$$

for any $c > 0$. To satisfy the conditions for the existence of a well-defined optimal price $p(c)$, we assume that $\theta(s) > 1$ and that the second-order condition $2\theta(s) > \zeta(s)$, where $\zeta(s) \equiv -v'''(s)s/v''(s)$ is a measure of demand curvature, is satisfied for all $s \in (b, a)$ where $b \equiv p(0)/E$. The markup of each firm, $m(c) = (p(c) - c)/c$, is independent from the number of goods available and from the price of any other firm. However, it is immediate to verify that the markup increases in income and decreases in the marginal cost *whenever* the demand elasticity is increasing (Bertoletti and Etro, 2016a).

Let us actually assume $\theta' \geq 0$,[7] which is equivalent to what Mrázová and Neary (2013) define as "subconvexity" of the demand function, and it is sometimes called "Marshall's Second Law of Demand". When demand elasticity is strictly increasing, the model has four main implications for pricing. First, prices are lower but markups are higher for more productive firms, which differs from the Melitz (2003) model. Second, markups increase with the income of consumers: this effect is absent in any model based on homothetic preferences (Melitz, 2003; Feenstra, 2014) or quasilinear preferences (Melitz and Ottaviano, 2008). Third, and differently from models based on directly additive preferences (Behrens *et al.*, 2014; Bertoletti and Epifani, 2014 and Simonovska, 2015) or quasilinear utility (Melitz and Ottaviano, 2008), markups are also independent from market size. Fourth, it is easy to verify that the elasticities of prices

[6] The dependence of the choke price on income alone is a key property of IA. In other models based on homothetic or directly additive preferences, the choke price depends on the marginal utility of income, i.e., on the price distribution and on the measure of consumed varieties (see Feenstra, 2014, and ACDR). While the marginal utility of income is unitary in the quasilinear model of Melitz and Ottaviano (2008), the choke price depends on the number of varieties and on their average price.

[7] This implies $\theta' s/\theta = \theta + 1 - \zeta \geq 0$ (see Bertoletti and Etro, 2016a, for details).

with respect to income and marginal cost sum to one:

$$\epsilon^E(c) \equiv \frac{\partial \ln p}{\partial \ln E} = \frac{\theta + 1 - \zeta}{2\theta - \zeta} = 1 - \frac{\partial \ln p}{\partial \ln c} \equiv 1 - \epsilon^c(c) \in (0,1)\,, \tag{6}$$

which shows the *inverse* relation between pricing to market and incomplete pass-through.

The individual consumption of the variety produced by a c-firm is either $x(c) = v'(p(c)/E)/\mu$, or zero if its price if above the choke level $\widehat{p}$. The equilibrium set of active firms is simply given by the interval $[0, \widehat{c}]$, where the marginal cost cutoff:

$$\widehat{c} = aE \tag{7}$$

is just the choke price.[8] The model is closed equating the expected gross profits:

$$\mathbb{E}\left\{\pi(c)\right\} = \int_0^{\widehat{c}} \frac{(p(c) - c)v'(p(c)/E)L}{\mu} dG(c)$$

to the entry cost F_e. Since $\mu = N \int_0^{\widehat{c}} v'(s(c))s(c)dG(c)$, this gives:

$$N = \frac{EL}{\bar{\theta} F_e} \qquad \text{with } \overline{\theta} \equiv \left[\int_0^{\widehat{c}} \frac{1}{\theta(p(c)/E)} \frac{p(c)x(c)}{\int_0^{\widehat{c}} p(c)x(c)dG(c)} dG(c)\right]^{-1}, \tag{8}$$

where $\bar{\theta}$ is the harmonic average of demand elasticities weighted by the market shares. In particular, notice that the equilibrium distribution of normalized prices $F_s(s)$ has support $[b, a]$ and is given by:

$$\begin{aligned} F_s(s) &= \Pr\left\{p(c) \leq sE; c \leq \widehat{c}\right\} \\ &= \Pr\left\{c \leq h(s)E; c \leq \widehat{c}\right\} = \frac{G\left(h(s)E\right)}{G\left(aE\right)}, \end{aligned}$$

where $h = s\frac{\theta(s)-1}{\theta(s)}$ $(h' > 0)$. This allows us to express the average demand elasticity as:

$$\overline{\theta} = \left[\int_b^a \frac{1}{\theta(s)} \frac{sv'(s)}{\int_b^a sv'(s)dF_s(s)} dF_s(s)\right]^{-1}, \tag{9}$$

which is independent from the market size (but can depend on income). Accordingly, the measure of consumed varieties $n = NG(\widehat{c})$ must be linear in population.

The familiar case of CES preferences should clarify the nature of the equilibrium. Consider

[8]This assumes that the constraint $\widehat{c} \leq \overline{c}$ never binds.

$v(s) = s^{1-\theta}$ with $\theta > 1$, which delivers the *isoelastic demand* $x(\omega) = (\theta - 1)s(\omega)^{-\theta}/|\mu|$, or:[9]

$$x(\omega) = \frac{p(\omega)^{-\theta} E}{\int_\Omega p(\omega)^{1-\theta} d\omega}.$$

In this case there is no *finite* choke price, the equilibrium prices are $p(c) = \theta c/(\theta - 1)$ and $\bar{\theta} = \theta$. Therefore, the number of goods created is just $N = \frac{EL}{\theta F_e}$ and all these goods are consumed in positive quantity (since we have abstracted from fixed costs of production).

Consider now a new example with $v(s) = (a - s)^2/2$, which, as we will see in Sections 3.3 and 5, is not only tractable but also appealing from an empirical point of view. Notice that the subutility for variety ω is quadratic in $a - s(\omega)$, and the Roy identity (2) delivers a *linear demand* function $x(\omega) = (a - s(\omega))/|\mu|$, or:

$$x(\omega) = \frac{aE - p(\omega)}{\int_\Omega (aE - p(\omega))(p(\omega)/E) d\omega}.$$

The demand elasticity $\theta(s) = s/(a - s)$ is now increasing in the price-income ratio $s < a$. It is immediate to derive the optimal price as:

$$p(c) = \frac{c + aE}{2},$$

which is indeed increasing less than proportionally in income and in the marginal cost, and independent from population. The profits of an active c-firm ($c \leq \widehat{c}$) are then $\pi(c) = \frac{(ae-c)^2 L}{4e|\mu|}$. Further results can be obtained by assuming (as in Chaney, 2008, and the subsequent literature) that the cost distribution corresponds to a productivity distribution that is Pareto (unbounded above), namely $G(c) = (c/\overline{c})^\kappa$ with $\overline{c} > 0$ finite and $\kappa > 1$ as the shape parameter. The expected profits can then be computed as $\mathbb{E}\{\pi(c)\} = \frac{a^{\kappa+2} e^{\kappa+1} L}{2(\kappa+1)(\kappa+2)\overline{c}^\kappa |\mu|}$, and the free-entry condition provides the equilibrium value for $|\mu|$ and the average demand elasticity $\bar{\theta} = \kappa + 1$,[10] so that the measure of created firms is:

$$N = \frac{EL}{(\kappa + 1)F_e}.$$

It is important to notice that only a fraction $G(\widehat{c})$ of the firms are active in this case, namely $n = N(aE/\overline{c})^\kappa$.

The distinctive characteristic of IA preferences, namely the neutrality of population on prices, finds empirical support in markets with a large number of firms as in a monopolistic competition environment (see Handbury and Weinstein, 2014, Simonovska, 2015, Dingel, 2015

[9]The indirect utility can be expressed (up to a mononotic transformation) as $V = E\left[\int_\Omega p(\omega)^{1-\theta} d\omega\right]^{1/(\theta-1)}$.
[10]One can compute (9) by using the equilibrium distribution $F_s = \left(\frac{2s-a}{a}\right)^\kappa$.

and Section 5.2.1 below). As well known, a negative equilibrium relationship between market size and prices emerges on the contrary in existing (non-CES) models based on directly additive or homothetic preferences, and is often regarded as a pro-competitive effect. However, this relationship is not due to a strengthening of competition on the supply side, since strategic interactions are absent under monopolistic competition. It depends only on changes in substitutability between products on the demand side, whose nature and direction can be hardly verified empirically. While we consider the neutrality of population on prices an attractive feature of our setting, competition effects could be easily introduced by adding strategic interactions,[11] or demand externalities.[12]

2.2 Welfare and trade among identical countries

The impact of an expansion of the market size under IA replicates a key property of the Krugman (1980) model, for which a larger population (which is equivalent to opening up to costless trade with identical countries) increases proportionally the number of firms/varieties created in equilibrium without affecting markups. Since the range of created goods which are actually consumed and their prices are independent from population, this generates pure gains from variety due to opening up to costless trade. To see this, notice that welfare can be easily computed as follows:

$$V = n \int_0^{aE} v\left(\frac{p(c)}{E}\right) \frac{dG(c)}{G(aE)}. \tag{10}$$

This is linear in the measure of consumed varieties $n = G(aE)EL/\bar{\theta}F_e$, which in turn is linear in the population size. Therefore, costless trade leads to welfare gains that are due *only* to an increase of the mass of consumed varieties for any IA preferences and cost distribution.

With the notable exception of CES preferences, our setting implies an inefficient market allocation. To verify this, in Appendix A we solve the social planner problem for the maximization of utility under the resource constraint.[13] The optimal allocation delivers the following number of firms:

$$N^* = \frac{EL}{(\bar{\eta}+1)F_e} \qquad \text{with} \;\; \bar{\eta} \equiv \int_0^{\widehat{c}^*} \eta\left(s(c)\right) \frac{v(s(c))}{\int_0^{\widehat{c}^*} v\left(s(c)\right) dG(c)} dG(c), \tag{11}$$

[11] It is well known that markets with a small number of firms would exhibit equilibrium markups decreasing in the size of the market due to strategic interactions (which depend on the number of competitors). For recent trade models with strategic interactions see Atkeson and Burstein (2008) and Etro (2015).

[12] As a simple example, if the model choke price $a(n)$ is decreasing in the number of consumed varieties n, the latter solves as $n = NG(a(n)E)$ in a free entry equilibrium, which must increase less than proportionally in population: this implies that larger markets have lower prices and select a more efficient set of firms.

[13] Dhingra and Morrow (2015) and Nocco *et al.* (2014) have analyzed optimality in the cases of direct additivity of preferences and of quasilinearity, respectively.

where $\bar{\eta} > 0$ is a weighted average of the elasticity of the subutility function v, $\eta = -v'(s)s/v(s) > 0$, with relative utilities as weights, and is independent from L. This allows for equilibrium entry either above or below optimum ($\bar{\theta}$ should be compared to $\bar{\eta}+1$). More important, the social planner sets a constant mark up $m^* = 1/\bar{\eta}$, as needed to equalize the marginal rate of substitution between any two produced goods to their marginal cost ratio:

$$p^*(c) = \left(1 + \frac{1}{\bar{\eta}}\right) c. \tag{12}$$

Finally, the optimal marginal cost cutoff is smaller than the equilibrium one (when they are finite):

$$\hat{c}^* = \frac{aE\bar{\eta}}{1+\bar{\eta}} < \hat{c}. \tag{13}$$

It follows that the equilibrium prices must be above optimal for the most efficient firms and below optimal for the most inefficient firms.[14] Therefore, a redistribution of production from high cost to low cost firms would indeed improve the allocation of resources.

To gain further insights, our two examples can be useful. With CES preferences $\bar{\eta} = \theta - 1$ and the equilibrium is optimal (Dhingra and Morrow, 2014). Instead, for any other IA preferences with a finite choke price, we can derive a simple result assuming that the cost distribution corresponds to a productivity distribution that is Pareto: in such a case we have $\bar{\eta} = \kappa$ (see Appendix A). This shows an interesting property of our earlier example with linear demand: this (as its "addilog" generalization of Section 3.3) delivers in equilibrium the creation of the optimal number of firms. Nevertheless, a pervasive inefficiency remains: too many goods are consumed relative to the mass of firms created and low-cost firms produce too little while high-cost firms produce too much.

In conclusion we should notice that our framework can be easily extended to trade frictions between identical countries for any IA preferences, which indeed include the CES case of Melitz (2003). First, notice that identical countries must have the same wage and the same value of μ. Second, given an iceberg transport cost $\tau > 1$, the pricing rules are the same as before, with $p(c)$ given by (5) for domestic sales and $p(\tau c)$ for foreign sales, both independent from the market size. However, as long as $\theta' > 0$, each exporting firm applies a lower markup on exports compared to the markup on domestic sales. Moreover, as long as there are positive fixed costs of production, the model delivers an equilibrium partition of firms between exporters and non-exporters and selection effects of trade liberalization.[15] With empirical applications in mind, the next section develops a fully-fledged multicountry model.

[14] Indeed $p^*(0) = 0 \le p(0)$ and $p^*(\hat{c}^*) = \hat{c} > p(\hat{c}^*)$, and $p^{*\prime}(c) > 1 > p'(c)$ under the assumption that $\theta' > 0$.

[15] Assume that production in each market requires a fixed cost $F \ge 0$. The net profits from domestic sales are $\pi(c) - F$ and those from exports are $\pi(\tau c) - F$, where $\pi(c)$ is always given by (4). The cutoff cost for domestic

3 Trade among Heterogeneous Countries

From this section we consider costly trade between heterogeneous countries (with respect to the population size and per-capita labour endowment) assuming a cost distribution that corresponds to a productivity distribution that is Pareto, $G(c) = (c/\overline{c})^{\kappa}$, where $\overline{c}$ is now finite but large enough to exceed the relevant marginal cost cutoffs, and $\kappa > 1$ is the shape parameter of the distribution. The "iceberg" cost of exporting from country i (source) to country j (destination) is $\tau_{ij} \geq 1$, with $\tau_{ii} = 1$ for $i, j = 1, .., I$ where $I \geq 2$ is the number of countries. Country i has N_i firms paying the entry cost F_e, population L_i, wage w_i, marginal costs $\tau_{ij} w_i c$ in destination country j and *per-capita* labor endowment e_i, so zero expected profits imply that individual income is $E_i = w_i e_i$. For tractability, we neglect fixed costs of production (as in Melitz and Ottaviano, 2008 and ACDR), whose role is already well understood in the literature.

The gross profit function of a c-firm from country i selling to country j is:

$$\pi_{ij}(c) = \frac{\left(p_{ij}(c) - \tau_{ij} w_i c\right) v'\left(\frac{p_{ij}(c)}{E_j}\right) L_j}{\mu_j}, \tag{14}$$

where $|\mu_j|$ is as usual the marginal utility of income (times per capita income) of country j. Maximizing these profits delivers the price rule:

$$p_{ij}(c) = \tau_{ij} w_i c \left(\frac{\theta\left(p_{ij}(c)/E_j\right)}{\theta\left(p_{ij}(c)/E_j\right) - 1}\right). \tag{15}$$

This confirms that prices and markups are higher in countries that enjoy higher per-capita income levels, but they are independent of the population of the destination country. As noticed earlier, this prediction is supported by evidence at the international level. Moreover, since the markup in expression (15) is falling in the firm's intrinsic cost of production, c, the model predicts that more productive firms enjoy higher markups, which is in line with wide evidence, for instance with observations in Slovenian data documented by De Loecker and Warzynski (2012). As before, for any firm from country i selling in j, the elasticities of prices with respect to income, $\epsilon_{ij}^{E}(c) \equiv \partial \ln p_{ij}/\partial \ln E_j$, and to marginal cost, $\epsilon_{ij}^{c}(c) \equiv \partial \ln p_{ij}/\partial \ln c$, sum to 1.

The individual quantity sold by a c-firm of country i to destination j is given by $x_{ij}(c) =$

sales is $\widehat{c} = \pi^{-1}(F)$, and the cutoff for the marginal exporting firm is $\widehat{c}_x = \widehat{c}/\tau$. The free-entry condition:

$$\int_0^{\widehat{c}} \left[\pi(c) - F\right] dG(c) + \int_0^{\widehat{c}/\tau} \left[\pi(\tau c) - F\right] dG(c) = F_e$$

closes the model. As long as $F > 0$, one can easily obtain by total differentiation that $\partial \widehat{c}/\partial \tau > 0$. The intuition is simple: lower trade costs increase the expected profits of exporting firms at the expense of non-exporters, which implies that the domestic cut-off firm must now be more efficient (for a similar result with directly additive preferences see Bertoletti and Epifani, 2014).

$v'\left(p_{ij}(c)/E_j\right)/\left|\mu_j\right|$. The value of the corresponding sales $t_{ij}(c) = p_{ij}(c)x_{ij}(c)L_j$ is:

$$t_{ij}(c) = \frac{p_{ij}(c)v'\left(\frac{p_{ij}(c)}{E_j}\right)L_j}{\mu_j}.$$

The most inefficient firm in country i which is actually able to serve country j, has therefore the cutoff marginal cost:

$$\widehat{c}_{ij} = \frac{aE_j}{\tau_{ij}w_i}, \tag{16}$$

(remember that $a = v^{-1}(0)$) which simplifies to $\widehat{c}_{ii} = ae_i$ for the domestic sales of country i. Therefore, in our model the range of the firms active domestically is wider in the country with higher individual labor endowment, and depends neither on the population size (since there are no fixed costs) nor on the trade costs. Instead, the set of exporters from a country enlarges with per capita income of the importing country and shrinks with the trade cost and its domestic wage. A key consequence is that trade liberalization does not affect the range of the firms active at home but enlarges the set of exporters, and therefore the measure of imported varieties. However, like in other models, production is reallocated across firms toward exporters and across countries. If trade costs are sufficiently high, exporters are more productive than non-exporters and represent a minority of the active firms, as documented by Bernard *et al.* (2003), and they may sell tiny amounts per export market (in fact, the marginal exporter realizes zero sales), as documented in Eaton et al. (2011).

Defining $n_j^C \equiv \sum_{i=1}^{I} n_{ij}$ the measure of goods consumed in country j we have:

$$\mu_j = \sum_{i=1}^{I} n_{ij} \int_0^{\widehat{c}_{ij}} v'(s_{ij}(c))s_{ij}(c)\frac{dG(c)}{G\left(\widehat{c}_{ij}\right)} = n_j^C \int_b^a v'(s)sdF_s(s),$$

where $F_s(s)$ is the equilibrium distribution of normalized prices. This distribution has support $[b, a]$ and is equal across countries and independent from incomes and trade costs:

$$F_s(s) = \Pr\left\{c \leq h(s)\frac{E_j}{\tau_{ij}w_i}; c \leq \widehat{c}_{ij}\right\} = \left(\frac{h(s)}{a}\right)^{\kappa},$$

where $h(s) = s\left[1 - 1/\theta(s)\right]$. The neutrality of the distribution of normalized prices (as well as markups) from trade costs is due to the fact that while liberalization reduces prices of the inframarginal exporting firms (and increases their markups), it also attracts the entry of new exporters with higher prices (and smaller markups), and these effects exactly balance each other. Instead, it is immediate to verify that the distribution of individual consumption is affected by any change in μ_i and, in particular, by changes in trade costs.[16]

Taking the expectations of sales and profits, we obtain the constant ratio:

$$\frac{\mathbb{E}\{\pi_{ij}\}}{\mathbb{E}\{t_{ij}\}} = \frac{1}{\overline{\theta}}, \tag{17}$$

where the constant $\overline{\theta}$ is the same equilibrium harmonic average of demand elasticity defined in (9), which under the Pareto distribution is identical across countries. Under endogenous entry, total expected profits $\mathbb{E}\{\Pi_i\} = \sum_{j=1}^{I} \mathbb{E}\{\pi_{ij}\}$ in country i must equate the fixed cost of entry $w_i F_e$. Let us define total (expected) sales from country i, as $Y_i = \sum_{j=1}^{I} T_{ij}$, where $T_{ij} = N_i \mathbb{E}\{t_{ij}\}$ are the (expected) sales in country j that originated from country i. The endogenous entry condition reads as:

$$\mathbb{E}\{\Pi_i\} = w_i F_e,$$

and the income/spending equality for country i implies $w_i e_i L_i = Y_i$, where $Y_i = \sum_j T_{ji}$ is GDP in country i. Therefore, we can derive the number of firms created in country i as:

$$N_i = \frac{w_i e_i L_i}{\sum_{j=1}^{I} \mathbb{E}\{t_{ij}\}} = \frac{e_i L_i}{F_e} \frac{\sum_{j=1}^{I} \mathbb{E}\{\pi_{ij}\}}{\sum_{j=1}^{I} \mathbb{E}\{t_{ij}\}} = \frac{e_i L_i}{\overline{\theta} F_e}, \tag{18}$$

which is the same as in autarky. Accordingly, trade will not affect the number of firms created in each country or the number of domestic firms active in each country.[17]

3.1 Trade margins and general equilibrium

We can now derive the measure of firms actually exporting to any country j from country i, $n_{ij} = N_i G(\widehat{c}_{ij})$, the so-called extensive margin of trade, as:

$$n_{ij} = \frac{e_i L_i}{\overline{\theta} F_e} \left(\frac{a E_j}{\tau_{ij} w_i \overline{c}} \right)^{\kappa}. \tag{19}$$

This depends negatively on the trade cost and positively on per-capita income of the destination country, and on the "aggregate labor supply" $e_i L_i$ of the exporting country, but it is independent from the population size of the destination country. Hence, the model predicts that the extensive

[16]This is just the opposite of models based on directly additive preferences with a finite choke price, where changes in trade costs are neutral on the distribution of individual consumption and modify the distribution of prices.

[17]Notice that only if trade costs are high enough (or countries are symmetric) we can exclude that some firms produce only to export to other countries with higher per capita income. We will assume this to be the case.

margin is falling in the distance to the destination (to the extent that trade costs are increasing in distance) and potentially rising in overall GDP of the destination country (which is the product of per-capita income and population), as reported in Bernard *et al.* (2007).

The positive relationship between destination population size and the extensive margin can be restored by the introduction of fixed costs *à la* Melitz (2003) (see footnote 28 for the case of "addilog" preferences). The evidence on the relationship between the extensive margin and population size is mixed. Authors who use internet data (ex. Macedoni, 2015[18]) find that the extensive margin is neutral in population size as predicted by the baseline IA model. In contrast, authors who use traditional trade data such as firm-level or product-category-level manufacturing data (ex. Macedoni, 2015 when using the Exporter Dynamics Database or Hummels and Klenow (2002) when using disaggregate bilateral trade-flow trade), find that the extensive margin is increasing in population size and the coefficient estimates vary across countries and industries. This suggests that there is heterogeneity in fixed costs across countries and industries, ranging from nearly zero in online markets to positive and potentially large costs in traditional retail markets.

Another implication of our model is that the extensive margin is increasing as the importing country gets richer, which is in line with the growth in the measure of imported varieties documented by Broda and Weinstein (2006) for the US over three decades. The authors document that, during the three decades spanning 1972-2001, the number of imported varieties in the United States has increased by a factor of three. They also note that half of the rise can be attributed to new products sold by existing trade partners. We should remark that, contrary to the predictions of the IA framework, models based on directly additive or homothetic preferences (without fixed costs of production, as in ACDR) imply that the extensive margin is decreasing in the population of the destination country and it is neutral (increasing) with respect to income under homotheticity (direct additivity), while the Melitz-Chaney model (with fixed costs expensed in source country wages) generates an extensive margin that is increasing in both destination income and population.

The total measure of varieties consumed in country j can be expressed as follows:

$$n_j^C = \frac{a^\kappa E_j^\kappa}{\overline{\theta}\overline{c}^\kappa F_e} \sum_{i=1}^{I} e_i L_i \left(\tau_{ij} w_i\right)^{-\kappa}, \tag{20}$$

which crucially depends on its per-capita income, on the trade costs and on the dimensions of its trading partners. It follows that countries that are richer in per capita income (and larger in labor endowment) tend to consume more goods. This makes a remarkable difference with

[18] The author collects data for Samsung and verifies the results using data for Zara, Apple, H&M, and Ikea from the Billion Prices Project.

analogous models based on homothetic preferences and (untruncated) Pareto distribution (see Arkolakis *et al.*, 2010, and Feenstra, 2014), in which the number of consumed goods is equal across countries and independent of their income, population and trade costs.

Expected sales from country i to country j can be derived, by computing $\mathbb{E}\{t_{ij}\}$, as follows:

$$T_{ij} = N_i \mathbb{E}\{t_{ij}\} = Y_j \frac{n_{ij}}{n_j^C} = Y_j \frac{e_i L_i (\tau_{ij} w_i)^{-\kappa}}{\sum_{k=1}^{I} e_k L_k (\tau_{kj} w_k)^{-\kappa}} = n_{ij} \bar{t}_{ij},$$

where we decomposed trade into the product of the extensive margin and the intensive margin $\bar{t}_{ij}$. We can rewrite the latter as:

$$\bar{t}_{ij} = \frac{\mathbb{E}\{t_{ij}\}}{G(\widehat{c}_{ij})} = \frac{\bar{\theta} F_e L_j E_j^{1-\kappa}}{a^{\kappa} \sum_{k=1}^{I} e_k L_k (\tau_{kj} w_k \bar{c})^{-\kappa}}. \tag{21}$$

This is independent from the country of origin of the commodities, but it depends on both per-capita income and population of the destination country, which is in contrast with the intensive margin of the Melitz-Chaney model, that is constant as long as the (fixed) costs of export are in labor of the source country.[19] Two direct effects are immediately observable: the intensive margin is increasing in the destination's population size and decreasing with respect to the destination's per capita income. Therefore, the model can jointly generate a positive (and in fact linear) relationship between the intensive margin and the overall GDP of a destination, and a negative relationship with the destination's per-capita income, as documented for several source countries by Eaton *et al.* (2011). Notice that these implications are in contrast also with comparable models without fixed costs of production (ACDR): directly additive and homothetic preferences generate an intensive margin which is always increasing in destination income.

To close the model in general equilibrium, notice that:

$$\frac{T_{ij}}{T_{jj}} = \frac{Y_i}{Y_j} \left(\frac{w_i}{w_j}\right)^{-(\kappa+1)} \tau_{ij}^{-\kappa}. \tag{22}$$

This simple result can be interpreted as follows: the assumption of a Pareto distribution gives rise to a generalized "gravity" equation that governs the trade shares (see e.g. Head and Mayer, 2014, and Allen *et al.,* 2014), where κ is the "trade elasticity" according to the terminology

[19]The Melitz-Chaney model relates the intensive margin to the fixed cost to serve a destination and to the unit in which it is expensed. If this cost is parameterized to be source- and destination-specific as in Eaton *et al.* (2011), and if one assumes that the cost is systematically related to destination characteristics, the model can generate a systematic relationship between the intensive margin and destination characteristics.

suggested by ACR. In particular, the *trade share* of i-goods in country j is given by:

$$\lambda_{ij} = \frac{T_{ij}}{Y_j} = \frac{n_{ij}}{n_j^C} = \frac{e_i L_i \left(\tau_{ij} w_i\right)^{-\kappa}}{\sum_{k=1}^{I} e_k L_k \left(\tau_{kj} w_k\right)^{-\kappa}}. \tag{23}$$

Finally, using the expressions for the trade shares we can express the income-spending equation of each country i as:

$$w_i e_i L_i = \sum_{j=1}^{I} \lambda_{ij} E_j L_j. \tag{24}$$

Using (23) and (24) provides the equilibrium wage system:

$$w_i = \sum_{j=1}^{I} \frac{w_j e_j L_j \left(\tau_{ij} w_i\right)^{-\kappa}}{\sum_{k=1}^{I} e_k L_k \left(\tau_{kj} w_k\right)^{-\kappa}} \quad i = 1, .., I, \tag{25}$$

which is similar to those of related models (ACR; ACDR; Simonovska, 2015). It implies wage equalization only under free trade or identical countries (as in the previous sections). Moreover, it can be proved (Alvarez and Lucas, 2007) that (25) has a unique solution (up to a normalization) and that the relative wage of country j is increasing in its aggregate labor supply $e_j L_j$ and decreasing in its trade costs $\boldsymbol{\tau}_j\prime = [\tau_{1,j}, .., \tau_{I,j}]$.

3.2 Welfare and comparison with other models

Utility for a consumer of country j can be expressed as:

$$V_j = n_j^C \int_b^a v\left(s\right) dF_s(s), \tag{26}$$

which is the product of the total mass of consumed (domestic and imported) varieties n_j^C and the expected utility from each good: the former depends on trade costs (as well as on size and income of all countries) as shown in (20), but the latter depends only on preferences and the cost distribution. Accordingly, trade liberalization affects welfare only through a change in the consumed varieties. More precisely, a reduction in trade costs reduces prices for each imported good, but consumers exploit this by increasing the number of imported varieties without dropping any of the domestic varieties (indeed, the domestic cutoff cost does not change). Since the equilibrium distribution of the (normalized) prices of the purchased varieties remains the same, welfare changes in our setting only with changes in the number of imported varieties.[20]

[20] It is worth noticing that, in contrast to the implication of the Melitz and Ottaviano (2008) model, in our setting the welfare gains from trade do depend (through n_j^C) not only on the trade costs but also on the

Our final aim is to derive a global quantitative measure of the gains from trade liberalization as in ACR. First of all, taking logs and differentiating (26) with respect to $\tau_{\ j}$and $\mathbf{w}'=[w_1, .., w_I]$ for a given E_j (we can always normalize wage changes in such a way that $d\ln w_j = 0$) we get:

$$d\ln V_j = d\ln n_j^C = \frac{-\kappa \sum_{i=1,i\neq j}^{I} n_{ij}\left(d\ln \tau_{ij} + d\ln w_i\right)}{n_j^C}, \tag{27}$$

where the last step exploits the differentiation of (20) with respect to $\boldsymbol{\tau}_j$ and $\mathbf{w}$ for a given E_j. Let us indicate the proportional change of a variable z from $\underline{z}$ to $\overline{z}$ as $\widehat{z} = \overline{z}/\underline{z}$. Integrating (27), we obtain that the proportional utility change $\widehat{V}_j$ due to a (possibly *large*) trade shock to $\tau=[\tau_1, .., \tau_I]$ (and then to $\mathbf{w}$) is equal to the change $\widehat{n}_j^C$. In turn, through (23), the latter is simply related to the change in the domestic share λ_{jj} by $d\ln n_j^C = -d\ln \lambda_{jj}$ (i.e., $\widehat{n}_j^C = \widehat{\lambda}_{jj}^{-1}$).

Notice that, by (23) and (25), the changes in the domestic share λ_{jj} do *not* depend on the specific preferences. In fact, similarly to ACR, one can actually determine the impact of any reduction in trade costs by computing:[21]

$$\hat{w}_i Y_i = \sum_{j=1}^{I} \frac{\lambda_{ij}(\hat{w}_i\hat{\tau}_{ij})^{-\kappa}}{\sum_{k=1}^{I}\lambda_{kj}(\hat{w}_k\hat{\tau}_{kj})^{-\kappa}}\hat{w}_j Y_j \quad \text{and} \quad \hat{\lambda}_{jj} = \frac{(\hat{w}_j\hat{\tau}_{jj})^{-\kappa}}{\sum_{k=1}^{I}\lambda_{kj}(\hat{w}_k\hat{\tau}_{kj})^{-\kappa}}. \tag{28}$$

However, the specific preferences matter for translating these changes into a "quantitative" measure of the welfare gains from liberalization, to be compared with those arising in other models. In particular, here we want to derive the (proportional) variation of per-capita income in country j, $\widehat{W}_j$, which is "equivalent" to the welfare change $\widehat{V}_j$ due to trade liberalization.

A convenient "money metric" is provided by the Equivalent Variation of income, EV_j, such that a consumer would be indifferent between the post-shock prices induced by the change of trade costs and the new income level $W_j = E_j + EV_j$ evaluated at pre-shock prices (see Varian, 1992, Par. 10.1), with proportional variation $\widehat{W}_j = W_j/E_j$. To compute EV_j is convenient to write the equilibrium value of utility as:

$$V_j(W_j, E_j; F_{ij}) = \sum_{i=1}^{I} N_i \int_{bE_j}^{aW_j} v\left(\frac{p}{W_j}\right) dF_{ij}(p),$$

where F_{ij} is the unconditional distribution of prices p_{ij} posted by all firms of country i in country j (varieties with prices above the cut-off value aW_j are welfare irrelevant). By taking

dimensions of the trading partners.

[21]Since the present model satisfies the requirements of what Allen *et al.* (2014) define as "universal gravity", we can also rely on their comparative statics results to guarantee that any trade cost reduction increases "world welfare", defined as a weighted average of the welfare of all countries. We will verify this in our counterfactual analysis.

logs and differentiating with respect to W_j the last expression (see Appendix C), one can get:

$$d \ln V_j = \frac{\kappa}{1 - \bar{\epsilon}_j^E (W_j, E_j)} d \ln W_j,$$

where $\bar{\epsilon}_j^E (W_j, E_j)$ captures the average (across firms) elasticity of price with respect to income W_j, and it is thus related to the shape of the demand function. Therefore, the income variation that is equivalent to the impact of trade liberalization is implicitly determined by the solution of the equation:

$$\int_{E_j}^{W_j} \frac{\kappa}{1 - \bar{\epsilon}_j^E (t, E_j)} d \ln t = - \ln \widehat{\lambda}_{jj}. \tag{29}$$

To understand this formula, notice that a rigid demand function implies that firms set high prices and that prices react a lot to changes in income and not to changes in costs ($\bar{\epsilon}_j^E (W_j, E_j)$ is high). Accordingly, high prices generate a high marginal utility of income, which in turn reduces the income variation needed to match a given cost shock. As a consequence, a rigid demand is associated with low gains from trade liberalization. Instead, when the demand function becomes more elastic, cost reductions due to trade liberalization are shifted more into lower prices and the gains are higher.

We can then approximate small changes in welfare by:

$$d \ln W_j = -(1 - \bar{\epsilon}^E) \frac{d \ln \lambda_{jj}}{\kappa}, \tag{30}$$

where $\bar{\epsilon}^E = \bar{\epsilon}_j^E (E_j, E_j) \in (0, 1)$ is the weighted average across firms (with relative sales as weights) of the elasticity of prices with respect to income - which is the same as in (6).

This result can be compared to those of a variety of traditional models. ACR have shown that a formula for the welfare gains as $d \ln W_j = -d \ln \lambda_{jj} / \sigma$, where σ is the elasticity of relative imports with respect to variable trade costs, applies to models different on the supply side but all based on *CES preferences* (as Anderson, 1979, Krugman, 1980, Eaton and Kortum, 2002, Melitz, 2003, Chaney, 2008 and others). Thus, estimating such a trade elasticity allows one to measure the welfare gains from liberalization episodes. Notice that in models with homogenous firms, such as the Armington model (Anderson, 1979) and the Krugman (1980) model, the trade elasticity is related to the constant elasticity of substitution (namely $\sigma = \theta - 1$ in our notation): in these cases low substitutability between goods induces high imports of foreign varieties, which leads to high gains from trade liberalization. However, in a large class of heterogeneous firm models with an untruncated Pareto distribution of productivities, including the celebrated Melitz-Chaney model (Melitz, 2003; Chaney, 2008), ACR show that the trade elasticity σ is independent from preference parameters and just related to the shape of the Pareto distribution (namely $\sigma = \kappa$ in our notation), and therefore the gains from trade liberalization are neutral with respect to the underlying model details.[22]

In a further generalization of the heterogenous firm models, ACDR have adopted general *homothetic preferences*, confirming the ACR formula for the welfare gains:

$$d\ln W_j = -\frac{d\ln \lambda_{jj}}{\kappa}. \tag{31}$$

As already noticed for translog preferences by Arkolakis *et al.* (2010) and for a larger class of homothetic preferences by Feenstra (2014), trade liberalization induces consumers to replace the most expensive domestic goods with an identical number of cheaper imported varieties, which excludes any gains from variety associated with trade. In the terminology of ACDR, reductions in marginal costs due to trade liberalization are here the only source of gains because what they call the "direct" markup effect (which tends to induce an increases of the average markup on exports due to incomplete pass-through) is exactly counterbalanced by what they call the "indirect" markup effect due to the reduction of the choke price (which induces a selection effect on the set of domestic firms).

ACDR also derive the following approximation of the welfare changes (valid for small reductions of trade costs) in the case of *directly additive preferences*:

$$d\ln W_j = -\left(1 - \frac{\rho}{\kappa+1}\right)\frac{d\ln \lambda_{jj}}{\kappa}, \tag{32}$$

where ρ, a weighted average (with relative sales as weights) of the elasticity of markups to productivity, is positive but smaller than unity in common models with incomplete pass-through. In this case, by reducing the choke price, trade liberalization not only creates a selection effect but affects the equilibrium distribution of prices increasing the measure of consumed goods (while leaving unchanged the distribution of individual consumption levels). As shown by ACDR, the domestic gains from the reduction of the choke price compensate only in part the losses due to the average increase in markup, leading to smaller gains compared to homothetic preferences. However, the difference is quite limited since $(1 - \frac{\rho}{\kappa+1}) \in (\frac{\kappa}{\kappa+1}, 1)$.

On the contrary, since $\bar{\epsilon}^E \in (0, 1)$ in (30), *indirectly additive preferences* emphasize the crucial role of the demand side in determining the gains from trade liberalization. Trade liberalization leads to an increase in the number of imported and consumed goods - see (20) - whose impact on welfare depends crucially on the preferences. The less elastic is demand, the smaller are the gains from trade liberalization because cost reductions are poorly translated into

[22]A similar result applies even to Ricardian models as the one by Eaton and Kortum (2002), which adopts a Fréchet distribution of productivities.

price reductions. Accordingly IA preferences generate welfare gains that can be substantially different from models based on CES or homothetic preferences, and even from those based on directly additive preferences.

3.3 An "addilog" example

In the remainder of the paper and in the empirical application we will adopt a new convenient specification of IA preferences, which we define as "addilog" in honour of Houthakker (1960), who used this terminology for generic IA preferences. Our specification is the following:[23]

$$V = \int_{\Omega} \frac{(a - s(\omega))^{1+\gamma}}{1+\gamma} d\omega. \tag{33}$$

Here $\gamma > 0$ is the key preference parameter (notice that the subutility function for each variety ω is isoelastic in $a - s(\omega)$). By Roy identity, the demand for each variety ω is now:

$$x(\omega) = \frac{(a - s(\omega))^{\gamma}}{|\mu|}. \tag{34}$$

The elasticity of demand with respect to price is $\theta(s) = \gamma s/(a - s)$, which is increasing in γ. Clearly, demand is linear (as in the example of Section 2) for $\gamma = 1$, it tends to become perfectly elastic for $\gamma \to \infty$ and perfectly rigid for $\gamma \to 0$. The rest of the model is the same as above. We can summarize the relevant exogenous variables/parameters in our setting by the objects $\tilde{\mathbf{P}} = \{a, \kappa, \gamma, \boldsymbol{\tau}, \mathbf{e}, \mathbf{L}, F_e\}$ in matrix notation, where $\mathbf{e}' = [e_1, .., e_I]$ and $\mathbf{L}' = [L_1, .., L_I]$.

The optimal price of a c-firm from country i willing to sell to country j is easily derived as:

$$p_{ij}(c) = \frac{\gamma \tau_{ij} w_i c + a E_j}{1+\gamma}, \tag{35}$$

which shows that the degree of pass-through is increasing in γ. Indeed, for $\gamma \to 0$ any reduction in costs would be exploited by the firms without price reduction (prices would approach the limit aE_j with full expropriation of consumer welfare), while for $\gamma \to \infty$ any reduction in costs would be fully translated into a price reduction (prices would approach the nominal marginal cost $\tau_{ij} w_i c$ as in perfect competition).

[23] As shown in Bertoletti and Etro (2016a), the direct utility dual to (33) is:

$$U = \frac{\left(a \int_{\Omega} x(\omega) d\omega - 1\right)^{1+\gamma}}{(1+\gamma)\left(\int_{\Omega} x(\omega)^{\frac{1+\gamma}{\gamma}} d\omega\right)^{\gamma}},$$

which is not directly additive.

The individual quantity sold by a c-firm from country i to destination j is then given by:

$$x_{ij}(c) = \frac{\gamma^{\gamma}\left(\widehat{c}_{ij} - c\right)^{\gamma}\left(\tau_{ij}w_i\right)^{\gamma}}{(1+\gamma)^{\gamma}E_j^{\gamma}\left|\mu_j\right|}. \tag{36}$$

where $\widehat{c}_{ij}$ is always given by (16). Notice that consumption decreases in c and it has a finite value even when marginal cost is null. The value of the sales of a c-firm from country i to country j is:

$$t_{ij}(c) = \frac{\gamma^{\gamma}\left(\gamma c + \widehat{c}_{ij}\right)\left(\widehat{c}_{ij} - c\right)^{\gamma}\left(\tau_{ij}w_i\right)^{1+\gamma}L_j}{(1+\gamma)^{1+\gamma}(E_j)^{\gamma}\left|\mu_j\right|}. \tag{37}$$

The corresponding profits are given by:

$$\pi_{ij}(c) = \frac{\gamma^{\gamma}\left(\widehat{c}_{ij} - c\right)^{1+\gamma}\left(\tau_{ij}w_i\right)^{1+\gamma}L_j}{(1+\gamma)^{1+\gamma}E_j^{\gamma}\left|\mu_j\right|}, \tag{38}$$

and are a decreasing and convex function of c.

3.3.1 Markups, prices and sales

We now derive the model's key prediction regarding markup and price variation across destinations and across firms. Denote by $m_{ij}(c)$ the mark-up that a firm with cost draw c from country i enjoys in destination j (assuming that it actually serves that market, i.e. $c \leq \hat{c}_{ij}$):

$$m_{ij}(c) = \left(\frac{1}{1+\gamma}\right)\left(\frac{\widehat{c}_{ij} - c}{c}\right). \tag{39}$$

This markup is decreasing in γ, reflecting a more elastic demand, and rising in the cost cutoff $\hat{c}_{ij}$, reflecting pricing to market. Moreover, more productive firms set lower prices but enjoy higher markups.

Furthermore, from (35), the elasticity of prices with respect to the "intrinsic" marginal cost c (or the transport cost τ_{ij}, or the wage of the source country w_i) can be expressed as:

$$\epsilon_{ij}^{c}(c) = \frac{\gamma c}{\gamma c + \widehat{c}_{ij}} \in \left[0, \frac{\gamma}{1+\gamma}\right]. \tag{40}$$

Similarly, the elasticity of prices with respect to income of the destination country E_j is its complement to one:

$$\epsilon_{ij}^{E}(c) = \frac{\widehat{c}_{ij}}{\gamma c + \widehat{c}_{ij}} \in \left[\frac{1}{1+\gamma}, 1\right]. \tag{41}$$

It is easy to verify that the latter is also the elasticity of prices with respect to the real exchange rate between the source and the destination country, which is often the subject of empirical investigations.[24]

We can think of $\epsilon_{ij}^{c}(c)$ as a *pass-through index* because it says which percentage of cost changes is reflected in price changes, and we can think of $\epsilon_{ij}^{E}(c)$ as an *index of pricing-to-market* because it says which percentage of income or exchange rate changes is reflected in price changes. Moreover, both of them vary with a firm's productivity in a monotonic way. For instance, pass-through is zero for the most efficient firms ($\epsilon_{ij}^{c}(0) = 0$) and the highest for the least efficient firms ($\epsilon_{ij}^{c}(\widehat{c}_{ij}) = \gamma/(1+\gamma)$). Pricing-to-market in turn is as high as 1 for the most productive firm and only $1/(1+\gamma)$ for the least productive one. These differences are due to the fact that efficient firms set their prices low and change them mainly on the basis of changes in income, while inefficient firms set high prices and change them mainly on the basis of changes in costs. These predictions are in line with empirical evidence provided by Berman *et al.* (2012) that pricing to market is more sensitive for more productive firms.[25]

Finally, let us consider the reaction of the sales of a firm of country i toward country j when the relevant trade cost decreases. We know from (40) that such a bilateral liberalization reduces prices $p_{ij}(c)$ more for the small (high-c) firms. As a consequence, these small firms increase more their production, as can be verified by evaluating the elasticity of quantity $x_{ij}(c)$ in (36). Whether the sales $t_{ij}(c)$ of small firms are more or less reactive is not obvious. However, computing the elasticity $d\ln t_{ij}(c)/d\ln\tau_{ij}$ (after normalizing $d\ln w_i = 0$)[26] and differentiating it with respect to c we obtain:

$$\frac{\partial}{\partial c}\left\{\frac{d\ln t_{ij}(c)}{d\ln\tau_{ij}}\right\} = \left[\frac{-\gamma\widehat{c}_{ij}}{(\widehat{c}_{ij}+\gamma c)^2} + \frac{\gamma\widehat{c}_{ij}}{(\widehat{c}_{ij}-c)^2}\right]\frac{d\ln\widehat{c}_{ij}}{d\ln\tau_{ij}} < 0,$$

where $d\ln\widehat{c}_{ij}/d\ln\tau_{ij} = d\ln w_j/d\ln\tau_{ij} - 1 < 0$. Since a reduction of τ_{ij} corresponds to trade liberalization, this shows that smaller firms respond more to trade liberalization, which is in line

[24]It is straightforward to extend the model to feature nominal and real exchange rates: let r_{ij} be the nominal exchange rate between i and j, so that p_{ij}/r_{ij} is the export price in the currency of country j. Define $\underline{r}_{ij} = r_{ij}w_j/w_i$ as the real rate of exchange (see e.g. Berman *et al.*, 2012): accordingly the profit-maximizing rule of a c-firm from country i is

$$p_{ij}(c) = \frac{\tau_{ij}w_i\left(\widehat{c}_{ij}+\gamma c\right)}{1+\gamma}, \qquad \text{where } \widehat{c}_{ij} = \frac{ar_{ij}E_j}{\tau_{ij}w_i} = \frac{a\underline{r}_{ij}e_j}{\tau_{ij}}.$$

[25]Using detailed French exporter data, these authors find that the exporter with average productivity raises prices by 0.8% when experiencing a 10% home currency depreciation. Furthermore, the response is 1.3% for exporters with a productivity level equal to the mean plus one standard deviation, namely, for more productive exporters.

[26]Taking logs of p_{ij} and x_{ij} and differentiating we get:

$$\frac{\partial\ln t_{ij}(c)}{\partial\ln\tau_{ij}} = \frac{\partial\ln x_{ij}(c)}{\partial\ln\tau_{ij}} + \frac{\partial\ln p_{ij}(c)}{\partial\ln\tau_{ij}} = 1 - \frac{\partial\ln|\mu_j|}{\partial\ln\tau_{ij}} + \left[\frac{\widehat{c}_{ij}}{\widehat{c}_{ij}+\gamma c} + \gamma\frac{c}{\widehat{c}_{ij}-c}\right]\frac{\partial\ln\widehat{c}_{ij}}{\partial\ln\tau_{ij}}.$$

with the evidence presented by Eaton *et al.* (2008) and Arkolakis (2015). Together with the fact that trade liberalization induces entry of foreign varieties in our model, this implies that adjustments on the extensive margin (changes to new and least traded varieties) are critical in understanding the welfare gains from trade (as argued by Broda and Weinstein, 2006, and Kehoe and Ruhl, 2013).

3.3.2 Equilibrium distributions

Given our functional form, we can fully characterize the equilibrium in closed form solutions (see Appendix B). The distribution of normalized prices on the support $[\frac{a}{1+\gamma}, a]$ can be derived as:

$$F_s(s) = \left(\frac{(1+\gamma)\, s}{\gamma a} - \frac{1}{\gamma}\right)^{\kappa}, \tag{42}$$

which depends only on the three parameters γ, κ and a. Analogously, prices in country j, given by expression (35), are distributed according to $F_j(p) = [(1+\gamma)\, p/\gamma a E_j - 1/\gamma]^{\kappa}$, which is independent from trade costs and the identities of the exporting countries, but depends crucially on the income of the importing country j. The markup distribution can be derived as follows:

$$F_m(m) = 1 - \frac{1}{[1+(1+\gamma)\, m]^{\kappa}}, \tag{43}$$

which is also the same across countries.

The expected profit and expected sales of a firm from country i selling in country j can be expressed as (see Appendix B):

$$\mathbb{E}\left\{\pi_{ij}\right\} = \frac{\gamma^{\gamma}\kappa B(\kappa,\gamma+2) a^{\kappa+\gamma+1} E_j^{\kappa+1} L_j}{(1+\gamma)^{1+\gamma}\bar{c}^{\kappa}\left(\tau_{ij} w_i\right)^{\kappa} |\mu_j|} \quad \text{and} \quad \mathbb{E}\left\{t_{ij}\right\} = \frac{a^{\kappa+\gamma+1}\gamma^{\gamma+1} B(\kappa+2,\gamma) E_j^{\kappa+1} L_j}{(1+\gamma)^{\gamma}\bar{c}^{\kappa}\left(\tau_{ij} w_i\right)^{\kappa} |\mu_j|},$$

where we introduced the Euler Beta function $B(z,h) = \int_0^1 t^{z-1}(1-t)^{h-1}dt$.[27] Using its properties expression (17) yields a value for $\bar{\theta}$ of:

$$\bar{\theta} = \kappa + 1, \tag{44}$$

which is independent from the preference parameters: this implies that the return on sales (17) is uniquely determined by the shape parameter of the Pareto distribution. Moreover,

[27] Its value is also given by:

$$B(z,h) = \frac{\Gamma(z)\Gamma(h)}{\Gamma(z+h)},$$

where $\Gamma(t)$ is the Euler Gamma function (see Appendix B). Its basic recursive properties can be expressed as $B(z+1,h) = zB(z,h)/(z+h)$ and $B(z,h+1) = hB(z,h)/(z+h)$.

it allows us to solve for the number of firms created in country i in closed form solution as $N_i = e_i L_i/(\kappa+1)F_e$, which is the same as in autarky (both in the decentralized equilibrium and in the social optimum). The extensive margin $n_{ij} = N_i G(\hat{c}_{ij})$ is independent from population and demand elasticity.[28] The number of goods consumed in country j is:[29]

$$n_j^C = \frac{a^\kappa E_j^\kappa}{(\kappa+1)\overline{c}^\kappa F_e} \sum_{i=1}^{I} e_i L_i \left(\tau_{ij} w_i\right)^{-\kappa}. \tag{45}$$

which is independent from the preference parameter γ, while it increases in the willingness to pay for each good, a. Finally, we can also evaluate the market share in country j of an exporting c-firm from country i, $\alpha_{ij}(c) \equiv t_{ij}(c)/\overline{t}_{ij}$. This can be expressed as:

$$\alpha_{ij}(c) = \frac{\left(1+\gamma\frac{c}{\hat{c}_{ij}}\right)\left(1-\frac{c}{\hat{c}_{ij}}\right)^\gamma}{\gamma(1+\gamma)B(\kappa+2,\gamma)}, \tag{46}$$

and it can be verified that also the distribution of the market share is identical across countries and depends only on the two parameters γ and κ.[30] This result demonstrates an attractive feature of this framework relative to alternatives: the distribution of (normalized) firm sales is not uniquely tied to the distribution of firm productivities. Given a certain degree in productivity dispersion, governed by κ, the dispersion in firm sales is pinned down by γ.[31] Hence, the model can potentially reconcile both the measured productivity and sales advantages of exporters over non-exporters reported by Bernard *et al.* (2003).

[28] Notice that our model can generate an extensive margin that is increasing in population simply by adding small fixed export costs. If these are in units of local labor, say F_j, it is easy to derive from (38) the modified cutoff:

$$\hat{c}_{ij} = \frac{aE_j}{\tau_{ij} w_i}\left[1 - \frac{1+\gamma}{a}\left(\frac{|\mu_j| F_j}{\gamma^\gamma e_j L_j}\right)^{\frac{1}{1+\gamma}}\right]$$

so that the extensive margin is directly increasing in the destination population L_j. Notice that the same extension induces selection effects on the measure of domestic firms through the negative impact of the price aggregator $|\mu_i|$ on the domestic cutoff $\hat{c}_{ii}$.

[29] We can also compute $|\mu_j|$ as a linear function of the number of consumed varieties, with $|\mu_j| = \frac{a^{\gamma+1}\gamma^{\gamma+1}B(\kappa+2,\gamma)}{(1+\gamma)^\gamma} n_j^C$.

[30] The crucial element is the distribution of $l = H(t) = (1+\gamma t)(1-t)^\gamma$, where $t = c/\widehat{c}_{ij}$ with $F_t(t) = \Pr\{c/\widehat{c}_{ij} \leq t\} = t^\kappa$ on the support $[0,1]$. Notice that $H'(t) < 0$ and $H''(t) < 0$ if and only if $t < 1/2$, therefore l is distributed on $[0,1]$ according to $F_l(l) = 1 - (H^{-1}(l))^\kappa$.

[31] Jung *et al.* (2015) demonstrate that the distributions of firm sales and productivity depend uniquely on the Pareto productivity shape parameter in existing models that feature consumers with directly additive preferences, including quadratic preferences (as in Melitz and Ottaviano, 2008, but without the outside good) and those of Behrens *et al.* (2014) and Simonovska (2015). Therefore, these models cannot jointly reconcile moments from the two distributions observed in US data. The authors outline a flexible, albeit not tractable, extension of Simonovska (2015) that falls within the directly-additive class and has more desirable quantitative features.

3.3.3 Welfare

Our specification of the indirect utility allows us to characterize the impact of trade in detail. The equilibrium value of utility in country j is now:

$$V_j = n_j^C \int_{\frac{a}{1+\gamma}}^{a} \frac{(a-s)^{\gamma+1}}{1+\gamma} dF_s(s) = n_j^C \frac{\kappa (\gamma a)^{\gamma+1} B(\kappa, \gamma+2)}{(\gamma+1)^{\gamma+2}}, \tag{47}$$

which is linear in the number of consumed goods (45). The coefficient represents the utility expected from each consumed good and depends on the willingness to pay a, on the preference parameter γ, which governs the level of market competitiveness, and on κ, which governs the cost distribution.

It is useful to examine how changes in this utility translate into a "quantitative" measure of welfare changes. As in the general model (see Appendix C), we calculate the equivalent variation on income EV_j keeping prices unchanged at their initial level before the trade shock. To this end, it is convenient to use the unconditional distribution of prices p_{ij} of goods from i faced by consumers in country j, F_{ij}. This is the distribution of prices posted by all firms from country i in country j, and, using (35), it can be expressed as:

$$F_{ij}(p) = \left(\frac{(1+\gamma) p - aE_j}{\gamma \tau_{ij} w_i \overline{c}} \right)^{\kappa} \tag{48}$$

on the interval $[\underline{p}, \overline{p}]$, where $\underline{p} = p(0) = aE_j / (\gamma+1)$ and $\overline{p} = p(\overline{c}) = (\gamma \tau_{ij} w_i \overline{c} + aE_j) / (\gamma+1)$. Notice that this distribution and its support depends on τ_{ij}, w_i, and E_j, to be taken as given at their levels before the shock.[32] Since the expected utility from varieties with prices in the interval $[aW_j, \overline{p}]$ is null, we can write the welfare of a consumer in country j after receiving the income variation EV_j, as follows:

$$\begin{aligned} V_j(W_j, E_j; F_{ij}) &= \frac{1}{\gamma+1} \sum_{i=1}^{I} N_i \int_{\underline{p}}^{aW_j} \left(a - \frac{p}{W_j} \right)^{\gamma+1} dF_{ij}(p) \\ &= \kappa \int_{bE_j}^{aW_j} \left(a - \frac{p}{W_j} \right)^{\gamma+1} [(1+\gamma) p - aE_j]^{\kappa-1} dp \sum_{i=1}^{I} N_i (\gamma \tau_{ij} w_i \overline{c})^{-\kappa}. \end{aligned}$$

[32]The optimal prices of the varieties unsold in country j are not uniquely defined above the cutoff price aE_j, because demand and profits are zero. For the sake of simplicity (and to avoid any asymmetry between positive and negative equivalent variations), we assume that they follow the same pricing rule (35) as the varieties actually sold.

Taking logs of $V_j(W_j, E_j; F_{ij})$ and differentiating with respect to W_j, we obtain:

$$d\ln V_j = \frac{(\gamma+1)(\kappa W_j + E_j)}{(\gamma+1)W_j - E_j} d\ln W_j. \tag{49}$$

For "small" income changes (i.e., evaluating the previous differential at $W_j = E_j$), we obtain the approximation $d\ln V_j = (\gamma+1)(\kappa+1)\, d\ln W_j/\gamma$. Recalling that gravity implies that $n_j^C = a^\kappa e_j^\kappa N_j/\overline{c}^\kappa \lambda_{jj}$, and a shock to trade costs causes a proportional change of utility denoted by $d\ln V_j = d\ln n_j^C = -d\ln\lambda_{jj}$, this immediately delivers the local measure:

$$d\ln W_j = -\frac{\gamma d\ln\lambda_{jj}}{(\gamma+1)(\kappa+1)}, \tag{50}$$

whose coefficient is in the range $(0, \frac{1}{\kappa+1})$ for $\gamma \in (0,\infty)$. Notice that the upper bound of this range is the lower bound of the range obtained by ACDR for directly additive preferences in (32).

The exact measure of the gains from trade liberalization, $\widehat{W}_j$, valid also for "large" trade shocks, can be obtained by integrating (49), which implicitly characterizes W_j as follows:

$$\int_{E_j}^{W_j} \frac{(\gamma+1)(\kappa t + E_j)}{(\gamma+1)t - E_j} d\ln t = -\ln\widehat{\lambda}_{jj}, \tag{51}$$

where we can further compute:

$$\int_{E_j}^{W_j} \frac{(\gamma+1)(\kappa t + E_j)}{(\gamma+1)t - E_j}\frac{dt}{t} = [(\gamma+\kappa+1)\ln(\gamma t + t - E_j) - (\gamma+1)\ln t]_{E_j}^{W_j}.$$

It is easy to verify that the approximation derived from (50) provides a lower bound for the exact welfare changes in (51),[33] therefore it can be used as a conservative measure of the benefits of trade liberalization. The welfare gains from trade liberalization depend on κ, as in ACR, but also on γ, which governs the level of competitiveness in the markets. Accordingly, for given values of the Pareto shape parameter κ, the gains from trade liberalization are larger in more competitive markets: intuitively, a more competitive environment implies lower prices, which in turn requires a larger equivalent income variation due to the decreasing marginal utility of income.[34]

[33] This follows from the concavity of function:

$$g(W) = \int_E^W \frac{(\gamma+1)(\kappa t + E)}{(\gamma+1)t - E} d\ln t.$$

[34] Similarly, the exact income variation equivalent to a positive trade shock is larger when we take into account

4 Quantitative Analysis

In this section, we design several exercises that aim to quantify the welfare gains from trade predicted by the model. To proceed, we outline several strategies to estimate the addilog model's parameters with the ultimate goal to evaluate the quantitative fit of the model to observations from cross-firm and cross-country data. To that end, we revisit the model's implications and we derive testable predictions that can be compared to moments in the data.

4.1 Background

In order to quantify the welfare gains from trade predicted by the addilog model, we need data on trade shares and per-capita income as well as estimates of two key parameters, κ and γ. We opt for a structural approach toward identifying these two parameters. In particular, the identification approach demands that we also take a stand on a number of additional (but not all) parameters that characterize the model. The model falls within a large class of models that generate a log-linear gravity equation of trade. As a consequence, the two key parameters, κ and γ, together with a set of country- and country-pair-specific parameters that can be estimated using the model's structural gravity equation of trade, are sufficient to generate a set of moments that can be used to judge the model's fit to the data.[35]

We begin by deriving the theoretical gravity equation of trade. Taking the log of the ratio of country j's import share from source i, λ_{ij} in expression (23), and j's domestic expenditure share, the corresponding expression for λ_{jj}, obtains

$$\log\left(\frac{\lambda_{ij}}{\lambda_{jj}}\right) = \tilde{S}_i - \tilde{S}_j - \kappa \log \tau_{ij}, \tag{52}$$

where $\tilde{S}_i = \log(e_i L_i w_i^{-\kappa})$ for all $i = 1, .., I$. Let $S_i = \exp(\tilde{S}_i)$, a transformation that will be used extensively as we proceed.

Once we have obtained estimates for the parameters κ and γ, as well as for the objects S_i for all $i = 1, .., I$ and τ_{ij} for all country-pairs i, j, using data for actual trade shares λ_{ij} for all i, j pairs and population size L_j for all countries j, we can compute predicted per-capita income levels for each country from the model's predicted market clearing conditions. In particular, refer to (24), where by definition per-capita income in country i is $E_i = w_i e_i$. After normalizing population size, L_i, relative to a numeraire, we can obtain per-capita incomes, E_i, relative to a numeraire, using data on L_i and λ_{ij} for all i, j from this very expression. Let $\mathbf{P}$ denote the vector of the parameters necessary for simulation in matrix notation, namely $\mathbf{P} = \{\kappa, \gamma, \boldsymbol{\tau}, \mathbf{E}, \mathbf{L}, \mathbf{S}\}$,

the decreasing marginal utility of income.

[35] Simonovska and Waugh (2014,a,b) demonstrate this fact for models that rely on homothetic preferences, while Jung *et al.* (2015) analyze models that belong to a class of directly additive preferences.

where $\mathbf{E}' = [E_1, .., E_I]$ and $\mathbf{S}' = [S_1, .., S_I]$, and let $\mathbf{\Lambda}$ denote the bilateral trade-share matrix with typical element λ_{ij}.

With $\mathbf{P}$ and $\mathbf{\Lambda}$ in hand, we can compute all endogenous objects in the model that are necessary to derive a number of moments that we can use to identify κ and γ. We begin by computing cost cutoffs. Expression (16) suggests that a value for the parameter a would be needed in order to obtain cost cutoffs. As it turns out, it is sufficient to compute cost cutoffs relative to a numeraire cutoff, in order to derive the moments of interest. Below we will describe how we select this numeraire. We begin by revisiting the model's predictions and translating them into moments from the model that are expressed as functions of normalized cutoffs, $\mathbf{P}$, and $\mathbf{\Lambda}$.[36]

4.2 Empirical predictions

4.2.1 Prices across destinations

A key testable prediction of our model relates to cross-country price variation. Prices should be increasing in destination per-capita income and independent of destination population size: $\partial p_{ij}/\partial E_j > 0$ and $\partial p_{ij}/\partial L_j = 0$. In the absence of data on firms' costs, the expected values of the elasticities of prices are of particular interest for a comparison with corresponding moments in the data. In particular, we can derive an explicit expression for the average elasticity of price with respect to per-capita income:

$$\mathbb{E}\left\{\epsilon_E\right\} = F_{2,1}(1, \kappa; 1 + \kappa; -\gamma), \tag{53}$$

where $F_{2,1}$ is the hypergeometric function defined in Appendix B. Hence, with estimates of κ and γ in hand, we can compute this average elasticity and also the average pass-through $\mathbb{E}\left\{\epsilon_c\right\} = 1 - \mathbb{E}\left\{\epsilon_E\right\}$ and compare them to estimates from existing data. In turn, the predicted elasticity of price with respect to population size in the model is zero. This is another object that we can compare to estimates from data.

4.2.2 Pass-through and mark-ups across firms

In the model, more productive exporters price to market more or, alternatively, they enjoy lower cost pass-through. In expression (62) in Appendix B we have derived the distribution of the elasticity of price with respect to income, which, as already mentioned, corresponds to the

[36] It is worth to note that we will not need to estimate the parameter F_e for the purpose of our exercises.

elasticity with respect to the real exchange rate. We reproduce it below for convenience:

$$\Pr\left\{\epsilon^E \leq \epsilon\right\} = 1 - \left(\frac{1-\epsilon}{\gamma\epsilon}\right)^{\kappa}.$$

Given estimates of κ and γ, in addition to the mean of this distribution as illustrated above, we can also compute the mean plus one standard deviation response to exchange rate changes. This allows us to compare both measures to the corresponding moments in the data so as to test the prediction that small (or less productive) firms pass through cost changes more.

Finally, the distribution of mark-ups is given in expression (43). With estimates of κ and γ at hand, we can derive moments from the mark-up distribution and compare them to data. In particular, the mean markup is:

$$\mathbb{E}\left\{m\right\} = \frac{1}{(\gamma+1)(\kappa-1)},$$

which is decreasing in $\kappa > 1$ and γ.

4.2.3 Extensive margin of trade

The extensive margin of trade was derived in expression (19) for general IA preferences. It varies across source and destination countries. Given a source country i, let j^* denote a numeraire destination. The ratio of the extensive margin for destination j, relative to the numeraire, is:

$$ext_{ij} = \left(\frac{E_j}{E_{j^*}}\right)^{\kappa}\left(\frac{\tau_{ij}}{\tau_{ij^*}}\right)^{-\kappa}. \tag{54}$$

Taking logs of the above expression allows us to obtain elasticities of the extensive margin with respect to destination specific characteristics. Hence the model predicts that, for a given source country, the extensive margin of trade is increasing in per-capita income with an elasticity of κ and falling in trade costs with an elasticity of $-\kappa$. With an estimate of trade costs at hand, we can also compute the elasticity of the extensive margin with respect to distance to the destination, and compare it to data.

4.2.4 Intensive margin of trade

The intensive margin of trade was derived in expression (21) for general IA preferences. It measures the average sales for firms in a particular destination and it is independent of the source country. Letting country j^* be a numeraire destination, and using the definition of the gravity object S_i, the ratio of the intensive margin for destination j, relative to the numeraire, can be rewritten as:

$$int_j = \frac{E_j L_j}{E_j^* L_j^*} \left(\frac{E_j}{E_{j^*}}\right)^{-\kappa} \left(\frac{\sum_k S_k \tau_{kj}^{-\kappa}}{\sum_k S_k \tau_{kj^*}^{-\kappa}}\right)^{-1} \tag{55}$$

Taking logs of both sides of the expression yields the following: controlling for aggregate effects, the elasticity of the intensive margin with respect to destination GDP is 1 and the elasticity of the intensive margin with respect to destination per-capita income is $-\kappa$. The second elasticity is negative and its value can be computed with an estimate of κ in hand.

4.2.5 Sales and measured productivity advantage of exporters

More efficient firms realize higher sales. Moreover, trade barriers prevent less efficient firms from exporting, which implies that exporters enjoy an efficiency and sales advantage over non-exporters. Below, we derive two moments of interest from the distributions of measured productivity and sales of firms: the measured productivity and sales advantage of exporters over non-exporters. We derive these moments because we can readily compare them to their data counterparts.

Exporter sales advantage In order to derive moments for exporters and non-exporters from any source country i, it is useful to define a cost cutoff that separates firms into these two groups. In particular, using the characterization for cost cutoffs in expression (16), define the cost cutoff for exporters from country i as

$$\tilde{c}_{ij} \equiv \max_{k \neq i} \frac{aE_k}{\tau_{ik} w_i} \tag{56}$$

Notice that any firm from country i with cost $c < \tilde{c}_{ij}$ is an exporter to some country k and any firm with cost $c \in [\tilde{c}_{ij}, \hat{c}_{ii}]$ serves the domestic market only.[37] This follows from the fact that firms differ only along the cost dimension, so there is a strict ordering of markets by toughness, with the destination k'' being toughest for i's producers if $\hat{c}_{ik''} \leq \hat{c}_{ik'}$ $\forall k'$. Thus, we can refer to country j that satisfies the definition in expression (56) as the most accessible foreign destination for firms from i.

Having categorized firms into exporters and non-exporters, the first moment we are interested in is the ratio between the average domestic sales of exporters and the average sales of non-exporters from any country i.[38] Consider any firm from country i; its domestic sales are given by expression (37), where destination $j = i$. Integrating over all exporters, then inte-

[37]The definition implicitly assumes that trade barriers are high enough so that $\hat{c}_{ii} > \hat{c}_{ik}$ $\forall k \neq i$.

[38]We follow Bernard *et al.* (2003) and derive this ratio because we will be comparing the model's predicted moment to the corresponding moment from the US distribution reported by these authors.

grating over all non-exporters, and finally taking the ratio of the two yields the exporter sales advantage at home, which we denote by $\tilde{H}_1$:

$$\tilde{H}_1 = \frac{\left[\left(\frac{\hat{c}_{ii}}{\tilde{c}_{ij}}\right)^{\kappa} - 1\right]\left[B\left(\frac{\tilde{c}_{ij}}{\hat{c}_{ii}}; \kappa, \gamma+2\right) + (1+\gamma)\, B\left(\frac{\tilde{c}_{ij}}{\hat{c}_{ii}}; \kappa+1, \gamma+1\right)\right]}{B(\kappa, \gamma+2) - B\left(\frac{\tilde{c}_{ij}}{\hat{c}_{ii}}; \kappa, \gamma+2\right) + (1+\gamma)\left[B(\kappa+1, \gamma+1) - B\left(\frac{\tilde{c}_{ij}}{\hat{c}_{ii}}; \kappa+1, \gamma+1\right)\right]},$$

where $B(u; z, h)$ is the incomplete (Euler) Beta function:

$$B(u; z, h) = \int_0^u t^{z-1}(1-t)^{h-1} dt.$$

To see that $\tilde{H}_1$ depends on $\mathbf{P}$ only, define $y_{ij} \equiv \frac{max_{k \neq i} E_k \tau_{ik}{}^{-1}}{E_i}$. Using the expressions for cost cutoffs in (16) and (56), it immediately follows that $\frac{\hat{c}_{ii}}{\tilde{c}_{ij}} = y_{ij}^{-1}$. Then, our desired moment, now denoted by H_1, can be rewritten as:

$$H_1(\mathbf{P}) = \left[y_{ij}^{-\kappa} - 1\right] \cdot \frac{B(y_{ij}; \kappa, \gamma+2) + (1+\gamma)\, B(y_{ij}; \kappa+1, \gamma+1)}{B(\kappa, \gamma+2) - B(y_{ij}; \kappa, \gamma+2) + (1+\gamma)\left[B(\kappa+1, \gamma+1) - B(y_{ij}; \kappa+1, \gamma+1)\right]}, \tag{57}$$

where the dependence on $\mathbf{P}$ is made explicit.

Exporter measured productivity advantage The second moment of interest is the measured productivity advantage of exporters over non-exporters. In the absence of intermediate goods, the value added of a firm is the ratio of its sales to the number of employees. Firm sales are given in expression (37). To derive the number of workers, notice that the production function of a $c-$firm from country i selling in country j is $x_{ij} = l_{ij}/(\tau_{ij} c)$, where $\tau_{ij} c$ is its "unit labor requirement" and $l_{ij}(c) = \tau_{ij} c x_{ij}(c)$ its conditional labor demand. The corresponding number of employed workers is given by $\tau_{ij} c x_{ij}(c)/e_i$.

With this in mind, the measured productivity, or the value added per worker, of a non-exporter with cost draw $c \in [\tilde{c}_{ij}, \hat{c}_{ii}]$ from country i is:

$$va_i^{nx}(c) = \frac{e_i t_{ii}(c)}{c \tau_{ii} x_{ii}(c)} = w_i e_i \left[1 + m_{ii}(c)\right].$$

Similarly, the measured productivity, or the value added per worker, of an exporter with cost draw $c < \tilde{c}_{ij}$ is:

$$va_i^{x}(c) = \frac{e_i \sum_{k \in K_i(c)} t_{ik}(c)}{c \sum_{k \in K_i(c)} \tau_{ik} x_{ik}(c)},$$

where $K_i(c)$ is the set of destinations k such that $c \leq \widehat{c}_{ik}$.

Taking logs of both variables, integrating over all exporters and non-exporters, respectively, and taking the difference of the two yields the exporter measured productivity advantage (in percentage terms)[39], which we denote by $\tilde{H}_2$:

$$\tilde{H}_2 = \int_0^{\tilde{c}_{ij}} \log(va_i^x(c)) \frac{\kappa c^{\kappa-1}}{\tilde{c}_{ij}^{\kappa}} dc - \int_{\tilde{c}_{ij}}^{\hat{c}_{ii}} \log(va_i^{nx}(c)) \frac{\kappa c^{\kappa-1}}{\hat{c}_{ii}^{\kappa} - \tilde{c}_{ij}^{\kappa}} dc.$$

As was the case for $\tilde{H}_1$ above, it can be shown that $\tilde{H}_2$ can be re-expressed in terms of $\mathbf{P}$ and $\mathbf{\Lambda}$, and denoted by $H_2(\mathbf{P}, \mathbf{\Lambda})$. Due to the length of the argument, we relegate the details to Appendix D.

Wages The two firm-level moments derived above rely on the endogenous wage, w_i, of the country whose exporters are simulated. In principle, should we simulate exporters for all countries, we would need to separately identify wages for all countries. However, the exporter moments that we will try to reconcile are only made available for US exporters by Bernard *et al.* (2003). Assuming that the two key parameters, κ and γ, are not country-specific, we can generate the moments from the model for US exporters by only simulating observations for US exporters. In this case, we let $w_{US} = 1$.

4.3 Simulation algorithm

In this model, there exists a continuum of firms; hence, the first step in the simulation is to recognize that the continuum needs to be discretized and the number of simulated draws has to be large enough so as to best approximate the entire continuum. In principle, one would need to simulate a very large number of draws for each country; which can be a daunting task. The task, however, is greatly simplified due to the fact that cost draws are transformations of random variables drawn from a parameter-free uniform distribution, where the transformation function depends on $\mathbf{P}$. This powerful insight draws on arguments first made transparent by Bernard *et al.* (2003) within the context of a model with a fixed measure of firms and subsequently by Eaton *et al.* (2011) within a model with an endogenous measure of firms.

Recall that our goal is to simulate a large number of cost draws, c, from the pdf given by $g_i(c) = \kappa c^{\kappa-1}/\hat{c}_{ii}^{\kappa}$, which ensures that $c \in [0, \hat{c}_{ii}]$ for all i.[40] Given these draws, we can proceed to compute exporting costs and determine the subset of firms from each source country i that serve

[39] See the preceding footnote.

[40] It would be futile to simulate firms with higher cost draws than this upper bound because they would immediately exit in equilibrium.

each destination j. With this in mind we proceed as follows. We draw 500,000 realizations[41] of the uniform distribution on the $[0, 1]$ domain, $U[0, 1]$, we order them in increasing order, and find the maximum realization, denoted by $u^{\max}$. Then, we let $c = (u/u^{\max})^{\frac{1}{\kappa}} \hat{c}_{ii}$. Notice that $c \in [0, \hat{c}_{ii}]$ by construction, and it has pdf of $g_i(c) = \kappa \frac{c^{\kappa-1}}{\hat{c}_{ii}^{\kappa}}$; yet the normalization allows us to utilize all draws. Multiplying each c by the appropriate wage rate and trade cost yields the cost to serve each market. Comparing this cost to the cost cutoff for each source-destination pair determines the set of exporters to every destination.

What remains is to decide the source-destination cost cutoff pair that serves as numeraire. This choice depends on the particular exercise that one intends to engage in. The objective of the normalization, however, is always the same: the numeraire is chosen so as to maximize the usage of the 500,000 draws from the uniform distribution. As we describe below, we choose to identify the key parameters of interest, κ and γ, from moments for US firms; thus, we need to simulate observations for all US producers—both domestic and exporting. To maximize the number of draws used, we choose the numeraire cost cutoff to be $\hat{c}_{US,US}$. Hence, all simulated firms serve at least the US and a subset of them serve different export markets.

4.4 Estimation

In order to numerically generate the moments from the model that we outline above, we first need to estimate the model's parameters and then simulate micro-level data. The estimation can be divided into the following three steps: (i) estimate a set of country(-pair) parameters using the model's predicted gravity equation of trade and data; (ii) use gravity-based estimates, together with data on population size, to estimate per-capita income levels from the model's market clearing condition; (iii) use parameters from (i) and (ii), together with moments of choice to identify the remaining parameters, γ and κ.

Step 1 The empirical gravity equation of trade that corresponds to the theoretical prediction derived in expression (52) is given by:

$$\log\left(\frac{\lambda_{ij}}{\lambda_{jj}}\right) = \tilde{S}_i - \tilde{S}_j - \kappa \log \tau_{ij} + \varepsilon_{ij}, \tag{58}$$

where ε_{ij} is a country-pair residual error term. We assume that the bilateral trade cost takes on the following functional form:

$$\log \tau_{ij} = \beta_d \log d_{ij} + ex_i + \boldsymbol{\beta}_k \mathbf{d}_k + \beta_h d_h, \tag{59}$$

[41] The quantitative results are nearly identical when we use a grid of 2,000,000. One key difference is that US exporters serve a larger number of destinations in this case; namely, there are fewer zeros in the trade matrix.

where β_d is the coefficient estimate on the log of the bilateral distance in kilometers, d_{ij}, ex_i is an exporter fixed effect as in Waugh (2010), d_h is an indicator that takes on the value of 1 if trade is internal with coefficient β_h, and $\boldsymbol{\beta}_k$ is a 5×1 vector of coefficients on a matrix of 5 indicators, $\mathbf{d}_k$, where each indicator takes on the value of 1 if countries i and j: (i) share a border, (ii) have a common official or primary language, (iii) have a common colonizer post 1945, (iv) have a regional trade agreement (RTA) in force, and (v) share a common currency.

After substituting expression (59) into (58), we estimate the coefficients for 123 countries via OLS using source and destination fixed effects.[42] We exclude trade share observations that take on the value of zero. A description of the (standard) datasets used in the estimation and the results from the gravity estimation can be found in Appendix E. We present the estimates of the gravity equation in Appendix G, and we plot the predicted and actual trade shares in Appendix F.

A couple of notes are in order. First, all parameter estimates pertaining to the trade costs are scaled by κ. Thus, the gravity equation allows us to estimate $\kappa \log \tau_{ij}$ only, rather than to separately identify κ from τ_{ij}. We present our identification strategy for κ in Step 3 below. Second, domestic trade costs are also estimated in this step and they are not necessarily equal to unity. Hence, before we proceed, we normalize all international trade costs, relative to their domestic counterparts.

Step 2 We compute per-capita incomes using the model's implied market clearing equation together with data on trade shares and population size for all 123 countries. In particular, we employ the first equality in expression (24), where by definition per-capita income in country i is $E_i = w_i e_i$. After normalizing population size, L_i, relative to a numeraire country, which we take to be the US, we can obtain per-capita incomes, E_i, for all $i \neq US$, relative to the US, using data on L_i and λ_{ij} for all i, j from this very expression. We describe the data sources in Appendix E and we plot the predicted and actual per-capita income in Appendix F.

Step 3 It remains to choose an identification strategy for the key remaining parameters that characterize the welfare gains from trade: κ and γ. In principle, these two parameters govern more than two moments in the model. Hence, different sets of moments will result in different estimates for these parameters, different fits of model to data, and different estimates of the gains from trade. The main challenge is to select the moments that are (i) most informative about these two parameters and (ii) directly informative about the welfare gains from trade. To the extent that we also intend to quantify the importance of the assumptions made regarding

[42]For a detailed discussion on how to separately identify the coefficients S_i from ex_i see Simonovska and Waugh (2014a).

consumer preferences, and to compare the welfare gains of our model to the ones predicted by the standard homothetic model, an additional challenge is to select moments that yield identical parameter estimates of κ across models so that all departures relative to the standard framework are due to the "demand" side of the model. With these challenges in mind, we engage in alternative identification exercises, which we describe below.

Step 3.a.—Fixing the Supply Side The parameter κ is a supply-side parameter in models of micro-level heterogeneity. It is the shape parameter that governs the dispersion of the intrinsic productivity distribution, Pareto, in our model as well as in the ACR class of models based on CES preferences.[43] Since these models differ in their pricing predictions, however, the distribution of the measured productivity, defined above as the value added per worker of each firm, differs across them. Thus, targeting moments from the measured productivity distribution will result in different estimates of κ across models, which will make it difficult to distinguish the contribution of the demand versus the supply side of each model toward welfare. From the gravity equation of trade, however, κ can be interpreted as the partial elasticity of trade flows with respect to variable trade costs. Crucially, since both models yield an identical gravity equation of trade, if the parameter could be estimated using the gravity moment alone, then both models would have to yield identical estimates of κ.

Estimating this parameter using the gravity equation alone is challenging and has been the focus of many papers—see Simonovska and Waugh (2014a,b) and Caliendo and Parro (2015) for recent contributions and a discussion of the related literature. Such a task is beyond the scope of this paper. Instead, for the purposes of this exercise, we let $\kappa = 5$, which is the preferred estimate of ACR and ACDR, and approximately the average estimate of the trade elasticity across sectors obtained by Caliendo and Parro (2015). For robustness, we will propose below another strategy to identify this parameter and we will explore the quantitative implications of our model within that setting.

The parameter γ is a demand-side parameter in our model—it governs the elasticity of demand with respect to price as well as the elasticity of price with respect to income. Consequently, the parameter is at the heart of the model's pricing predictions, which are the key departure from the standard ACR framework. In addition, for given κ, γ governs the distribution of firm sales. These two observations imply that γ is a critical input into the firm sales-weighted elasticity of price with respect to income, which quantifies the differences in welfare gains predicted by our and the homothetic model. Hence, we proceed with an overidentified estimation strategy for γ and target (i) the average elasticity of price with respect to income from micro-level data and (ii) the domestic sales advantage of exporters over non-exporters for

[43] The same statement applies to the class of directly additive models in ACDR.

the US.

We choose these moments for the following reasons. First, our model differs from existing alternatives precisely along the pricing dimension—it predicts that the price elasticity with respect to income is positive, while the price elasticity with respect to market size is zero. Therefore, targeting the price elasticity with respect to income seems to be a natural choice. Second, it is the price elasticity with respect to income, weighted by each firm's relative sales, that constitutes the object that governs the welfare gains in our model. Therefore, the distribution of firm sales together with the price elasticity with respect to income are crucial elements in determining the magnitude of welfare gains from trade.

In sum, we let $\kappa = 5$ and, to identify γ, we combine objects from Steps 1 and 2 with the following model-generated moments: (i) the domestic sales advantage of US exporters over non-exporters, or $H_1(\mathbf{P})$ given in expression (57) and (ii) the average elasticity of price with respect to income from micro-level data, or $\mathbb{E}\left\{\epsilon_E\right\}$ given in expression (53). To compute the first moment, we fix the source country $i = US$ and we consider all 123 potential destinations referred to in Steps 1 and 2 above (the second moment is country invariant in the model). Finally, we employ the simulated methods of moment (SMM) estimator with an identity weighting matrix.

Step 3.b—Flexible Estimation The previous exercise aims at quantifying the differences in welfare gains predicted by our model and the ACR benchmark. Another interesting exercise is to let our model attempt to match a number of moments in the data and to evaluate its quantitative fit along different dimensions. Once parameterized as such, the model can be used to perform counterfactual exercises of interest.

For this purpose, we engage in the following quantitative exercise: We identify γ and κ by jointly targeting the following three moments: (i) the average elasticity of price with respect to income from micro-level data, (ii) the domestic sales advantage of exporters over non-exporters for the US, and (iii) the measured productivity advantage of exporters over non-exporters for the US. The third moment, which is new to this strategy, seems natural as κ governs the shape of the productivity distribution in the model. We proceed to evaluate the estimated model's performance along a number of dimensions including moments from the cost pass-through elasticity and mark-up distributions, export intensity, and the margins of trade. Finally, we use the estimated model to quantify the welfare gains and losses from the Transatlantic Trade and Investment Partnership to negotiating members as well as non-members.

In sum, to identify κ and γ we combine objects from Steps 1 and 2 with three model-generated moments: (i) the domestic sales advantage of US exporters over non-exporters, or $H_1(\mathbf{P})$ given in expression (57); (ii) the value-added advantage of US exporters over non-exporters, or $H_2(\mathbf{P}, \mathbf{\Lambda})$ given in expression (69) in Appendix D; and (iii) the average elasticity of price with respect to income from micro-level data, or $\mathbb{E}\{\epsilon_E\}$ given in expression (53). To compute the first two moments, we let the source country $i = US$ and we consider all 123 potential destinations referred to in Steps 1 and 2 above (the third moment is country invariant in the model). Once again, we employ the SMM estimator with an identity weighting matrix.

On the technical side, to compute the first two moments, we need to separately identify w_{US} from e_{US} because only w_{US} enters unit costs of production as well as cost cutoffs. Since we normalize all per-capita incomes (and sizes) relative to the US, this would imply that both $w_{US} = 1$ and $e_{US} = 1$. Notice that by construction this implies that we need to normalize all S_k's relative to S_{US} so that $S_{US} = 1$. Because $\log(S_k)$ is the object that we estimate from gravity, we first exponentiate this object for every k and then we divide it through by the exponent of the object for the US.

5 Quantitative Results

In this section we report the results from the two quantitative exercises described above.

5.1 Welfare Gains from Trade: Addilog vs CES

Let us focus on the first exercise described in Step 3.a. Table 1 summarizes the two moments that we target, the data sources, as well as the resulting parameters that match those moments.[44] The price elasticity moment is the preferred estimate obtained by Simonovska (2015).[45] In this overidentified approach, we employ the identity matrix to weigh the two moments that the two parameters attempt to jointly match.[46]

[44]The firm-level moments reported in Bernard *et al.* (2003) are for the universe of US firms in 1992. Bernard *et al.* (2007) document similar statistics using 2002 US firm-level data.

[45]In Table 1 of their paper, Alessandria and Kaboski (2011) estimate this parameter using HS-10 digit unit value data for US exports of final/consumption goods recorded at the port of shipping to 28 destinations during the 1989-2000 period. While the prices do not include shipping costs and destination-specific non-tradable components, they may reflect quality variations, which is why we opt to target the moment in Simonovska (2015) instead. Two observations are in order. First, our model predicts that the mean price elasticity is country invariant; thus, combining the sales moment for the US with the price elasticity moment for Spain is not problematic. Second, re-estimating the model with Alessandria and Kaboski's (2015) moment as a target yields a value for γ of 1.0304, which is nearly identical to the estimate obtained in this section.

[46]For robustness, we added a third moment to the estimation in this section, namely, the measured productivity advantage of US exporters over non-exporters. Using the identity weighting matrix, we obtain a value for γ of 1.0307, which is nearly identical to the estimate obtained in this section. Hence, this moment does not contain much additional information on γ, given κ.

Table 1: Moments and Parameters

Moment	Model	Data	Source
US Exporter Sales Advantage	4.81	4.8	BEJK
Mean Price Elasticity of Income	0.54	0.14	Simonovska
Population, relative to US	(N-1)x1 vector		WDI
Bilateral trade shares	Gravity		Comtrade
Parameter	**Value**		
γ	1.031		
κ	5		
L	(N-1)x1 vector		
τ	Gravity		

5.1.1 The estimated demand is linear

Table 1 shows that our model matches the sales advantage moment nearly perfectly. However, this comes at a cost: the model is unable to perfectly match the average price elasticity reported in the data and it predicts an elasticity that is considerably higher. Intuitively, for a given κ, there is a tension between the sales advantage and the price elasticity moment. The sales advantage moment is relatively more sensitive to changes in values of γ than the price elasticity moment — the former rises very rapidly with increases in γ — so the model requires γ to remain relatively low. The quantitative result, however, is striking: the estimate of γ is nearly unity, which corresponds to the linear demand case of the addilog preferences.

Therefore, to proceed with the quantitative comparison of welfare relative to the ACR framework based on CES preferences, we focus on this simple linear demand model. First of all, a comparison of our approximate formula for the welfare gains (50) and the formula (31) that holds for CES and homothetic preferences provides an immediate "back of the envelope" calculation. Given $\kappa = 5$ and $\gamma = 1$, the linear demand model implies gains from any liberalization experiment that are approximately $\frac{\gamma}{(\gamma+1)(\kappa+1)}/\frac{1}{\kappa} = \frac{5}{12}$ of the ACR gains. Hence, the mismeasurement of welfare is quantitatively large (our model yields welfare gains that are less than one half of the ACR gains). In the next section we make this insight more precise looking at the exact formula for the welfare gains (51).

5.1.2 Welfare cost of autarky

We now compute the exact welfare gains of moving from autarky to the observed trade share for each country in year 2004 as predicted by the ACR framework for the CES model and by our "addilog" model. For the first case, we let $\kappa = 5$ and we use the formula (31) to arrive at the welfare measure. For the "addilog" model, we let $\kappa = 5$, and we use the welfare measure for large shocks (51) with $\gamma = 1$. For both models, we use the domestic expenditure shares

(1-trade share) before and after the shock. In the case of the linear demand model, the welfare gains due to a global shock require values for per-capita income, and we let those correspond to the values before the shock. In this particular exercise, the domestic expenditure share goes from the observed share in the data to unity (autarky).

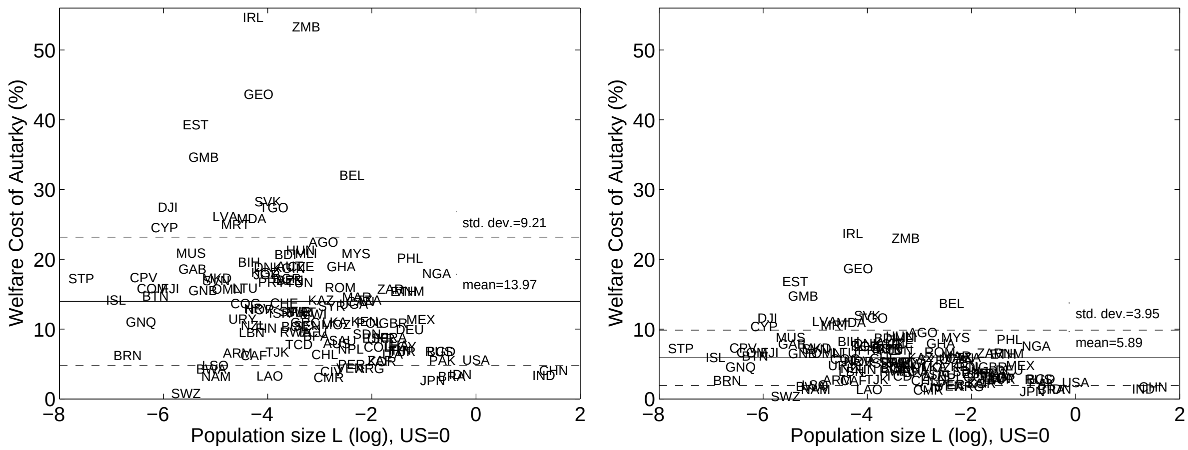

Figure 1: Welfare Cost of Autarky in CES and Linear Demand Models, 123 Countries

The left panel of Figure 1 plots the results for the ACR framework based on CES preferences, while the right shows the predictions of our linear demand model. The differences are striking. The average country enjoys an 14% welfare gain from trade according to the ACR framework. In contrast, our linear demand model yields a mean value of only 6%, less than a half of that predicted by the homothetic model. While the ranking of countries according to welfare gains is identical in the two models, the dispersion in the ACR framework is much larger than the one predicted by the linear demand model.

To further understand the difference in magnitudes that we obtain relative to the literature, we focus attention on the US. ACR report that, for a US domestic expenditure share of 0.93 and a value for the Pareto shape parameter of 5-10, the welfare gains of moving away from autarky range from 0.7% to 1.4%. First, we point out that, in our database, for year 2004, we obtain a US domestic expenditure share on *manufacturing*, adjusted for trade imbalances, of 0.75. Thus, we cannot directly compare the estimate for the US reported in the plot above to the estimate reported in ACR. Second, let us assume that indeed the domestic expenditure share is 0.93 as reported in ACR and that κ is 5. Then, the welfare gains from trade for the US predicted by the ACR framework would amount to 1.4%. In contrast, the welfare gains predicted by the linear demand model would amount to a mere 0.6%, less than half of the value predicted by ACR. Thus, it is reasonable to conclude that the welfare gains from trade may be substantially overestimated, should one rely on CES (or homothetic) preferences.[47]

5.2 Quantitative Performance of the Addilog Model

In this subsection, we focus on the second exercise described in Step 3.b above.

Table 2: Moments and Parameters

Moment	Model	Data	Source
US Exporter Productivity Advantage	0.35	0.33	BEJK
US Exporter Sales Advantage	4.81	4.8	BEJK
Mean Price Elasticity of Income	0.43	0.14	Simonovska
Population, relative to US	(N-1)x1 vector		WDI
Bilateral trade shares	Gravity		Comtrade
Parameter	**Value**		
γ	1.919		
κ	2.772		
L	(N-1)x1 vector		
τ	Gravity		

Table 3: Predicted VS. Actual Moments

Moments	Model	Data	Source
US Exporters, % All firms	16.27	18 - 21	Bernard et al., BEJK
Export Intensity (%)			BEJK
0-10	80.2	66	
10-20	10.5	16	
20-30	4.4	7.7	
30-40	2.0	4.4	
40-50	1.2	2.4	
50-60	0.7	1.5	
60-100	1.0	2.8	
Mark-up, mean, %	19.34	5 - 40	Jaimovich & Floetotto
Cost pass-through, mean, %	0.57	0.36 - 0.57	De Loecker et al.
Log E, rel. US, mean	-3.03	-2.70	WDI
(standard deviation)	(2.67)	(1.66)	
Moments	**Corr**	**(model,data)**	
Log E, 123 countries	0.87		
λ , 123 countries	0.91		

Table 2 summarizes the three moments that we target in the estimation as well as the resulting parameter estimates. When we let κ and γ jointly match moments from the sales,

[47] It is important to remark that ACDR estimate a model based on directly additive preferences that generalizes CES preferences and obtain a measure of welfare gains that is 96% of the value predicted by the standard ACR framework.

measured productivity, and price elasticity distribution, the estimated γ amounts to 1.92, while κ centers around 2.77. In practice, the estimate implies a slightly convex demand function and higher dispersion of costs. Moreover, the model generates roughly the same values for the targeted moments as in the previous exercise, although the predicted welfare gains nearly double (plugging the values for κ and γ in the local welfare formula in expression (50) arrives at this conclusion).

In Table 3 we explore the basic fit of the estimated model to a variety of moments. Unlike the moments displayed in Table 2, which we target in the identification of the model's parameters, the moments in Table 3 serve for external validation as they are not targeted. The model predicts that the share of US firms that export is roughly 16%, in line with US data for year 1992 reported in Bernard *et al.* (2003). The resulting export intensity in the model is even more skewed than observed in the data and it reflects the prediction that a large number of US firms that export sell very little abroad—that is to say most exporters sell tiny amounts abroad even though they enjoy a large domestic sales advantage over non-exporters.

Furthermore, the mean price elasticity with respect to the real exchange rate is equivalent to the mean price elasticity with respect to per-capita income of 0.43 (the median being 0.4), while the mean plus one standard deviation estimate is 0.51. We interpret these elasticities as equilibrium elasticities for the broad manufacturing sector. These estimates are qualitatively in line with, but exceed in magnitude, the findings in Berman *et al.* (2012) for a set of French exporters to non-Eurozone destinations.

The average cost pass-through predicted by the model is exactly one minus the pricing-to-market elasticity reported above and amounts to 0.57, which is within the range of 0.36-0.57 reported by De Loecker *et al.* (2015) for Indian manufacturing firms. Finally, given our estimated parameters, the average markup amounts to 19%, which is in line with common findings in the macroeconomic literature (see Jaimovich and Flotetto, 2008).

5.2.1 Prices across destinations

Our model predicts that prices are increasing in destination per-capita income and are independent of destination population size. Given our estimates of κ and γ , the mean elasticity of price with respect to per-capita income is 0.43. In turn, the price elasticity with respect to population is zero. These estimates compare qualitatively to estimates reported in the empirical literature, although the predicted elasticity of price with respect to income does exceed the corresponding moment in the data. In particular, Simonovska (2015) finds that a Spanish apparel retailer systematically price discriminates according to the per-capita income of destinations. The typical elasticity estimate that the author obtains circles around 0.14, which corresponds to one of the targets that we use in our estimation. While the predicted moment exceeds the target, we interpret the model as representing the broad manufacturing sector rather than apparel alone.

Table 4: The Cross-Section of Prices

	(1)	(2)
Log(pcincome)	0.137***	0.130***
	(0.030)	(0.036)
Log(L)	0.021	0.016
	(0.023)	(0.025)
Log(τ)	0.044	
	(0.056)	
Log(weighted tariff)	-0.006	0.001
	(0.029)	(0.040)
Landlocked		-0.016
		(0.111)
Island		0.027
		(0.088)
Eurozone		0.067
		(0.073)
R^2	0.47	0.47
# Observations	7480	7480

Notes: All variables are relative to US. *** indicate significance at 1%-level. Standard errors in parentheses.

Estimates of the elasticity of price with respect to destination income and population size for a broad set of manufacturing products are not available as detailed price data as the dataset employed by Simonovska (2015) are only available for a handful of producers/sectors. We do, however, find supporting evidence in favor of the author's findings, which are in line with the indirectly additive model, using more aggregate data. In particular, we obtain prices for 110 products with identical characteristics available in a subset of 71 of the countries used in the analysis above. The source of the data is the International Economist Unit (EIU), which we describe in Appendix E. Unlike in Simonovska (2015), our data are not sufficiently detailed so as to be able to argue that price variation across destinations is entirely due to pricing to market; in particular, prices in our dataset may differ across destinations due to differences in quality or non-tradable components as well. Nonetheless, we can use the data to verify whether similar patterns hold true as in the existing empirical literature.

In Table 4, we perform two sets of exercises whereby we regress logged prices, relative to the price in the US, against logged per-capita income and logged size, controlling for trade costs. In the first exercise, we approximate trade costs by the average tariff in each destination and the average iceberg trade cost as estimated from the gravity equation of trade, weighted by trade shares. In the second exercise, we replace the estimated iceberg trade cost with three indicator variables that take on the value of one if the destination is: (i) landlocked; (ii) an island; or

(iii) in the Eurozone. We estimate the coefficients via OLS, using product-level fixed effects, and we cluster all standard errors by country. We describe all data sources in Appendix E.

The elasticity of price respect to per-capita income that we obtain from the two regressions is roughly 0.13 and it is statistically significant at the 1% level. Hence, we confirm that, even in a broader set of countries and industries, the positive elasticity of price with respect to per capita income persists. The elasticity with respect to size in both regressions is not statistically different from zero, which is in line with our theory.

5.2.2 Aggregate moments and the margins of trade

In Appendix F, we report the model's predicted per-capita income levels and bilateral trade flows for all 123 countries used in the quantitative analysis. As summarized in Table 3, the correlation between predicted and actual per-capita income is 0.87 (in logs), and the correlation between bilateral trade flows is 0.91. In the same Appendix we discuss the model's quantitative predictions regarding the extensive and intensive margin of trade. The model predicts that the elasticity of the extensive margin with respect to destination per-capita income equals κ, while the same elasticity with respect to trade costs equals $-\kappa$ (see expression (54)). Since trade barriers are increasing in distance, our model's predicted elasticity with respect to distance is necessarily negative. In Appendix F, we show that the estimated model yields elasticities of the US extensive margin with respect to destination per-capita income, size, and distance of 2.8, 0.05, and -1.9, respectively, and only the first and the last are statistically significant. Along the intensive margin dimension, the model predicts that, controlling for aggregate effects, (i) the elasticity of the intensive margin with respect to destination GDP is 1; (ii) the elasticity of the intensive margin with respect to destination per-capita income is $-\kappa$, or -2.8 given our estimate.

Both findings are potentially in line with the existing empirical literature; however, the literature typically does not distinguish between the effects that per-capita income and market size have on the margins of trade. We leave for future research to conduct empirical investigations using detailed firm-level data to help discern the role of these two variables in driving the margins of trade so as to better evaluate the performance of different models.

5.2.3 Counterfactual analysis: the TTIP

Given the addilog model's favorable performance with respect to data, in this section, we use the estimated addilog model to evaluate the welfare gains from a bilateral reduction in trade costs between the US and the European countries that are currently involved in the negotiation of the TTIP.[48] We view the exercise as a first pass toward understanding the welfare gains from such an agreement. Clearly, a detailed multi-sector model as well as detailed recent data would be needed in order to carefully analyze the gains from the agreement for the countries involved.

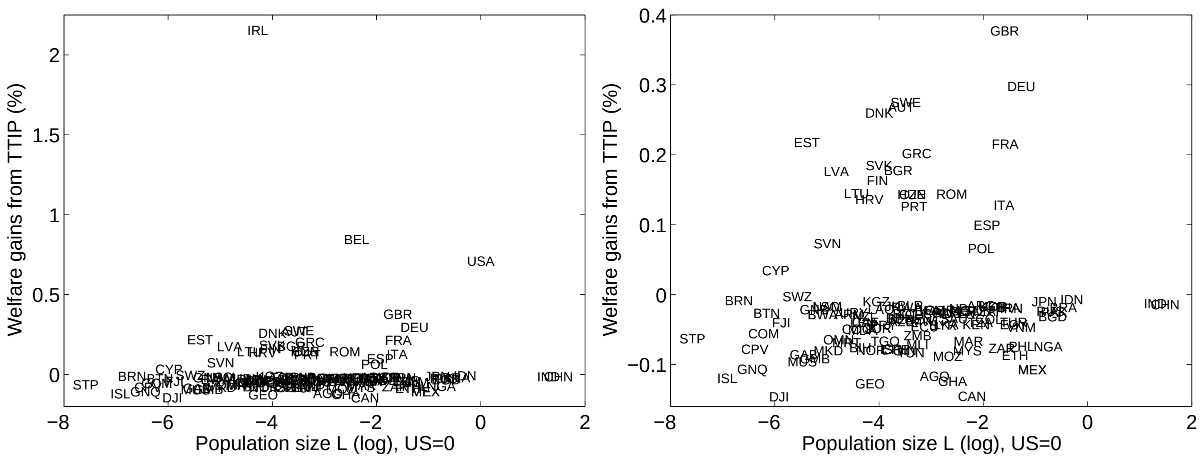

Figure 2: Welfare Gains From TTIP, 123 Countries

To quantify the gains from TTIP, we proceed as follows. First, we set the RTA indicator in the trade-cost function in expression (59) to unity for the country pairs that involve the USA and each of the European TTIP potential members. Second, we use the gravity coefficient estimates, as well as the estimate of κ, to compute new bilateral trade barriers. Third, we compute the percent reduction on trade barriers for the US and the European TTIP potential members. The mean percent reduction in trade barriers among TTIP countries is 16%, while the trade barriers for non-TTIP countries remain unchanged by construction. Finally, to compute the welfare gains, we plug the computed change in trade barriers into the system (28), using actual trade shares and predicted income, which jointly satisfy the market clearing conditions given by the system of equations in (24).

We report the results for all the countries in the left panel of Figure 2. Clearly, TTIP members gain from the liberalization, but the gains are asymmetric. The US enjoys welfare gains of roughly 0.7% and Belgium (alongside Luxembourg and the Netherlands) gains by roughly 0.8%. Ireland is the biggest winner with gains amounting to more than 2%. To obtain a better sense of the results, in the right panel of Figure 2, we zoom in on the countries with gains below 0.4%. The mean gains among TTIP members are 0.3% with a standard deviation of

[48] These countries include: Austria, Belgium (together with Luxembourg and the Netherlands in our dataset), Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Latvia, Poland, Portugal, Romania, Slovenia, Slovakia, Sweden. Malta is also involved in the TTIP negotiations, however, it is not in our sample due to data limitations.

0.4%. Non-members suffer losses which amount to an average of -0.04%. Among non-members, USA's major trade partners Mexico and in particular Canada experience some of the largest losses.[49] Overall, however, the gains far exceed the losses in world welfare.

6 Conclusion

The contribution of this work is to introduce IA preferences to the international trade literature, quantify the welfare gains from trade under this class of preferences, and propose a parametric specification, the addilog, that is highly tractable and useful for quantitative work. The model avoids the pervasive markup neutralities emerging in the CES model (Melitz, 2003) and the limits of quasilinear preferences in general equilibrium applications (Melitz and Ottaviano, 2008). Between variable markup models, this is the only one able to deliver prices increasing in destination income, independent from population of the destination country and characterized by incomplete pass-through, with variable elasticities for firms of different productivity. Moreover, the model has novel implications for the extensive and intensive margins of trade that appear promising in front of the limited evidence. The implication of such a model for the gains from trade liberalization, however, is our main result: these gains can be much lower than those implied by the models based on homothetic or directly additive preferences analyzed in ACR and ACDR.

Our setting could be usefully extended to consider strategic interactions (Atkeson and Burstein, 2008 and Etro, 2015), heterogenous consumers and quality differentiation (Fajgelbaum *et al.*, 2011), more general preferences,[50] endogenous labor supply and a 2x2x2 model with an outside good sold in a perfectly competitive setting to study the interplay with inter-industry trade. Our tractable non-homothetic preferences could also be exploited for dynamic analysis of structural change and business cycles.

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[49] The losses suffered by TTIP non-member countries in our exercise are of some interest since it is often claimed by the proponents that the benefits for the EU and the US would not be at the expense of the rest of the world (see e.g. Francois, 2013). However, it is also usually recognized that it will be somehow necessary to harmonize TTIP with NAFTA on the American side and with EFTA on the European side.

[50] A first analysis of monopolistic competition with general symmetric preferences (including any non-additive and non-homothetic preferences) can be found in Bertoletti and Etro (2016b).

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Appendix

A Social Planner Solution with IA Preferences

Consider the Social Planner Problem for the model of Section 2:

$$\begin{aligned} & \max_{N,\widehat{c},x(c),s(c)} \left\{ N \int_0^{\widehat{c}} v\left(s(c)\right) dG(c) \right\} \\ s.v. \quad : \quad & N \left[\int_0^{\widehat{c}} cx(c) L dG(c) + F_e \right] = eL, \\ x(c) \quad = \quad & \frac{v'\left(s(c)\right)}{N \int_0^{\widehat{c}} v'\left(s(c)\right) s(c) dG(c)}, \end{aligned}$$

where the first is a resource constraint and the second is the demand associated with our preferences. Combining the two constraints we simplify them to the condition:

$$L \int_0^{\widehat{c}} v'\left(s(c)\right) c dG(c) = \left(eL - NF_e\right) \int_0^{\widehat{c}} v'\left(s(c)\right) s(c) dG(c).$$

Given positive values for N and $\widehat{c}$, consider the Lagrangian:

$$\ell = \int_0^{\widehat{c}} \left\{ v\left(s(c)\right) - \lambda v'\left(s(c)\right) \left[\left(eL - NF_e\right) s(c) - Lc \right] \right\} g(c) dc.$$

Pointwise maximization for $s(c)$ provides:

$$v'\left(s(c)\right) - \lambda v''\left(s(c)\right) \left[\left(eL - NF_e\right) s(c) - Lc \right] - \lambda v'\left(s(c)\right) \left(eL - NF_e\right) = 0,$$

which can be rearranged as:

$$s(c) = \frac{\lambda\theta(c)Lc}{\lambda\left[\theta(c)-1\right](eL-NF_e)+1}$$

after using $\theta(c) \equiv -v''(s(c))s(c)/v'(s(c))$, assumed larger than unity. Replacing in the constraint we have:

$$\int_0^{\widehat{c}} v'\left(s(c)\right)c\left[L - \frac{(eL-NF_e)\,\lambda\theta(c)L}{\lambda\left[\theta(c)-1\right](eL-NF_e)+1}\right]dG(c) = 0,$$

which requires that the squared parenthesis is null, or $\lambda = 1/\left(eL - NF_e\right)$. This implies a linear optimal price function:

$$s(c) = \frac{Lc}{eL - NF_e}.$$

Using this, we can consider the residual problem:

$$\max_{\widehat{c},N}\left\{N\int_0^{\widehat{c}} v\left(\frac{Lc}{eL-NF_e}\right)dG(c)\right\}.$$

Due to the absence of fixed costs of production, it is always optimal to consume any good that provides positive utility by setting:

$$\widehat{c}(N) = ae\left(1 - \frac{NF_e}{eL}\right).$$

Therefore, the previous problem simplifies to:

$$\max_N N\int_0^{\widehat{c}(N)} v\left(\frac{Lc}{eL-NF_e}\right)dG(c),$$

whose first order condition is:

$$\int_0^{\widehat{c}(N)} v\left(s(c)\right)dG(c) + \frac{NF_e}{eL-NF_e}\int_0^{\widehat{c}(N)} v'\left(s(c)\right)s(c)dG(c) = 0.$$

This can be solved for:

$$N^* = \frac{eL}{F_e(1+\bar{\eta})},$$

where we defined $\bar{\eta}$ as a weighted average of the elasticity of the subutility $\eta(s) = -v'(s)s/v(s) > 0$, that is:

$$\bar{\eta} \equiv \int_0^{\widehat{c}(N^*)} \eta\left(s(c)\right)\frac{v(s(c))}{\int_0^{\widehat{c}(N^*)} v\left(s(c)\right)dG(c)}dG(c) > 0.$$

It follows that the optimal cost cutoff is:

$$\widehat{c}^* = \frac{ae\bar{\eta}}{1+\bar{\eta}} < ae,$$

which implies that an excessive fraction of goods is consumed in equilibrium. Finally, the optimal price is:

$$p^*(c) = c\left(1+\frac{1}{\bar{\eta}}\right),$$

which is linear in the marginal cost.

Notice that, integration per parts (using the linearity of $s(c)$ and assuming that $v(s(0))$ is finite) delivers:

$$\int_0^{\widehat{c}(N^*)} v'\left(s(c)\right) s(c) dG(c) = \left[v\left(s(c)\right) cg(c)\right]_0^{\widehat{c}(N^*)} - \int_0^{\widehat{c}(N^*)} v\left(s(c)\right)\left[g(c) + cg'(c)\right] dc$$

$$= -\int_0^{\widehat{c}(N^*)} v\left(s(c)\right)\left[g(c) + cg'(c)\right] dc,$$

which allows one to simplify $\bar{\eta}$ as:

$$\bar{\eta} = \frac{\int_0^{\widehat{c}(N^*)} v\left(s(c)\right)\left[g(c) + cg'(c)\right] dc}{\int_0^{\widehat{c}(N^*)} v\left(s(c)\right) dG(c)}.$$

If G is a Pareto distribution we then have $g(c) + cg'(c) = \kappa g(c)$, therefore $\bar{\eta} = \kappa$ independently from the specification of IA preferences.

B Derivations for the "Addilog" Model

Under our assumption of a Pareto distribution, the prices p_{ij} of firms from country i which are actually active at destination j (i.e., conditional on $c \leq \hat{c}_{ij}$) are distributed on the support $[aE_j/(1+\gamma), aE_j]$ according to:

$$F_j(p) = \Pr\left\{p_{ij} \leq p\right\} = \Pr\left\{\frac{\gamma c + \widehat{c}_{ij}}{1+\gamma}\tau_{ij} w_i \leq p\right\} = \left(\frac{(1+\gamma)\,p}{\gamma a E_j} - \frac{1}{\gamma}\right)^{\kappa}.$$

This distribution is independent from trade costs and the identity of the exporting country, but depends on the income of the importing country j. However, the distribution of the normalized prices $s_{ij} = p_{ij}/E_j$ is identical across countries. Namely, on the support $[\frac{a}{1+\gamma}, a]$ it is given by (42), which depends only on the three parameters γ, κ and a. The average price in country j can then be easily calculated as follows:

$$\mathbb{E}\left\{p_j\right\} = \int_{\frac{aE_j}{1+\gamma}}^{aE_j} p dF_j(p) = \left[pF_j(p)\right]_{\frac{aE_j}{1+\gamma}}^{aE_j} - \int_{\frac{aE_j}{1+\gamma}}^{aE_j} F_j(p) dp$$

$$= \frac{\kappa a E_j}{\kappa+1} + \frac{aE_j}{(\gamma+1)(\kappa+1)}, \tag{60}$$

which is increasing in income and decreasing in γ.

To verify the result concerning the distribution of the corresponding markups, notice that they are distributed on $[0, \infty]$ with:

$$F_m(m) = \Pr\{m_{ij} \le m\} = \Pr\left\{\left(\frac{1}{1+\gamma}\right)\left(\frac{\widehat{c}_{ij} - c}{c}\right) \le m\right\}$$

$$= \Pr\left\{\frac{\widehat{c}_{ij}}{1 + (1+\gamma)\, m} \le c\right\} = 1 - \frac{G\left(\frac{\widehat{c}_{ij}}{1+(1+\gamma)m}\right)}{G\left(\widehat{c}_{ij}\right)}$$

$$= 1 - \frac{1}{\left[1 + (1+\gamma)\, m\right]^{\kappa}}. \tag{61}$$

The average markup can be calculated as follows:

$$\mathbb{E}\{m\} = \int_0^{\infty} m dF_m(m) = \left[mF_m(m)\right]_0^{\infty} - \int_0^{\infty} F_m(m) dm$$

$$= \frac{1}{(\gamma+1)(\kappa-1)}.$$

This value averages low markups by marginal firms (selling virtually nothing) and high markups by better producers, especially by the extremely productive exporters. Given the skewed distribution, the median mark-up is also of interest: this can be computed directly from (61) as $m^{Med} = \left(2^{1/\kappa} - 1\right)/(1+\gamma)$.

Furthermore, it is straightforward to derive the distributions of the pass-through and pricing-to-market elasticities across all producing firms and compute moments from them. Using the Pareto distribution, the distributions of pass-through and pricing-to-market elasticities, which are the same across countries and independent from trade cost, satisfy:

$$\Pr\{\epsilon^c \le \epsilon\} = 1 - \left(\frac{\epsilon}{\gamma(1-\epsilon)}\right)^{\kappa} \quad \text{and} \quad \Pr\left\{\epsilon^E \le \epsilon\right\} = 1 - \left(\frac{1-\epsilon}{\gamma\epsilon}\right)^{\kappa}, \tag{62}$$

respectively. Given these closed-form distributions, the mean and median values can be easily computed, while the means plus standard deviations can be derived numerically. The average elasticity of price with respect to income, $E\left\{\epsilon^E\right\}$, is:

$$\mathbb{E}\left\{\epsilon^E(c)\right\} = \frac{\widehat{c}_{ij}}{G(\widehat{c}_{ij})} \int_0^{\widehat{c}_{ij}} \frac{dG(c)}{\gamma c + \widehat{c}_{ij}} = \frac{\kappa}{\widehat{c}_{ij}^{\kappa-1}} \int_0^{\widehat{c}_{ij}} \frac{c^{\kappa-1}}{\gamma c + \widehat{c}_{ij}} dc$$

$$= \kappa \int_0^1 t^{\kappa-1} (1+\gamma t)^{-1} dt \quad \text{with } t \equiv \frac{c}{\widehat{c}_{ij}}$$

$$= F_{2,1}(1, \kappa; 1+\kappa; -\gamma), \tag{63}$$

where $F_{2,1}$ is the hypergeometric function

$$F_{2,1}(\alpha, \beta; \delta; z) = \frac{\Gamma(\delta)}{\Gamma(\beta)\Gamma(\delta-\beta)} \int_0^1 \frac{t^{\beta-1}(1-t)^{\delta-\beta-1}}{(1-tz)^{\alpha}} dt,$$

with vector $(\alpha, \beta) = (1, \kappa)$, scalar $\delta = \kappa + 1$ and argument $z = -\gamma$,[51] and

$$\Gamma(t) = \int_0^{\infty} z^{t-1} e^{-z} dz$$

is the Euler Gamma function (if the real part of t is positive). The median elasticity of price with respect to income is $\epsilon^E_{Med} = 1/\left(1 + \gamma 2^{-1/\kappa}\right)$. One can also evaluate a weighted average elasticity with relative sales as weights, which corresponds to:

$$\bar{\epsilon}^E = \frac{1+\gamma+\kappa}{(1+\gamma)(1+\kappa)}$$

and is higher because more productive firms have larger market shares.

Finally, to derive the distribution of market shares in the text and to demonstrate that profits are a constant share of sales which does depend neither on the source country nor on the destination, we compute the expected value of the exports to country j of a firm based in country i as follows:

$$\mathbb{E}\left\{t_{ij}\right\} = \int_0^{\widehat{c}_{ij}} t_{ij}(c) dG(c) =$$

$$= \frac{-\gamma^{\gamma} \left(\tau_{ij} w_i\right)^{\gamma+1} L_j}{(1+\gamma)^{\gamma+1} E_j^{\gamma} \left|\mu_j\right|} \int_0^{\widehat{c}_{ij}} \left[\gamma \left(\widehat{c}_{ij} - c\right)^{\gamma} - \gamma \left(\gamma c + \widehat{c}_{ij}\right) \left(\widehat{c}_{ij} - c\right)^{\gamma-1}\right] G_i(c) dc$$

$$= \frac{\gamma^{\gamma+1} a^{\gamma+1} E_j L_j}{(1+\gamma)^{\gamma} \overline{c}^{\kappa} \left|\mu_j\right| \widehat{c}_{ij}^{\gamma+1}} \int_0^{\widehat{c}_{ij}} \left(\widehat{c}_{ij} - c\right)^{\gamma-1} c^{\kappa+1} dc,$$

where we integrated by parts. Changing the variable of integration with $t = c/\widehat{c}_{ij}$ we obtain:

$$\mathbb{E}\left\{t_{ij}\right\} = \frac{\gamma^{\gamma+1} a^{\gamma+1} E_j L_j \widehat{c}_{ij}^{\kappa}}{(1+\gamma)^{\gamma} \overline{c}^{\kappa} \left|\mu_j\right|} \int_0^1 (1-t)^{\gamma-1} t^{\kappa+1} dt$$

$$= \frac{a^{\kappa+\gamma+1} \gamma^{\gamma+1} B(\kappa+2, \gamma)}{(1+\gamma)^{\gamma} \overline{c}^{\kappa}} \frac{L_j E_j^{\kappa+1}}{\left|\mu_j\right| \left(\tau_{ij} w_i\right)^{\kappa}}. \tag{64}$$

[51] In Matlab, however, the Hypergeometric function, $hypergeom(a, b, z)$, corresponds to the generalized Hypergeometric function where a is a vector of "upper parameters", b is vector of "lower parameters" and z is the argument. $F_{2,1}(\alpha, \beta; \delta; z)$ is the special case where $a = (\alpha, \beta)$ is a 1 by 2 matrix and $b = \delta$ is a scalar.

This allows to derive the average sales and the expression for the market share (46). Similarly, the expected profit $\mathbb{E}\{\pi_{ij}\}$ in country j for a firm based in country i is given by:

$$\mathbb{E}\{\pi_{ij}\} = \int_0^{\widehat{c}_{ij}} \pi_{ij}(c)dG(c) = \frac{\gamma^\gamma \kappa B(\kappa,\gamma+2)a^{\kappa+\gamma+1}}{(1+\gamma)^{1+\gamma}\overline{c}^\kappa} \frac{L_j E_j^{\kappa+1}}{(\tau_{ij}w_i)^\kappa |\mu_j|}. \quad (65)$$

The ratio of the two aggregate objects is then obtained by the recursive properties of the Euler Beta function:

$$\frac{\mathbb{E}\{\pi_{ij}\}}{\mathbb{E}\{t_{ij}\}} = \frac{\kappa B(\kappa,\gamma+2)}{\gamma(1+\gamma)B(\kappa+2,\gamma)} = \frac{1}{\kappa+1}$$

C Equivalent Variation of Income

Consider the general case of IA preferences. In this case it is convenient to work with the "unconditional" distribution, $G_{ij}(\chi)$, of the marginal cost $\chi = \tau_{ij}w_i c$ in country j by firms from country i, which has a support $[0, \tau_{ij}w_i\overline{c}]$ and it is given by:

$$G_{ij}(\chi) = \Pr\left\{c \leq \frac{\chi}{\tau_{ij}w_i}\right\} = G(\frac{\chi}{\tau_{ij}w_i}) = \left(\frac{\chi}{\tau_{ij}w_i\overline{c}}\right)^\kappa.$$

Let $p_j(\chi)$ be the equilibrium mapping between marginal costs and prices which only depends on E_j.[52] We can then write welfare (26) as:

$$V_j = \sum_{i=1}^I N_i \int_{bE_j}^{aW_j} v\left(\frac{p}{W_j}\right) dF_{ij}(p)$$

$$= \sum_{i=1}^I N_i \int_0^{\overline{\chi}_j} v\left(\frac{p_j(\chi)}{W_j}\right) dG_{ij}(\chi)$$

$$= \int_0^{\overline{\chi}_j} v\left(\frac{p_j(\chi)}{W_j}\right) d(\chi)^\kappa \sum_{i=1}^I N_i (\tau_{ij}w_i\overline{c})^{-\kappa},$$

where $W_j = E_j + EV_j$ (see the discussion concerning the definition of the Equivalent Variation EV_j in the text) and $\overline{\chi}_j$ is defined by the condition $p_j(\overline{\chi}_j) \equiv aW_j$. Accordingly, taking logs, differentiating

[52]This is given by (15) for all the varieties actually sold in country j when income is E_j, but it is not uniquely defined above the cutoff aE_j. One can make the mild assumption that $p_j(\chi)$ is everywhere monotonic and differentiable: however, in computing the EV_j in the "addilog" case we assume that all prices follow the same pricing rule (35).

and integrating by parts we obtain :

$$d\ln V_j = d\ln\left\{\int_0^{\overline{\chi}_j} v\left(\frac{p_j(\chi)}{W_j}\right) d\left(\chi\right)^{\kappa}\right\}$$

$$= \frac{-\int_0^{\overline{\chi}_j} v'\left(\frac{p_j(\chi)}{W_j}\right)\frac{p_j(\chi)}{W_j} d\left(\chi\right)^{\kappa}}{\int_0^{\overline{\chi}_j} v\left(\frac{p_j(\chi)}{W_j}\right) d\left(\chi\right)^{\kappa}} d\ln W_j$$

$$= \frac{\kappa\int_0^{\overline{\chi}_j} v'\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}d\chi}{\int_0^{\overline{\chi}_j} v'\left(\frac{p_j(\chi)}{W_j}\right) p_j'(\chi)\chi^{\kappa}d\chi} d\ln W_j$$

$$= \kappa\left[\int_0^{\overline{\chi}_j}\frac{p_j'(\chi)\chi}{p_j(\chi)}\frac{v'\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}}{\int_0^{\overline{\chi}_j} v'\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}d\chi}d\chi\right]^{-1} d\ln W_j$$

$$= \kappa\left[\int_0^{\overline{\chi}_j}\epsilon_j^c(\chi)\frac{x\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}}{\int_0^{\overline{\chi}_j} x\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}d\chi}d\chi\right]^{-1} d\ln W_j$$

$$= \kappa\left[1-\int_0^{\overline{\chi}_j}\epsilon_j^E(\chi)\frac{x\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}}{\int_0^{\overline{\chi}_j} x\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}d\chi}d\chi\right]^{-1} d\ln W_j$$

$$= \kappa\left[1-\bar{\epsilon}_j^E\left(W_j, E_j\right)\right]^{-1} d\ln W_j, \tag{66}$$

where we define

$$\epsilon_j^c(\chi) \equiv \frac{\partial\ln p_j(\chi)}{\partial\ln\chi} \equiv 1-\epsilon_j^E(\chi),$$

and

$$\bar{\epsilon}_j^E\left(W_j, E_j\right) \equiv \int_0^{\overline{\chi}_j}\epsilon_j^E(\chi)\frac{x\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}}{\int_0^{\overline{\chi}_j} x\left(\frac{p_j(\chi)}{W_j}\right) p_j(\chi)\chi^{\kappa-1}d\chi}d\chi. \tag{67}$$

The local approximation in the text, valid for small EV_j, can be obtained by letting $W_j = E_j$ and computing $\bar{\epsilon}_j^E$ as a weighted average (with relative sales as weights) of the elasticity of prices with respect to income, $\epsilon_{ij}^E(c) = \partial\ln p_{ij}(c)/\partial\ln E_j$, which explains our notation.

For the "addilog" functional form we obtain $\overline{\chi}_j = a\left[\left(\gamma+1\right)W_j - E_j\right]/\gamma$ and

$$\bar{\epsilon}_j^E\left(W_j, E_j\right) = \int_0^{\overline{\chi}_j}\frac{aE_j}{\gamma\chi + aE_j}\frac{\left\{a\left[\left(\gamma+1\right)W_j - E_j\right]-\gamma\chi\right\}^{\gamma}\left(\gamma\chi + aE_j\right)\chi^{\kappa-1}}{\int_0^{\overline{\chi}_j}\left\{a\left[\left(\gamma+1\right)W_j - E_j\right]-\gamma\chi\right\}^{\gamma}\left(\gamma\chi + aE_j\right)\chi^{\kappa-1}d\chi}d\chi \tag{68}$$

$$= \frac{aE_j \int_0^{\overline{\chi}_j} \left\{1 - \frac{\gamma\chi}{a[(\gamma+1)W_j - E_j]}\right\}^{\gamma} \chi^{\kappa-1} d\chi}{\int_0^{\overline{\chi}_j} \left\{1 - \frac{\gamma\chi}{a[(\gamma+1)W_j - E_j]}\right\}^{\gamma} \left(\gamma\chi^{\kappa} + aE_j^{\kappa-1}\chi\right) d\chi}$$

$$= \frac{aE_j \int_0^1 \{1-t\}^{\gamma} t^{\kappa-1} dt}{\int_0^1 \{1-t\}^{\gamma} \left(\gamma\overline{\chi}_j t^{\kappa} + aE_j t^{\kappa-1}\right) dt}$$

$$= \frac{aE_j B(\kappa, \gamma+1)}{\gamma\overline{\chi}_j B(\kappa+1, \gamma+1) + aE_j B(\kappa, \gamma+1)}$$

$$= \frac{(\kappa+\gamma+1) E_j}{[\kappa W_j + E_j](\gamma+1)},$$

which gives (49) in the text.

D Derivation of Value-added Advantage Moment

In this Appendix we demonstrate that the moment that represents the value-added advantage of exporters is a function of data and parameters estimated in Steps 1 and 2 of the algorithm developed in the main text. Focus first on the value added of non-exporters and substitute out the mark-up equation to obtain:

$$va_i^{nx}(c) = \frac{E_i}{1+\gamma}\left(\gamma + \frac{\hat{c}_{ii}}{c}\right).$$

Taking logs yields:

$$\log(va_i^{nx}(c)) = \log\left(\frac{E_i}{1+\gamma}\right) + \log\left(\gamma + \frac{\hat{c}_{ii}}{c}\right).$$

Integrating over all non-exporters yields

$$VA_i^{nx} = \log\left(\frac{E_i}{1+\gamma}\right) + \frac{1}{\hat{c}_{ii}^{\kappa} - \tilde{c}_{ij}^{\kappa}} \int_{\tilde{c}_{ij}}^{\hat{c}_{ii}} \log\left(\gamma + \frac{\hat{c}_{ii}}{c}\right) \kappa c^{\kappa-1} dc.$$

Apply the following change of variables: $t_{ij} = \frac{c}{\hat{c}_{ij}}$. Then VA_i^{nx} becomes:

$$VA_i^{nx} = \log\left(\frac{E_i}{1+\gamma}\right) + \frac{\kappa}{1 - y_{ij}^{\kappa}} \int_{y_{ij}}^{1} \log\left(\gamma + t_{ii}^{-1}\right) t_{ii}^{\kappa-1} dt_{ii},$$

where y_{ij} is defined in the main text.

Next, focus on the value added for an exporter. For any exporter from country i with cost draw c define the following indicator function: $\delta_{ij}(c) = 1$ if $c < \hat{c}_{ij}$ and zero otherwise. Let $\Delta_{ij}(c)$ be a vector of size I with typical element $\delta_{ij}(c)$. Substituting in the equations for firm sales and output, the value added for an exporter can then be rewritten as

$$va_i^x(c) = \frac{e_i \sum_{k=1}^I \delta_{ik}(c) \frac{L_k(\tau_{ik}w_i)^{1+\gamma}(\gamma c+\hat{c}_{ik})(\hat{c}_{ik}-c)^\gamma}{(1+\gamma)(w_k e_k)^\gamma |\mu_k|}}{c \sum_{k=1}^I \delta_{ik}(c) \frac{\tau_{ik} L_k(\tau_{ik}w_i)^\gamma(\hat{c}_{ik}-c)^\gamma}{(w_k e_k)^\gamma |\mu_k|}}.$$

Furthermore, substituting in for $|\mu_k|$, and using the definition of λ_{kk} obtains:

$$va_i^x(c) = \frac{E_i}{1+\gamma}\left[\gamma + \frac{\sum_{k=1}^I \delta_{ik}(c) \frac{\tau_{ik}^{1+\gamma}(\hat{c}_{ik}-c)^\gamma \lambda_{kk} L_k}{(E_k)^{\gamma+\kappa} S_k} \frac{\hat{c}_{ik}}{c}}{\sum_{k=1}^I \delta_{ik}(c) \frac{\tau_{ik}^{1+\gamma}(\hat{c}_{ik}-c)^\gamma \lambda_{kk} L_k}{(E_k)^{\gamma+\kappa} S_k}}\right].$$

Taking logs and integrating over all exporters yields

$$VA_i^x = \log\left(\frac{E_i}{1+\gamma}\right) + \frac{1}{\tilde{c}_{ij}^\kappa}\int_0^{\tilde{c}_{ij}} \log\left[\gamma + \frac{\sum_{k=1}^I \delta_{ik}(c) \frac{\tau_{ik}^{1+\gamma}(\hat{c}_{ik}-c)^\gamma \lambda_{kk} L_k}{(E_k)^{\gamma+\kappa} S_k} \frac{\hat{c}_{ik}}{c}}{\sum_{k=1}^I \delta_{ik}(c) \frac{\tau_{ik}^{1+\gamma}(\hat{c}_{ik}-c)^\gamma \lambda_{kk} L_k}{(E_k)^{\gamma+\kappa} S_k}}\right] \kappa c^{\kappa-1} dc.$$

Applying the change of variables, $t_{ij} = \frac{c}{\hat{c}_{ij}}$, VA_i^x becomes:

$$VA_i^x = \log\left(\frac{E_i}{1+\gamma}\right) + \kappa y_{ij}^{-\kappa}\int_0^{y_{ij}} \log\left[\gamma + \frac{\sum_{k=1}^I \delta_{ik}(\hat{c}_{ii}t_{ii}) \frac{\lambda_{kk} L_k}{(E_k)^{\kappa-1} S_k}\left(1 - t_{ii}\frac{E_i \tau_{ik}}{E_k}\right)^\gamma \frac{1}{t_{ii}E_i}}{\sum_{k=1}^I \delta_{ik}(\hat{c}_{ii}t_{ii}) \frac{\tau_{ik}\lambda_{kk} L_k}{(E_k)^{\kappa} S_k}\left(1 - t_{ii}\frac{E_i \tau_{ik}}{E_k}\right)^\gamma}\right] t_{ii}^{\kappa-1} dt_{ii}.$$

Taking the difference between exporters and non-exporters yields the desired moment H_2:

$$H_2(\mathbf{P}, \mathbf{\Lambda}) = \kappa y_{ij}^{-\kappa}\int_0^{y_{ij}} \log\left[\gamma + \frac{\sum_{k=1}^I \tilde{\delta}_{ik}(t_{ii}) \frac{\lambda_{kk} L_k}{(E_k)^{\kappa-1} S_k}\left(1 - t_{ii}\frac{E_i \tau_{ik}}{E_k}\right)^\gamma \frac{1}{t_{ii}E_i}}{\sum_{k=1}^I \tilde{\delta}_{ik}(t_{ii}) \frac{\tau_{ik}\lambda_{kk} L_k}{(E_k)^{\kappa} S_k}\left(1 - t_{ii}\frac{E_i \tau_{ik}}{E_k}\right)^\gamma}\right] t_{ii}^{\kappa-1} dt_{ii}$$

$$- \frac{\kappa}{1-y_{ij}^\kappa}\int_{y_{ij}}^1 \log\left(\gamma + t_{ii}^{-1}\right) t_{ii}^{\kappa-1} dt_{ii}, \tag{69}$$

where the dependence on $\mathbf{P}$ and $\mathbf{\Lambda}$ is made explicit. In the above expression, $\tilde{\delta}_{ik}$ is a transformation of δ_{ik} that only depends on $\mathbf{P}$ and $\mathbf{\Lambda}$. Thus, it remains to show that t_{ii} and $\tilde{\Delta}_{ik}$ depend on $\mathbf{P}$ and $\mathbf{\Lambda}$. This argument can be found in the description of the simulation algorithm.

E Data Appendix

E.1 Gravity Equation

The description below follows closely the work of Simonovska and Waugh (2014a).

To construct trade shares, we used bilateral trade flows and production data as follows:

$$\lambda_{ij} = \frac{\text{Imports}_{ij}}{\text{Gross Mfg. Production}_j - \text{ Exports}_j + \text{Imports}_j},$$

$$\lambda_{jj} = 1 - \sum_{k \neq j}^{I} \lambda_{kj}.$$

To construct λ_{ij}, the numerator is the aggregate value of manufactured goods that country j imports from country i. Bilateral trade-flow data are for year 2004 from the update to Feenstra *et al.* (2005), who use UN Comtrade data. We obtain all bilateral trade flows for our sample of 123 countries at the four-digit SITC level. We then used concordance tables between four-digit SITC and three-digit ISIC codes provided by the UN and further modified by Muendler (2009).[53] We restrict our analysis to manufacturing bilateral trade flows only—namely, those that correspond with manufacturing as defined in ISIC Rev.#2.

The denominator is gross manufacturing production minus manufactured exports (for only the sample) plus manufactured imports (for only the sample). Gross manufacturing production data are the most serious data constraint we faced. We obtain manufacturing production data for 2004 from UNIDO for a large sub-sample of countries. We then imputed gross manufacturing production for countries for which data are unavailable as follows. We first obtain 2004 data on manufacturing (MVA) and agriculture (AVA) value added, as well as population size (L) and GDP for all countries in the sample. We then impute the gross output (GO) to manufacturing value added ratio for the missing countries using coefficients resulting from the following regression:

$$\log\left(\frac{MVA}{GO}\right) = \beta_0 + \boldsymbol{\beta}_{GDP}\mathbf{C}_{GDP} + \boldsymbol{\beta}_{L}\mathbf{C}_{L} + \boldsymbol{\beta}_{MVA}\mathbf{C}_{MVA} + \boldsymbol{\beta}_{AVA}\mathbf{C}_{AVA} + \epsilon,$$

where β_x is a 1×3 vector of coefficients corresponding to C_x, an $N \times 3$ matrix which contains $[\log(x), (\log(x))^2, (\log(x))^3]$ for the sub-sample of N countries for which gross output data are available. Data on geographic barriers (distance, shared border, official common language, colonial relationship, common currency and RTA) are from Head *et al.* (2010). Data on population size for year 2004 is from the World Development Indicators. Data on per-capita income is from Feenstra *et al.* (2013) (Penn World Tables 8.0).

[53] The trade data often report bilateral trade flows from two sources. For example, the exports of country A to country B can appear in the UN Comtrade data as exports reported by country A or as imports reported by country B. In this case, we take the report of bilateral trade flows between countries A and B that yields a higher total volume of trade across the sum of all SITC four-digit categories.

E.2 Prices

We use price data from the Economist Intelligence Unit (EIU) data. The EIU surveys the prices of individual goods across various cities in two types of retail stores: mid-priced, or branded stores, and supermarkets, or chain stores. The dataset contains the nominal prices of goods and services, reported in local currency, as well as nominal exchange rates relative to the US dollar, which are recorded at the time of the survey. The database spans a subset of 71 countries from our original data set, but provides prices for 110 individual tradable goods. While in the majority of the countries, price surveys are conducted in a single major city, in 17 of the 71 countries multiple cities are surveyed.[54] For these countries, we use the price data from the city which provided the maximum coverage of goods. In most instances, the location that satisfied this requirement was the largest city in the country. We use prices collected in mid-priced stores in the year 2004 and we combine them with the observations on trade and output from the benchmark analysis.[55]

Furthermore, we construct indicators for countries that are landlocked or islands using Google Maps. Finally, to compute the average tariff for each importer, we obtain applied tariffs (minimum of MFN and effective tariff) for year 2004 at the SITC-4-digit level for each country-pair in the dataset from Feenstra and Romalis (2014). For each importer, we compute the average tariff as the mean tariff across products and sources, weighted by source- and product-specific imports.

F Aggregate moments and the margins of trade

F.1 Aggregate moments

In this section, we present the model's fit to aggregate moments. The model generates per-capita income levels that are at par with the data. In particular, the model falls somewhat short of the mean per-capita income level among 123 countries, but it yields a higher variance. Despite the dispersion, the model's predictions line up with the data, as the correlation of the predicted and actual per-capita income among 123 countries is 0.87 (in logs). Figure 3 gives a visual representation of the model's fit along the income dimension. While countries line up along the 45-degree line, which represents a perfect fit, the model underpredicts the income levels of the poorest set of countries. Since per-capita incomes are chosen so as to match observed trade flows in the market clearing equation, this result may be due to the fact that these countries have relatively low import and export shares, even conditional on trade barrier levels. This would suggest that these countries may simply be plagued by very low

[54] These countries are Australia, Canada, China, France, Germany, India, Italy, Japan, New Zealand, Russian Federation, Saudi Arabia, South Africa, Spain, Switzerland, United Kingdom, USA, and Vietnam.

[55] The results are robust to using supermarket price data for the same year.

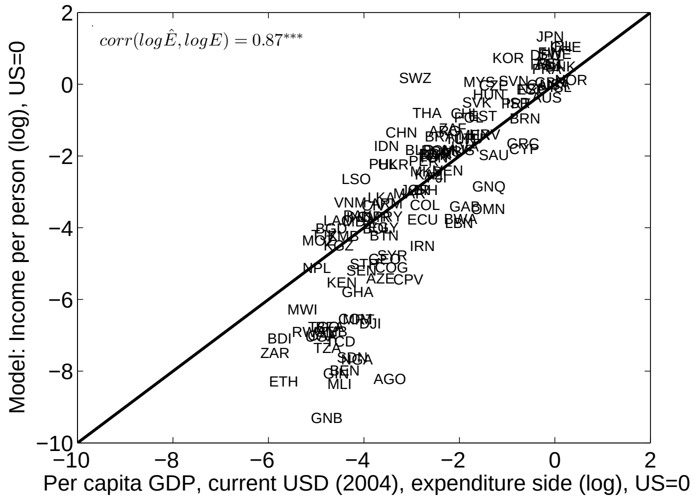

Figure 3: Predicted VS. Actual Per-Capita Income, 123 Countries

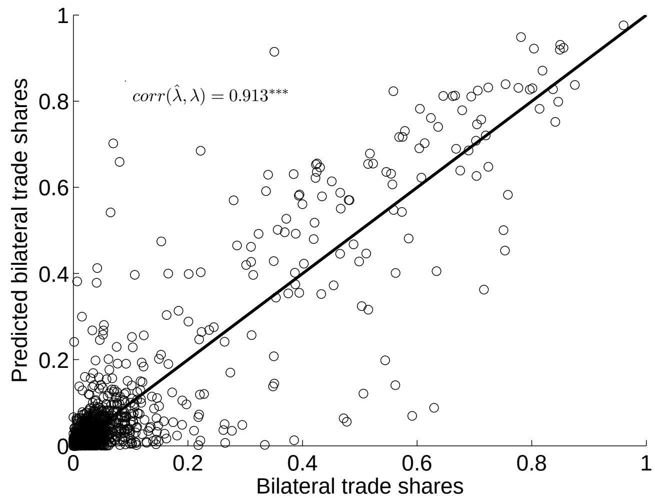

Figure 4: Predicted VS. Actual Trade Shares, 123 Country Pairs

productivities.

Figure 4 plots (non-zero) predicted against actual bilateral trade shares for all country pairs. A large cluster of bilateral trade shares can be seen around the origin representing the fact that, for the majority of countries, each individual destination accounts for a tiny fraction of its total sales. On the other hand, large numbers that are dispersed around the top right corner mostly capture domestic expenditure shares. Despite the large variation in trade shares, the model can match the cross-section of trade shares quite well due to the flexible specification for trade costs in the structural gravity equation.

F.2 The Margins of Trade

In this section, we quantify the model's predictions about the extensive and intensive margin of trade. Recall from (54) that the model predicts that the elasticity of the extensive margin with respect to destination per-capita income equals κ, while the same elasticity with respect to trade costs equals $-\kappa$. Since trade barriers are increasing in distance, our model's predicted elasticity with respect to distance is necessarily negative.

Table 5: Predicted US Extensive Margin of Trade

	(1)
Log(pcincome)	2.779***
	(0.117)
Log(L)	0.046
	(0.073)
Log(distance)	-1.890***
	(0.294)
R^2	0.93
# Observations	61

Notes: All variables relative to Mexico—the most popular US export destination in terms of number of exported products. *** indicate significance at 1%-level. Standard errors in parentheses.

In Table 5, we quantify the elasticity with respect to distance. Since the extensive margin in the model is source-destination specific, we focus on the US as a source country. We regress the predicted extensive margin on destination per-capita income, size, and distance from the US, all in logs. The estimated elasticities with respect to the three variables are 2.8, 0.05, and -1.9, respectively, and only the first and the last are statistically significant. The coefficients on per-capita income and distance are consistent with the findings in Bernard *et al.* (2007) for US data. In particular, the authors document that the elasticity of the number of exported products by US exporters with respect to destination GDP is 0.52 and with respect to distance is -1.06. While the authors do not decompose the elasticity with respect to GDP into the two components: per-capita income and population size, our model suggests that the positive slope in the data may be due to the per-capita income component.

Along the intensive margin dimension, the model predicts that, controlling for aggregate effects, (i) the elasticity of the intensive margin with respect to destination GDP is 1; (ii) the elasticity of the intensive margin with respect to destination per-capita income is $-\kappa$, or -2.8 given our estimate. Accordingly, in our model the intensive margin of trade is increasing in a destination's overall GDP and decreasing in the destination's per-capita income, which can reconcile findings in Eaton *et al.* (2011). Eaton *et al.* (2011) find that the intensive margin (defined as average per-firm sales) is increasing in destination GDP and either increasing or decreasing in destination per-capita GDP depending on the source country analyzed.

G Additional Tables

Table 6: Gravity equation: Estimates

Barrier	Parameter Estimates	S.E
Log distance	-1.30	0.03
Border shared	0.75	0.11
Official Common Language	1.06	0.06
Colonial Relationship	1.35	0.08
Common Currency	-0.08	0.15
RTA	0.48	0.06
Internal trade	1.46	0.22
# Observations	15,129	
TSS	160,320	
SSR	27,694	
σ_{ν}^2	2.67	

Table 7: Gravity equation: Estimates

Country	$\hat{S}_i$	S.E	ex_i	S.E.	Country	$\hat{S}_i$	S.E	ex_i	S.E.	Country	$\hat{S}_i$	S.E	ex_i	S.E.
Angola	-1.03	0.2	-2.62	0.33	Fiji	-0.47	0.19	-2.32	0.3	Nepal	0.42	0.22	-2.83	0.31
Argentina	1.01	0.17	2.63	0.23	Finland	0.96	0.16	2.41	0.22	New Zealand	-0.38	0.16	3.45	0.23
Armenia	0.67	0.19	-3.58	0.28	France	0.33	0.15	5.19	0.21	Nigeria	-0.66	0.19	-1.44	0.28
Australia	0.15	0.16	3.78	0.22	Gabon	-0.94	0.18	-1.81	0.26	Norway	0.14	0.16	2.24	0.22
Austria	0.23	0.15	3.01	0.22	Gambia, The	-2.07	0.21	-3.01	0.32	Oman	-0.3	0.18	-0.49	0.25
Azerbaijan	-0.17	0.19	-2.52	0.27	Georgia	-3.1	0.18	1.37	0.26	Pakistan	0.77	0.15	1.61	0.22
Bangladesh	0.79	0.17	0.42	0.23	Germany	0.21	0.15	5.95	0.21	Paraguay	0.01	0.19	-0.68	0.27
Belarus	1.12	0.17	-0.66	0.24	Ghana	-1.07	0.2	-0.10	0.28	Peru	0.38	0.17	1.32	0.24
Belgium	-2.08	0.15	7.55	0.21	Greece	0.45	0.16	1.23	0.22	Philippines	-0.33	0.17	2.60	0.23
Benin	-0.56	0.21	-3.93	0.34	Guinea	-1.53	0.21	-2.62	0.31	Poland	0.61	0.15	2.20	0.22
Bhutan	0.19	0.28	-5.04	0.41	Guinea-Bissau	-0.47	0.27	-5.60	0.45	Portugal	-0.34	0.16	2.99	0.22
Bolivia	0.26	0.18	-1.60	0.27	Hungary	0.66	0.16	1.39	0.22	Romania	0.33	0.16	1.26	0.22
Bosnia and Herzegovina	0.72	0.22	-2.84	0.31	Iceland	-0.27	0.17	-0.53	0.25	Russian Federation	1	0.16	2.74	0.22
Botswana	1.27	0.24	-4.36	0.35	India	1.19	0.15	3.02	0.24	Rwanda	0.42	0.23	-5.68	0.35
Brazil	1.13	0.15	3.99	0.22	Indonesia	1.16	0.16	3.44	0.22	Sierra Leone	-0.8	0.27	-4.04	0.39
Brunei Darussalam	1.76	0.24	-5.36	0.35	Iran, Islamic Rep.	0.68	0.2	-0.18	0.27	Saudi Arabia	0.52	0.19	1.05	0.26
Bulgaria	0.03	0.16	0.92	0.23	Ireland	-3.14	0.15	6.26	0.22	Senegal	-0.57	0.16	-1.20	0.24
Burkina Faso	0.46	0.19	-4.36	0.29	Israel	0.89	0.17	1.10	0.23	Slovak Republic	-0.5	0.16	1.70	0.22
Burundi	-1.5	0.19	-3.19	0.32	Italy	0.26	0.15	5.18	0.22	Slovenia	0.77	0.17	0.30	0.23
Cameroon	1.79	0.2	-3.91	0.29	Japan	1.22	0.15	5.47	0.22	South Africa	0.51	0.15	3.42	0.22
Canada	-0.01	0.15	4.06	0.22	Jordan	-0.17	0.17	-0.84	0.24	Spain	0.18	0.15	4.30	0.21
Cape Verde	-0.44	0.2	-4.83	0.36	Kazakhstan	0.19	0.17	0.13	0.25	Sri Lanka	-0.1	0.17	0.57	0.24
Central African Republic	0.6	0.24	-4.89	0.35	Kenya	-0.2	0.16	-0.75	0.22	Sudan	-0.09	0.2	-3.59	0.3
Chad	0.66	0.23	-6.61	0.39	Korea, Rep.	0.77	0.15	4.91	0.21	Swaziland	2.48	0.23	-4.00	0.31
Chile	0.29	0.18	1.98	0.25	Kyrgyz Republic	0.05	0.19	-2.96	0.28	Sweden	0.63	0.15	3.58	0.22
China	0.89	0.15	6.23	0.22	Lao PDR	1.23	0.26	-3.56	0.34	Switzerland	0.09	0.18	3.70	0.26
Colombia	0.23	0.16	0.77	0.23	Latvia	-0.42	0.18	-0.12	0.25	Syrian Arab Republic	-0.35	0.18	-0.90	0.25
Comoros	-0.8	0.26	-4.74	0.4	Lebanon	0.58	0.19	-2.24	0.26	Tajikistan	1.09	0.24	-3.14	0.33
Congo, Dem. Rep.	-0.66	0.23	-2.31	0.33	Lesotho	1.64	0.29	-6.35	0.42	Tanzania	-0.69	0.21	-2.07	0.3
Congo, Rep.	-0.82	0.2	-1.36	0.29	Lithuania	0.7	0.2	-0.95	0.28	Thailand	0.55	0.19	4.19	0.26
Côte d'Ivoire	0.96	0.2	-1.60	0.28	Macedonia, FYR	0.15	0.18	-2.22	0.26	Togo	-1.22	0.17	-1.77	0.26
Croatia	0.76	0.16	-0.68	0.23	Malawi	-0.17	0.18	-3.50	0.27	Tunisia	0.52	0.16	-0.65	0.23
Cyprus	-0.83	0.17	0.34	0.23	Malaysia	-1.04	0.15	6.19	0.22	Turkey	0.63	0.16	2.95	0.22
Czech Republic	0.24	0.15	2.38	0.22	Mali	-0.95	0.22	-2.73	0.3	Uganda	-0.4	0.17	-2.81	0.25
Denmark	-0.4	0.16	3.95	0.22	Mauritania	-1.97	0.22	-1.78	0.31	Ukraine	1.11	0.19	1.47	0.27
Djibouti	-1.85	0.23	-2.72	0.37	Mauritius	-1.07	0.17	0.32	0.23	United Kingdom	-0.21	0.15	5.44	0.21
Ecuador	-0.31	0.17	0.23	0.25	Mexico	0.21	0.15	2.58	0.23	United States	0.13	0.15	6.73	0.21
Egypt, Arab Rep.	0.28	0.16	0.94	0.22	Moldova	-0.65	0.18	-1.79	0.28	Uruguay	-0.56	0.19	1.52	0.25
Equatorial Guinea	0.6	0.23	-4.50	0.38	Morocco	-0.06	0.16	0.67	0.22	Venezuela, RB	0.61	0.18	-0.39	0.25
Estonia	-1.72	0.16	1.58	0.23	Mozambique	-0.36	0.21	-1.69	0.31	Vietnam	-0.62	0.2	3.02	0.27
Ethiopia	-0.58	0.2	-2.34	0.29	Namibia	1.15	0.22	-3.83	0.31	Zambia	-3.61	0.17	1.79	0.26

Table 8: 2004 EIU Data, List of 110 Tradable Goods

Product Name	Product Name	Product Name
White bread, 1 kg	Ham: whole (1 kg)	Business shirt, white
Butter, 500 g	Chicken: frozen (1 kg)	Men's shoes, business wear
Margarine, 500g	Chicken: fresh (1 kg)	Bacon (1 kg)
White rice, 1 kg	Frozen fish fingers (1 kg)	Men's raincoat, Burberry type
Spaghetti (1 kg)	Fresh fish (1 kg)	Socks, wool mixture
Flour, white (1 kg)	Instant coffee (125 g)	Dress, ready to wear, daytime
Sugar, white (1 kg)	Ground coffee (500 g)	Women's shoes, town
Cheese, imported (500 g)	Tea bags (25 bags)	Women's cardigan sweater
Cornflakes (375 g)	Cocoa (250 g)	Women's raincoat, Burberry type
Yoghurt, natural (150 g)	Drinking chocolate (500 g)	Tights, panty hose
Milk, pasteurized (1 l)	Coca-Cola (1 l)	Child's jeans
Olive oil (1 l)	Tonic water (200 ml)	Child's shoes, dresswear
Peanut or corn oil (1 l)	Mineral water (1 l)	Child' s shoes, sportswear
Potatoes (2 kg)	Orange juice (1 l)	Girl's dress
Onions (1 kg)	Wine, common table (1 l)	Boy's jacket, smart
Mushrooms (1 kg)	Wine, superior quality (700 ml)	Compact disc album
Tomatoes (1 kg)	Wine, fine quality (700 ml)	Television, colour (66 cm)
Carrots (1 kg)	Beer, top quality (330 ml)	Kodak colour film (36 exposures)
Oranges (1 kg)	Scotch whisky, six years old (700 ml)	International foreign daily newspaper
Apples (1 kg)	Gin, Gilbey's or equivalent (700 ml)	International weekly news magazine (Time)
Lemons (1 kg)	Vermouth, Martini & Rossi (1 l)	Paperback novel (at bookstore)
Bananas (1 kg)	Cognac, French VSOP (700 ml)	Personal computer (64 MB)
Lettuce (one)	Liqueur, Cointreau (700 ml)	Low priced car (900-1299 cc)
Eggs (12)	Soap (100 g)	Compact car (1300-1799 cc)
Peas, canned (250 g)	Laundry detergent (3 l)	Family car (1800-2499 cc)
Tomatoes, canned (250 g)	Toilet tissue (two rolls)	Deluxe car (2500 cc upwards)
Peaches, canned (500 g)	Dishwashing liquid (750 ml)	Regular unleaded petrol (1 l)
Sliced pineapples, canned (500 g)	Insect-killer spray (330 g)	Cost of six tennis balls eg Dunlop, Wilson
Beef: filet mignon (1 kg)	Light bulbs (two, 60 watts)	
Beef: steak, entrecote (1 kg)	Batteries (two, size D/LR20)	
Beef: stewing, shoulder (1 kg)	Frying pan (Teflon or good equivalent)	
Beef: roast (1 kg)	Electric toaster (for two slices)	
Beef: ground or minced (1 kg)	Aspirins (100 tablets)	
Veal: chops (1 kg)	Razor blades (five pieces)	
Veal: fillet (1 kg)	Toothpaste with fluoride (120 g)	
Veal: roast (1 kg)	Facial tissues (box of 100)	
Lamb: leg (1 kg)	Hand lotion (125 ml)	
Lamb: chops (1 kg)	Shampoo & conditioner in one (400 ml)	
Lamb: Stewing (1 kg)	Lipstick (deluxe type)	
Pork: chops (1 kg)	Cigarettes, Marlboro (pack of 20)	
Pork: loin (1 kg)	Business suit, two piece, medium weight	