EXPORTS AND INTERNATIONAL LOGISTICS

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Abstract

Do better international logistics reduce trade costs, raising a developing country's exports? Yes, but the magnitude of the effect depends on the country's size. We apply a gravity model that accounts for firm heterogeneity and multilateral resistance to a comprehensive new international logistics index. A one-standard deviation improvement in logistics is equivalent to a 14% reduction in distance. An average-sized developing country would raise exports by about 36%. Most countries are much smaller than average however, so the typical effect is 8%. This difference is chiefly due to multilateral resistance: it is bilateral trade costs *relative to multilateral trade costs* that matter for bilateral exports, and mutlilateral resistance is more important for small countries.

JEL Classifications: F10, F13, F14, F17, O24

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1 Introduction

Integration into the world economy is widely viewed as one of the key factors underlying the success of the fastest growing economies (Growth Commission, 2008), yet many developing countries remain isolated. This manifests itself in the form of relatively low international trade. Trade costs can be an important factor that shape trade patterns. Although tariffs on industrial products have generally declined, non-tariff barriers to trade remain. One example of non-tariff barriers is the cost of transporting products to foreign markets, both in pecuniary terms (freight costs) and in terms of the delays experienced in moving

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goods (Behar & Venables, 2011). For this reason, multilateral and donor organizations have sought to view "aid-for-trade" packages as a promising new developmental tool (Huchet-Bourdon, Lipchitz & Rousson, 2009).

Does such assistance work? Economists have studied the potential impact of transport and other costs on trade using gravity since at least Tinbergen (1962).[1] This paper makes a substantive contribution to our understanding of the importance of logistics for developing countries because we use a new World Bank index, which offers a number of advantages. It draws on a wide range of criteria, has broad country coverage from a single source, and is based on detailed evaluations provided by logistics professionals (Arvis, Muster, Panzer, Ojala & Naula, 2007).

This paper also makes a methodological contribution to the estimation and interpretation of gravity models and hence our understanding of the importance of transport costs for trade. We develop a new gravity model, which shows that standard approaches would produce an almost *three-fold* exaggeration of the typical impact of such factors for developing countries.

We uncover this dramatic exaggeration because our novel gravity modelling approach simultaneously accounts for two issues, namely multilateral resistance firm heterogeneity. Regarding the first issue, Anderson & van Wincoop (2003) show that it is not just bilateral trade costs, but those costs relative to multilateral trade costs, captured by price indices, that are relevant for predicting bilateral trade flows. In particular, imports by country i from country j, M_{ij}, are an increasing function $f(\cdot)$ of, *inter alia*, bilateral trade costs t_{ij} relative to the product of the two countries' price indices $P_i \times P_j$, such that

$$M_{ij} = f\left(\frac{P_i \times P_j}{t_{ij}}\right). \tag{1}$$

Anderson & van Wincoop call the price indices *multilateral resistance* because they work to aggregate trade costs across the two countries' multiple trading partners. Omitting controls for multilateral resistance (MR) can lead to biased coefficient estimates. More importantly, it can lead to grossly misleading comparative static estimates of the impact of changes in trade barriers on trade flows. This is because changes in trade costs affect both the denominator and the numerator of the argument on the right hand side of (1); empirical studies typically ignore the latter. Economically, for the exporter j, it is the trade cost associated with exporting to i relative to those trade costs incurred when trading with all other traders that matters for its exports to i. If a reduction in trade costs reduces t_{ij} but also reduces costs associated with trading with other countries, exports by j to i will increase by relatively less compared to the case where multilateral resistance, acting through $P_i \times P_j$, is ignored.

Trade elasticities are approximately proportional to country size because bigger countries are less affected by MR. Intuitively, since larger countries typically trade a smaller fraction of their total output

[1] See Clarke, Dollar & Micco; Limão & Venables, (2001); Wilson, Mann & Otsuki (2005); Djankov, Freund & Pham (2010) .

internationally, a change in international trade costs affects a proportionately smaller subset of their total production. Accordingly, their price indices, and hence multilateral resistance, change by less. MR therefore provides a smaller dampening effect on bilateral trade elasticities, such that the overall elasticity net of MR is larger. Conversely, smaller countries will have smaller elasticities net of MR. Given the skewness in the world's distribution of country size, most countries are small. Therefore, standard estimates overstate the impact of changes in logistics on bilateral trade flows for most countries. Conversely, for a handful of large developing countries, the impact is underestimated.

The second issue was addressed by Helpman, Melitz & Rubinstein (2008), who develop a method to account for the consequences of heterogeneous firm productivity in gravity models. Firm heterogeneity gives rise to two margins of adjustment to changes in trade barriers: the intensive margin, which captures exports per firm, and the extensive margin, which captures the number of exporting firms. If fixed trade costs are sufficiently high, no firms in a given country may export to a particular destination, which explains the zeros observed in aggregate trade data. These issues affect estimation and ignoring the effects of trade costs on firm entry results in misleading country-level comparative statics even if the countries do trade.

Behar & Nelson (2009) develop a model which accommodates both MR and firm heterogeneity. They demonstrate the importance of these effects for comparative statics when trade costs are captured by bilateral distance. In this paper, we adapt that approach to the case of logistics. Unlike distance, logistics might not be exogenous, so we take potential endogeneity seriously. Further, unlike bilateral distance, the logistics index is a country-specific variable which precludes the use of fixed effects to control for MR in estimation. Instead, we proxy MR terms using an adaptation of Baier & Bergstrand's (2009) method. Our approach allows us to implement this method together with Helpman, Melitz & Rubinstein's procedure to account for firm heterogeneity. While the application in this paper is to logistics, the implications fall on a wide class of country-specific international trade costs.

Section 2 provides an overview of the existing literature on logistics and international trade before expanding on the importance of MR and the selection issues associated with firm heterogeneity. Section 3 describes the data. The World Bank constructed its logistics performance index (LPI) using a principal component analysis of six indicators. We describe those indicators and describe how we extract only those that are relevant to international trade (as opposed to within-country trade) to produce what we call the International Logistics Index (ILI).

Section 4 formalizes our gravity modelling framework, which accounts for both firm heterogeneity and MR, and derives the Baier & Bergstrand (2009) approximation for country-specific trade costs in this context. In deriving the full comparative statics that take account of MR, this section illuminates how the trade impact varies with country size. Section 5 discusses estimation issues. Because trade flows may affect investments in logistics, logistics may be an endogenous regressor. To deal with this, we motivate and propose an instrumentation strategy based on the business start-up procedures in the importing country. We briefly recount the issues of MR and firm heterogeneity as omitted variable bias. While the homogeneous goods model can be estimated by OLS as in Baier & Bergstrand (2009, 2010) or two-stage-least-squares, we also incorporate Helpman, Melitz & Rubinstein's ("HMR's") two-step procedure to estimate the heterogeneous firm model.

In section 6, the benchmark linear specification suggests a one standard deviation improvement in logistics quality, which would put Rwanda on a par with Tanzania, raises exports 27%. We use our homogeneous firms model to model the impact of MR on estimation and to suggest that potential endogeneity is not materially biasing the logistics coefficient. Consistent with HMR and Behar & Nelson (2009), accounting for firm heterogeneity using the two-stage procedure produces bigger country-level comparative statics for an average-size country than does the homogeneous goods model estimated by OLS.

The estimates imply a one standard deviation rise in the index is equivalent to a reduction in distance of about 14% while our simulations in section 7 indicate it would raise exports by about 36% for an average-size country. Since the impact of MR varies by country size, we compute the elasticity for each of our exporters. For example, because Rwanda is small, its trade response would be 1% of the response implied by the benchmark specification. Because Brazil is big, its response would be three times the benchmark. Averaging over all exporters, the typical effect is only 8%, which is about one fifth of the average-size country effect, because most countries are small. The linear benchmark would exaggerate this almost three-fold. Section 8 concludes that small countries have much smaller trade responses than the average, but cautions against interpreting these results as a weak case for logistics upgrades in those countries.

2 Literature

This section reviews two important methodological advances and briefly discuss empirical work on transport costs in this context.

2.1 Methodological concepts

Our approach accounts for two important insights provided by the recent gravity literature on trade flow estimation. In particular, our estimation and comparative static exercises account for both MR and firm heterogeneity.

2.1.1 Multilateral resistance

Anderson & van Wincoop (2003) show that it is essential to account for the general equilibrium effects of changes in trade costs on imports by country i from country j, M_{ij}, if the trade elasticity $\partial \ln M_{ij} / \partial \ln t_{ij}$ is to be calculated correctly. General equilibrium effects work through the price indices $P_i \times P_j$ that enter the bilateral gravity equation, as illustrated in equation (1) above. Since these indices aggregate the trade costs incurred in consuming a given bundle of traded goods, Anderson & van Wincoop (2003) refer to them as indices of multilateral resistance (MR). The effects of MR are as follows. The bilateral trade flow between two countries depends not only on the bilateral trade barrier between them t_{ij}, but the severity of this barrier relative to those confronted when the two countries trade with others (including domestic trade), $\frac{t_{ij}}{P_i \times P_j}$. It follows that the overall impact of a change in a trade barrier must account for these potentially significant 'third party' effects. The impact on Brazil's exports to Peru of signing a trade agreement depends also on whether other countries are party to that agreement. Were the agreement bilateral only, a reduction in the Brazil-Peru trade barrier would stimulate Brazilian exports to Peru, potentially reducing exports to third parties (e.g. Uruguay) and to itself. Were the agreement to include Uruguay, the relevant cost for Brazilian exports to Peru is the new cost of exporting to Peru relative to that of exporting to Uruguay; in relative terms, these costs have not changed. In this case, the only change in relative trade costs is that between domestic and international trade, with the costs associated with the latter falling relative to the former.

These effects are shown to be quantitatively important by Anderson & van Wincoop in explaining the so-called US-Canada 'border puzzle' of McCallum (1995). Behar & Nelson (2009) show that the effects of MR are large for changes in trade costs that are multilateral in nature. Changes in a given country's logistics quality share some of this multilateral characteristic: if Kenya were to achieve an improvement in its logistics, its relative trade barrier across all export destinations would be affected, and our comparative statics on exports to a particular destination must reflect this. Put differently, since the gravity equation for bilateral trade flows is derived from a general equilibrium system, any statement about the likely impact of this change on bilateral trade flows must take general equilibrium effects, through MR, into account. Without doing so, comparative statics exercises will generally overestimate the true magnitude of the response of bilateral trade flows to a change in trade costs.

Furthermore, larger countries typically trade a larger fraction of their output domestically for a given international trade cost. For large countries, a smaller proportion of their total (i.e. domestic plus international) trade is affected by changes in international trade costs with all destinations, which are captured by changes in MR. As a result, MR effects are less important and hence trade elasticities are greater for larger countries. This is 'Implication 1' in Anderson & van Wincoop (2003).[2]

[2] AvW's Implication 1 states that "trade barriers reduce size-adjusted trade between large countries more than between small countries". So small countries experience smaller trade elasticities with respect to uniform changes in trade barriers. The reason, as AvW state, is that "a uniform increase in trade barriers raises multilateral resistance more for a small

There are a number of empirical approaches to controlling for MR in estimation. First, since MR terms are country-specific, they can be controlled for by including country fixed effects. This is not appropriate for our purposes as we want to identify the effect of country-specific logistics quality. Second, some attempts have been made to control for MR by using price data to construct the appropriate price indices. Data limitations are among the problems with this method. As noted in Feenstra (2004), published price indices are typically stated relative to an arbitrary base period, making comparison of levels impossible. Furthermore, they tend to include too many non-tradeable goods and thus fail to capture the additional costs embedded in internationally traded goods (Anderson & van Wincoop, 2004). Third, Anderson & van Wincoop (2003) propose solving for a system of price indices together with the gravity equation, but this involves a potentially problematic customized non-linear program. The research community has shown that, while gravity models are popular in empirical trade, estimating the entire non-linear system is not.[3] Fourth, Baier & Bergstrand (2009) introduce a method by which the MR terms are approximated using a first-order Taylor expansion, yielding a log-linear expression for MR which contains exogenous variables only. These approximated MR terms can then be included in a single linear equation. This approach has the advantage of yielding tractable comparative statics; in particular, the role of country size in determining the appropriate comparative static effect is made explicit, while Baier & Bergstrand show that the approximation error associated with this method is small for the majority of country pairs.

2.1.2 Firm heterogeneity

Models of monopolistic competition with firms of heterogeneous productivity predict selection into export markets in the presence of fixed costs of trade. The reason is that the least productive firms do not generate profits sufficient to cover the fixed costs incurred, preventing entry into overseas markets. As illustrated by HMR, this has at least two further implications. First, the impact of a change in a trade barrier affects both the amount a given firm exports, the intensive margin, and the number of firms that export, the extensive margin. The latter is a *firm* selection effect. 'Traditional' gravity equations conflate these two effects, whereas HMR's method allows for their decomposition. Second, for fixed costs sufficiently high, no firms in a given country may find it profitable to export to a particular destination. This is offered as an explanation of the 'zeros' observed in bilateral trade data: many country-pairs do not appear to trade at all. This is a *country* selection effect, and it induces bias in traditional gravity estimates. HMR propose a two stage estimation procedure to construct controls for both of these effects. In the procedure described below, we use the elements of their approach that allow us to control for the effects of firm heterogeneity and simultaneously account for MR using the Baier & Bergstrand (2009,

country than a large country" (p. 177).

[3] Furthermore, this method is especially demanding when considering about 100 countries and allowing for asymmetries in trade frictions. Bergstrand, Egger & Larch (2007) have shown that the system solution can yield complex numbers.

2010) approximation in both estimation and comparative statics.

2.2 Studies on transport costs

Behar & Venables (2010) summarise the literature on the determinants of transport costs and their consequent impact on trade. These determinants include geography, hard infrastructure and procedural/institutional characteristics of a country. For example, Limão & Venables (2001) map information on road, rail and phone infrastructure to shipping cost information garnered from freight forwarders. They calculate that variation in infrastructure accounts for 40 per cent of variation in transport costs. In a gravity framework, they find that a country improving its infrastructure from the median to the 75th percentile would increase its trade 68 per cent.

Clarke, Dollar & Micco (2004) study the importance of ports. A deterioration in port facilities and general infrastructure from the 25th to 75th percentile is associated with a 12% rise in ocean freight costs. They find that these costs, which are based on containerization, the regulatory environment, seaport infrastructure and other variables also materially impact trade. Nordås & Piermartini (2004) adopt a similar approach to Limão & Venables but use more infrastructure measures. They have separate specifications for a number of indicators – airports, roads, telephone lines, port efficiency and the median port clearance time – which are estimated separately. They find all components are significant determinants of trade, with port efficiency being the most influential.

Moving beyond infrastructure, Djankov, Freund & Pham (2010) calculate that a transit delay of one day reduced trade by 1%, which is equivalent to an additional bilateral distance of about 70km. Hummels (2001) finds that improvements in customs clearance sufficient to reduce waiting times by a day would be equivalent to a 0.8 per cent reduction in ad valorem tariffs.

These papers make important contributions to our understanding of the relationship between transport costs and trade flows. A number control for MR in estimation indirectly through the use of fixed effects. However, they do not explicitly control for MR or firm heterogeneity[4] in estimation and comparative statics. As suggested by the methodological discussion in this section, this means the effects of reforms on trade can be severely miscalculated. We are particularly concerned with grand simulations of worldwide trade effects based on gravity models. For example, Wilson et al (2005) find that improvements in all four different trade facilitation measures would have material impacts on world trade but the simulations are aggregates of simulations for 75 individual countries and take no account of the issues on which we focus in this study.

[4] Drawing on an earlier version of our paper, Portugal-Perez & Wilson (2010) follow our estimation approach but do not fully explore the comparative static implications.

3 Data

The 2007 Logistics Performance Index (LPI) is sourced from the World Bank[5] and is constructed on a scale from 1-5. The LPI is calculated by the World Bank using a Principal Components Analysis of six different sub-indicators. The indicators are listed below together with their weights in the LPI:[6]

1. Efficiency of the clearance process by customs and other border agencies (0.18);
2. Ease and affordability of international shipments (0.20);
3. The facility to track and trace shipments (0.16);
4. The timeliness with which shipments reach their destination (0.15).
5. Transport and information technology infrastructure (0.15);
6. Local logistics industry competence (0.16).

Further details of the construction of each indicator are available in Arvis et al (2007). In summary, the index is based on more than 5,000 country evaluations by logistics professionals. The perceptions-based measure is corroborated with a variety of qualitative and quantitative indicators. For example, Arvis et al (2007) calculate that, on average, a one-point rise in the LPI corresponds to exports taking three more days to travel from the warehouse to port. Unlike other studies, for example Wilson et al (2005), the components of the index are drawn from the same source.

Efficiency of the clearance process by customs and other border agencies, the ease and affordability of arranging international shipments, the ability to track and trace those shipments as well as the speed with which they reach their destinations are directly relevant to international trade. Transport and IT infrastructure are relevant to all trade, whether international or domestic, as is the competence of the local logistics industry. Originally, the World Bank also collected data on a seventh component: domestic logistics costs. This component was found to be uncorrelated with the others and was consequently dropped by the World Bank.

Costs given by t_{ij} $(i \neq j)$ reflect international trade cost factors relative to trading within borders. As a result, it is conceptually correct to measure those aspects of logistics which affect international trade costs and are relevant for cross-border trade. In fact, strictly speaking, measures that affect both internal and international costs equally have no impact on exports in fully-specified gravity models. We should focus on the relevant components listed, but separate treatment of each component would lead to serious

[5] http://go.worldbank.org/88X6PU5GV0

[6] The weights that are used are not reported by the World Bank but can be backed out. For each country i, we have $L_i = \mathbf{w}C_i$ where L_i is i's LPI score, C_i is a [6x1] vector of i's component scores, and $\mathbf{w}$ is a [1x6] vector of the weights. We can then use six different country LPI scores to form a [6x1] matrix $\mathbf{L}$ in which row i corresponds to country i's LPI score, L_i, together with each country's component scores to form a [6x6] matrix $\mathbf{C}$, in which column i corresponds to country i's vector of scores C_i. Then we solve $\mathbf{L} = \mathbf{wC}$ for $\mathbf{w} = \mathbf{C}^{-1}\mathbf{L}$ to obtain the weights. We do this for a number of different sets of countries to ensure that the weights we calculate are unaffected by rounding errors.

multicollinearity problems because the components are highly correlated. Therefore, we construct our own International Logistics Index (ILI) based on components 1-4 using the relative weights listed. A regression of the LPI on the ILI has an R^2 of more than 0.99, so the international logistics index explains a large proportion of the overall index. Therefore, while the ILI is conceptually more appropriate, using it makes little practical difference.[7]

Table 1 presents summary statistics for the full LPI and for our new International Logistics Index (ILI). High income countries have measures of quality that are of the order of three standard deviations higher. Approximately 70% of developing countries have an ILI of between 2 and 3, but there is still considerable variation. Appendix Table 1 lists the values for all countries. The worst performing country in our sample is Rwanda with an ILI value of 1.90 (although there is evidence of subsequent improvement from various anecdotal and data sources). Singapore has the best international logistics with an ILI of 4.28. South Africa (3.66) and Malaysia (3.63) have the highest ILI values out of the developing countries.

Our interest is exports from developing countries. Based on the availability of logistics data and possible instruments and controls, our sample consists of 88 low- and middle-income exporters. We have 116 importers regardless of income classification.[8] We use merchandise exports data for 2005, using the IMF Direction of Trade Statistics. We observe 7,246 positive cross-border trade flows, 2,548 zeros and 826 instances of missing values. We therefore need to account for potential sample selection issues in our model and econometric methodology.

We use 2005 GDP measured in constant (2000) US Dollars from the World Development Indicators. As will become clear, each country's GDP share is an important component of our analysis. We calculate each country's share of world GDP by dividing its GDP by world GDP, where world GDP is the sum of the 116 countries in our sample.

The measure of bilateral distance that we use captures the internal distance in a country, accounts for the distance from a number of major cities and is constructed by CEPII.[9] Border data are also sourced from CEPII. Our control variables, including dummies for whether or not two countries share a common language,[10] a common colonizer or were once the same country, as well as a dummy for a landlocked country, are sourced from CEPII. Additional variables for identification as fixed export costs or instruments are taken from the World Bank *Doing Business* database. These data include the number of procedures needed to start a business, the number of days it takes to start a business and the cost of registering to start a new business in a country. We also considered data on the number of documents required to export or to import goods. Finally, we took the newly recoded data on religious similarity used by Helpman, Melitz & Rubinstein (2008) from Elhanan Helpman's website.

[7] The 2009 version of this paper used the full LPI. That paper also restricted the sample to developing countries that are not islands or are not classified as having neighbouring countries sufficiently close to their major cities.

[8] Further discussion of why we drop rich exporters is postponed until Section A.3.

[9] The distance measure used is distw and is described at http://www.cepii.fr/anglaisgraph/bdd/distances.htm

[10] We construct a dummy that is equal to one if two countries share either a common official or common ethnic language.

4 Theory

We model the relationship between exports and logistics using a gravity equation. This equation has a long and successful history in explaining bilateral trade patterns, with much of the explanatory power coming from the two countries' GDPs and the distance between them. Theory has subsequently provided grounding for the empirical success of the gravity model (Anderson 1979, Bergstrand 1985). The importance of multilateral resistance was highlighted in Anderson & van Wincoop (2003) ("AvW") and that of firm heterogeneity by Helpman, Melitz and Rubinstein (2008). We present the full heterogeneous firms model first, before showing how it can be understood as a generalisation of its homogeneous firms counterpart. Empirically, we will distinguish between the two, highlighting the role played by multilateral resistance in each.

4.1 The Model

There are J countries, $j = 1, ..., J$. Within each country are monopolistically competitive firms which produce a continuum of differentiated products. Consumers have a 'taste for variety', embodied in CES preferences given by

$$u_j = \left[\int_{\iota \in B} x_j(\iota)^{\alpha} d\iota \right]^{\frac{1}{\alpha}}, \tag{2}$$

where $x(\iota)$ is consumption of variety ι, contained in the set of varieties available in j, B. Let $\sigma \equiv 1/(1-\alpha)$ be the elasticity of substitution. In this endowment[11] economy with exogenous income in j of Y_j, firms face demand of

$$x_j(\iota) = \frac{Y_j}{P_j^{1-\sigma}} p_j(\iota)^{-\sigma}, \tag{3}$$

where $p_j(\iota)$ is the price of variety ι in j and P_j is j's ideal price index, given by $P_j = \left[\int_{\iota \in B} p_j(\iota)^{1-\sigma} d\iota \right]^{\frac{1}{1-\sigma}}$.

Each country produces a number of varieties of measure one, with one variety per firm. The unit cost of production is a, which is firm-specific as in Melitz (2003). Firms draw a independently from the identical distribution function $G(a)$ with support $[a_L, a_H]$, such that a_L is the lower bound on possible unit input requirement draws, while a_H is the upper bound. We can identify a firm's variety with its cost draw a: though there may be a measure of varieties with the same cost, each variety with a given cost draw behaves symmetrically, such that they can be indexed by a alone.

There are two types of cost of exporting. The first is an 'iceberg' variable trade cost $t_{ij} > 1$, which we will specify further later. The second is a fixed cost of exporting $f_{ij} > 0$, $f_{ii} = 0$. Taken together, a firm in j exporting to i producing q_{ij} units of output has a cost function given by

$$C_{ij}(a) = a t_{ij} q_{ij} + f_{ij}. \tag{4}$$

[11] As in Anderson van Wincoop (2003) and most of the gravity literature, we do not allow for endogenous or excess capacity in any economy. This precludes the use of previously idle resources for exports. It also precludes vent-for-surplus exports, where goods are exported as a result of insufficient domestic demand.

Given demand and costs, each firm chooses price so as to maximise its profits. This gives the price and profit function for a firm exporting from j to i as

$$
\begin{aligned}
p_{ij}(a) &= \frac{t_{ij}a}{\alpha}, & (5)\\
\pi_{ij}(a) &= (1-\alpha)\left[\frac{t_{ij}a}{\alpha P_i}\right]^{1-\sigma} Y_i - f_{ij}. & (6)
\end{aligned}
$$

Sales by firms in country j are only profitable in country i if $\pi_{ij}(a) > 0$. Hence we define a productivity cut-off a_{ij} by $\pi_{ij}(a_{ij}) = 0$, which is the cost level (or inverse productivity level) below which it is profitable to export. Firms with $a > a_{ij}$ do not generate profits high enough to cover the fixed costs of exporting f_{ij}. Using an exporting firm's profit function above then gives us the cut-off as

$$
a_{ij} = \left[\frac{Y_i(1-\alpha)}{f_{ij}}\right]^{\frac{1}{\sigma-1}} \frac{\alpha P_i}{c_j t_{ij}}. \tag{7}
$$

This gives us the *extensive margin* of trade. When a_{ij} is higher, the extensive margin is greater, implying a larger subset of firms exports. It rises as the income of the importing country rises, and as both fixed and variable costs of trade fall. Whenever $a_{ij} < a_H$, there will be firm selection into exporting. In particular, firms with the highest variable costs will choose not to export.

The total value of imports by country i from country j is given by $M_{ij} = \int_{a_L}^{a_{ij}} p_j q_i dG(a)$. Substituting in for prices and quantities, we obtain

$$
M_{ij} = \left[\frac{t_{ij}}{\alpha P_i}\right]^{1-\sigma} Y_i \int_{a_L}^{a_{ij}} a^{1-\sigma} dG(a). \tag{8}
$$

We then define $V_{ij} \equiv \int_{a_L}^{a_{ij}} a^{1-\sigma} dG(a)$ as a term capturing the firm selection effect. Note that as a_{ij} rises, indicating that the cost level above which firms find it unprofitable to export rises, V_{ij} rises. In other words, as this export cut-off rises, a larger set of firms export. Using this, we have bilateral exports from j to i given by

$$
M_{ij} = \left[\frac{t_{ij}}{\alpha P_i}\right]^{1-\sigma} Y_i V_{ij}. \tag{9}
$$

V_{ij} in equation (9), which is the same as in Helpman, Melitz and Rubinstein (2008), forms the basis for accounting for firm heterogeneity. In (9), country i's price index is given by $P_i^{1-\sigma} = \sum_j \int_{a_L}^{a_{ij}} p_{ij}(a)^{1-\sigma} dG(a)$.[12] Using $p_{ij}(a) = at_{ij}/\alpha$ the price index can be written

$$
P_i^{1-\sigma} = \sum_j (t_{ij}/\alpha)^{1-\sigma} V_{ij}, \tag{10}
$$

where we have made use of the definition of V_{ij} above. Since $P_i^{1-\sigma}$ aggregates trade costs, Anderson and

[12] We have abstracted from differences in the sets of active traders across countries. See Behar and Nelson (2009) for discussion.

van Wincoop interpret the price indices in the gravity equation as *multilateral resistance* terms, which we discuss further below. In the presence of firm heterogeneity, they are affected by V_{ij}, the extensive margin.

4.2 General Equilibrium

Next we assume trade balance in order to close the model. We will show that this allows us to write an AvW style gravity equation for bilateral exports. In addition, Behar and Nelson (2009) show that trade balance allows us to derive a gravity equation for the extensive margin. Both of these equations make explicit the role of price indices, or multilateral resistance, in general equilibrium.

Assume trade balance for each country, such that $Y_j = \sum_i M_{ij}$. Using this in (9) allows one to write

$$M_{ij} = \frac{Y_i Y_j}{Y} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} V_{ij}, \tag{11}$$

where P_i is country i's multilateral resistance term, and $Y \equiv \sum_h Y_h$ is total income. In arriving at this equation, using trade balance allows one to write these price indices as

$$P_i^{1-\sigma} = \sum_j \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} s_j V_{ij}, \tag{12}$$

$$P_j^{1-\sigma} = \sum_i \left(\frac{t_{ij}}{P_i} \right)^{1-\sigma} s_i V_{ij}. \tag{13}$$

In these price index equations, the s_k terms represent country k's GDP as a share of the total income of all the countries. That is, $s_i \equiv Y_i/Y$ is country i's GDP as a share of total income.

The inclusion of two price terms makes system (11)-(13) resemble that of AvW, with the crucial difference that it allows for firm heterogeneity. Reductions in trade costs affect both the numerator and the denominator of the gravity equation. Because a reduction in t_{ij} affects the multilateral resistance terms, the resulting increase in bilateral trade will be smaller than in the absence of changes in multilateral resistance, all else being equal.

4.3 The extensive margin

A further implication of imposing trade balance is that equation (7) for the extensive margin also takes a gravity-like form. In particular Behar and Nelson (2009) show that

$$a_{ij}^{\sigma-1} = (1-\alpha) \frac{Y_i Y_j}{Y} \frac{1}{f_{ij}} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma}, \tag{14}$$

which is a gravity equation for the cost cut-off defining the extent of the extensive margin. Just as for bilateral exports, it responds positively to the product of the trading countries' GDPs, negatively to bilateral trade costs, and positively to multilateral resistance, captured by the P_iP_j term. Note also that the fixed trade cost f_{ij} enters equation (14), such that higher fixed costs reduce the cost level below which exporting is profitable. In this way, fixed costs affect the number of exporting firms, but not how much each exports. In other words, fixed costs affect the volume of bilateral exports, but only indirectly through their impact on a_{ij}, which determines V_{ij}. This is important for the identification strategy in the empirical section.

Further, (14) makes explicit the role of multilateral resistance on the extensive margin. Just as for bilateral trade flows, a multilateral increase in trade costs increases both the numerator and the denominator of (14); the effect of trade costs on the price indices in the denominator therefore acts to mitigate the direct effect in the numerator. Just as AvW show for bilateral trade flows, comparative statics on the extensive margin will be misleading where the latter effect is accounted for, but the former is not.

Imposing an assumption about the distribution of productivities grants us further analytical tractability. Following much of the recent trade literature, we impose a Pareto distribution on firm specific variable costs[13], such that

$$\frac{1}{a} \sim \text{Pareto}(k), \qquad a \in [a_L, a_H],$$

where a_L and a_H define the support of the distribution, consistent with above, and k is the shape parameter. In particular, this implies $G(a) = \frac{a^k - a_L^k}{a_H^k - a_L^k}$, and $g(a) = k\frac{a^k}{a_H^k - a_L^k}\frac{1}{a}$. Using this, we write the extensive margin V_{ij} as

$$V_{ij} = \max\left\{ \frac{k}{a_H^k - a_L^k} \left[\left(\frac{a_{ij}}{a_L} \right)^{k-\sigma+1} - 1 \right], 0 \right\}, \tag{15}$$

such that whenever $a_{ij} < a_L$, or no firms in j generate profits sufficient to cover the fixed costs of exporting, $V_{ij} = 0$. From (11), this generates zero bilateral exports from j to i when $a_{ij} < a_L$. When will this scenario arise? Following HMR, one way to operationalise (15) is to consider the profits of the firm in j with the lowest variable costs a_L. If this firm does not find it profitable to export to i, then no firm in j will. Accordingly, for firm a_L, the ratio of variable profits to fixed export costs can be written as

$$Z_{ij} \equiv \frac{Y_i(1-\alpha)}{f_{ij}} \left(\frac{t_{ij} a_L}{\alpha P_i} \right)^{1-\sigma}. \tag{16}$$

It then follows that

$$V_{ij} > 0 \quad \text{iff} \quad Z_{ij} > 1. \tag{17}$$

Z_{ij} is HMR's latent variable. It is unobserved, but can be estimated using a combination of the distributional assumption on firm-specific costs a, and observable variables such as GDP and trade costs. A

[13]See, *inter alia*, Chaney (2008) and Helpman, Melitz and Yeaple (2004), who use Pareto distributed firm productivity in theoretical and empirical work.

further consequence of the trade balance assumption is that HMR's Z_{ij} can be written as

$$Z_{ij} = \widetilde{Z}_{ij} \left(P_i P_j\right)^{\sigma-1}, \tag{18}$$

where

$$\widetilde{Z}_{ij} \equiv \frac{Y_i Y_j}{Y} \frac{(1-\alpha)(t_{ij} a_L)^{1-\sigma}}{f_{ij}}. \tag{19}$$

That is, the latent variable can be decomposed into two components: multilateral resistance, and a component $\widetilde{Z}_{ij}$ independent of prices. Next, using (14), (18) and (19) allows us to relate the extensive margin cut off and the latent variable according to

$$Z_{ij} = \left(\frac{a_{ij}}{a_L}\right)^{\sigma-1}, \tag{20}$$

which gives (15) according to

$$V_{ij} = \max\left\{\overline{k}\left[\widetilde{Z}_{ij}^{\delta}\left(P_i P_j\right)^{\delta(\sigma-1)} - 1\right], 0\right\}, \tag{21}$$

where $\delta \equiv \frac{k-\sigma+1}{\sigma-1}$ and where $\overline{k} \equiv \frac{k}{a_H^k - a_L^k}$. This again makes explicit the point that MR affects the extensive margin too; increases in trade costs will decrease $\widetilde{Z}_{ij}$, but will increase $P_i P_j$, mitigating the net effect on the latent variable Z_{ij} and hence on the extensive margin V_{ij}.

Taking logs of (11) yields the equation we work with for estimation and comparative statics. Specifying trade costs $(\sigma-1)\ln t_{ij} = \gamma d_{ij} - \frac{\lambda}{2}(L_i + L_j)$, where d_{ij} is log bilateral distance and L_k is a measure of country k's export logistics (such that trade frictions fall with better logistics) gives[14]

$$m_{ij} = \psi + y_i + y_j - \gamma d_{ij} + \frac{\lambda}{2}(L_i + L_j) + w_{ij} + \ln\left(P_i P_j\right)^{\sigma-1}, \tag{22}$$

where ψ is a constant and where the role of the $\frac{1}{2}$ coefficient on logistics will become clear. w_{ij} is given by

$$w_{ij} \equiv \ln\left\{e^{\delta\left[\widetilde{z}_{ij} + \ln(P_i P_j)^{\sigma-1}\right]} - 1\right\},$$

which is the term containing the extensive margin. This term contains $z_{ij} = \ln Z_{ij}$, which since $Z_{ij} = \widetilde{Z}_{ij}\left(P_i P_j\right)^{\sigma-1}$, is

$$z_{ij} = \chi + y_i + y_j - \gamma d_{ij} + \frac{\lambda}{2}(L_i + L_j) - \ln f_{ij} + (\sigma-1)\ln\left(P_i P_j\right), \tag{23}$$

in which χ is a constant. As in (22), better international logistics increase the extensive margin of bilateral trade flows.

[14] Dummies can be included on trade frictions to capture differences across subsets of countries if necessary. See A.3.

Accounting for MR requires a way of dealing with price index terms. We will use an extension of the approach taken by Baier and Bergstrand (2009), set out in Behar and Nelson (2009), which is a workhorse in macroeconomics: Taylor's method. In particular, Behar and Nelson show that when the extensive margin terms V_{ij} entering the price indices are approximately $V_{ij} \simeq \widetilde{Z}_{ij}^{\delta} (P_i P_j)^{\delta(\sigma-1)}$, the MR term $\ln (P_i P_j)^{\sigma-1}$ is well approximated by

$$\frac{1}{1+\delta} \times \left\{ \begin{array}{c} -\overbrace{\sum_l s_l \sum_h s_h \left[(\sigma-1)\ln t_{lh} - \delta \widetilde{z}_{lh}\right]}^{\text{World Trade Resistance}} \\ +\underbrace{\sum_h s_h \left[(\sigma-1)\ln t_{ih} - \delta \widetilde{z}_{ih}\right]}_{\text{Importer's MR}} + \underbrace{\sum_l s_l \left[(\sigma-1)\ln t_{lj} - \delta \widetilde{z}_{lj}\right]}_{\text{Exporter's MR}} \end{array} \right\}. \tag{24}$$

This provides a tractable and intuitive way of controlling for multilateral resistance, and can be used for computing comparative statics. Equation (24) extends Baier and Bergstrand's (2009) approximated MR term to the case of firm heterogeneity. The expression includes not only an intensive margin effect $(\sigma-1)\ln t_{ij}$ in each component of the MR term, but also an extensive margin component through $\delta \widetilde{z}_{ij}$. This approximated MR term shares with BB's method the advantage of yielding analytical tractability and a clear intuition for the comparative statics effects we subsequently compute. It also preserves a role for asymmetries in trade costs.

(24) shows that MR can be conveniently decomposed into three terms. The first of these captures world trade resistance, which averages the importing MR of all importers from j. When this world resistance term is higher, world trade in general is subject to higher trade frictions, reducing bilateral trade all else being equal. The second two terms in (24) are i's importing MR and j's exporting MR respectively. When either of these two terms is high, trading with other countries in the world trade system is subject to high trade costs, encouraging i and j to trade with each other instead. This clearly captures the idea that it is relative trade costs that matter in determining bilateral trade flows. For example, when $\sum_h s_h \left[(\sigma-1)\ln t_{ih} - \delta \widetilde{z}_{ih}\right]$ is large, all exporters to i incur high trade costs in trading with i. Country i therefore incurs relatively small trade costs in importing from j, raising exports from j to i.

Substituting our expression for trade frictions $(\sigma-1)\ln t_{ij} = \gamma d_{ij} - \frac{\lambda}{2}(L_i + L_j)$ into (24) allows us to write multilateral resistance terms for distance and logistics and fixed costs more compactly as[15]

$$\ln (P_i P_j)^{\sigma-1} = \gamma MR_{ij}^{\text{dist}} - \frac{\lambda}{2} MR_{ij}^{\text{logistics}} + \kappa MR_{ij}^{f}, \tag{25}$$

[15] Note conveniently that the $1/(1+\delta)$ coefficient on (24) cancels out for MR_{ij}^{dist} and $MR_{ij}^{\text{logistics}}$.

where $\kappa = 1/(1+\delta)$, and where

$$
\begin{aligned}
MR_{ij}^{\text{dist}} &\equiv -\sum_l s_l \sum_h s_h d_{lh} + \sum_h s_h d_{ih} + \sum_l s_l d_{lj}, && (26)\\
MR_{ij}^{\text{logistics}} &\equiv \sum_l s_l \sum_{h \neq l} s_h (L_l + L_h) - \sum_{h \neq i} s_h (L_i + L_h) - \sum_{l \neq j} s_l (L_l + L_j), && (27)\\
MR_{ij}^{f} &\equiv -\sum_l s_l \sum_h s_h \ln f_{lh} + \sum_h s_h \ln f_{ih} + \sum_l s_l \ln f_{lj}. && (28)
\end{aligned}
$$

Then

$$
m_{ij} = \psi + y_i + y_j - \gamma \left(d_{ij} - MR_{ij}^{\text{dist}} \right) + \frac{\lambda}{n} \left(L_i + L_j \right) + \kappa MR_{ij}^{f} + w_{ij}, \tag{29}
$$

gives our heterogeneous firms gravity equation accounting for MR.[16,17]

4.4 Special case: homogeneous firms

As heterogeneity disappears, this set-up reduces to a simple homogeneous firms model. To see this, note that, as (i) all firms export and (ii) the support of the distribution of firm productivities collapses, such that $a_{ij} \to a_H$ and $a_H \to a_L$, then, by L'Hopital's rule, we have[18]

$$
\lim_{a_H \to a_L} V_{ij} = \max \left\{ a_L^{1-\sigma}, 0 \right\}.
$$

In that case, the gravity equation is simply

$$
m_{ij} = \psi' + y_i + y_j - \gamma \left(d_{ij} - MR_{ij}^{\text{dist}} \right) + \frac{\lambda}{n} \left(L_i + L_j \right), \tag{30}
$$

[16] Note that $MR_{ij}^{\text{logistics}}$ can be simplified to $MR_{ij}^{\text{logistics}} = -\frac{2}{n}\overline{L} - (L_i + L_j)\left(\frac{n-2}{n}\right)$, where $\overline{L}$ is the average international logistics quality.

[17] The remaining terms in $\ln \left(P_i \widehat{P}_j \right)^{\sigma-1}$ generate constants, which enter through ψ. In particular

$$
\begin{aligned}
MR_{ij}^{y} &= \sum_l s_l \sum_{h \neq l} s_h (y_l + y_h) - \sum_{h \neq i} s_h (y_i + y_h) - \sum_{l \neq j} s_l (y_l + y_j)\\
&= \widetilde{y} - y_i \left(1 - \frac{1}{n} \right) - y_j \left(1 - \frac{1}{n} \right)
\end{aligned}
$$

which modifies the coefficients on the log GDP terms.

[18] since

$$
V_{ij} = \int_{a_L}^{a_{ij}} a^{1-\sigma} dG(a) = \frac{k}{k-\sigma+1} \frac{a_{ij}^{k-\sigma+1} - a_L^{k-\sigma+1}}{a_H^k - a_L^k}
$$

which when $a_{ij} = a_H$ (all firms export) is

$$
V_{ij} = \frac{k}{k-\sigma+1} \frac{a_H^{k-\sigma+1} - a_L^{k-\sigma+1}}{a_H^k - a_L^k}
$$

Then let $f(a_H) = a_H^{k-\sigma+1} - a_L^{k-\sigma+1}$ and $g(a_H) = a_H^k - a_L^k$, so $f'(a_H) = (k-\sigma+1) a_H^{k-\sigma}$ and $g'(a_H) = k a_H^{k-1}$, such that when $a_{ij} = a_H$

$$
\lim_{a_H \to a_L} \frac{a_H^{k-\sigma+1} - a_L^{k-\sigma+1}}{a_H^k - a_L^k} = \lim_{a_H \to a_L} \frac{k-\sigma+1}{k} a_H^{1-\sigma} = \frac{k-\sigma+1}{k} a_L^{1-\sigma}
$$

so for $V_{ij} > 0$, $\lim_{a_H \to a_L} V_{ij} = a_L^{1-\sigma}$.

where the constant ψ' now contains an additional term reflecting the magnitude of a_L. This is useful in that we can assess empirically the impact of allowing for firm heterogeneity in our application, and compare the empirical implications of this modelling feature to the quantitative impact of accounting for multilateral resistance.

4.5 Comparative statics

4.5.1 Homogeneous firms model

Next we consider comparative statics. In the simplest case, firm heterogeneity is abstracted from. Then when the exporter's logistics quality improves, the partial equilibrium effect, which ignores MR, is given simply by $\frac{\partial m_{ij}}{\partial L_j} = \frac{\lambda}{2}$.[19] But when accounting for MR the full general equilibrium effect is given by

$$\left.\frac{\partial m_{ij}}{\partial L_j}\right|_{\text{homog.}} = \frac{\lambda}{2}\left\{1 + 2s_j\left(1 - s_j\right) - s_j - \left(1 - s_j\right)\right\} \quad (31a)$$

$$= \lambda s_j\left(1 - s_j\right) \quad (31b)$$

$$\approx s_j \lambda. \quad (31c)$$

The first term in the $\{\cdot\}$ brackets in (31a) gives the partial equilibrium effect in the absence of MR. The third term is the effect operating through the importer's multilateral resistance, which falls by the exporter's GDP share, dampening the partial equilibrium effect. The fourth term is the exporter's multilateral resistance, which falls across all export destinations relative to domestic trade. The proportion of j's export demand this covers is $1 - s_j$. The second term is the effect operating through "world resistance", which captures how costly international trade is relative to domestic trade for all countries. $s_j\left(1 - s_j\right)$ enters twice because, on the one hand, it makes j export more directly. On the other hand, it also makes it *import* more, which through trade balance makes it export more.[20] The net general equilibrium effect after one allows for terms to cancel is $\lambda s_j\left(1 - s_j\right)$. It illustrates the diversion away from domestic trade and towards international trade as international trade costs fall.

Simplifying (31a) clearly shows that the net comparative static effect is not $\frac{\lambda}{2}$, but something *much* smaller. The comparative static effect (31c) is increasing in country size. This is consistent with Anderson & van Wincoop (2003), who found that smaller countries experience smaller comparative static effects because they are more affected by MR. As discussed in section 2.1.1, the reason for this is that smaller countries consume a smaller proportion of their produce domestically and export a larger proportion of their products abroad. More of their trade is international trade, so more is subject to international

[19] If both the importer and exporter were to improve logistics, the effect at the intensive margin, not accounting for MR, would be λ.

[20] If we do not specify importer logistics as part of the bilateral trade cost function, then we end up with the same comparative static effect, except we attribute it entirely to the first world resistance effect. It is impossible to identify how much of the effect is due to "exports" and how much is due to "imports", but the Anderson & van Wincoop cost symmetry assumption implies it is half each.

trade costs, so MR has more of an effect.

Specification (30) allows one to interpret the coefficient on $(L_i + L_j)$ as the effect of an improvement in international logistics quality on trade for an average-size country, for which $s_j = \frac{1}{n}$. Thus, the comparative static effect for an average-size country is

$$\overline{\left.\frac{\partial m_{ij}}{\partial L_j}\right|_{\text{homog.}}} \approx \frac{\lambda}{n} \equiv \hat{\lambda}. \tag{32}$$

4.5.2 Heterogeneous firms model

In the presence of firm heterogeneity, comparative statics must take into account three effects. As well as the intensive margin and MR, there is the effect of firm heterogeneity. In particular, a change in logistics quality must account for

1. the effect at the intensive margin, $\frac{-(\sigma-1)\partial \ln t_{ij}}{\partial L_j} = \frac{\lambda}{2}$;
2. the MR effect occurring at the intensive margin, $\frac{(\sigma-1)\partial \ln P_i P_j}{\partial L_j} = -\frac{\lambda}{2}(1 - 2s_j + 2s_j^2)$;
3. the effect at the extensive margin, which also has bilateral and multilateral components, where $\frac{\partial z_{ij}}{\partial L_j} = \lambda s_j (1 - s_j)$ and, by the chain rule, $\frac{\partial w_{ij}}{\partial L_j} = \left(\frac{\delta e^{\delta \hat{x}_{ij}}}{e^{\delta \hat{x}_{ij}} - 1}\right) \lambda s_j (1 - s_j)$.

As in the homogeneous case, combining effects (1) and (2) gives $\lambda s_j (1 - s_j)$ (cf. equation (31)). Adding the third effect at the extensive margin yields

$$\left.\frac{\partial m_{ij}}{\partial L_j}\right|_{\text{hetero.}} = \frac{\lambda}{2} \left[2s_j (1 - s_j)\right] \left[1 + \frac{\delta e^{\delta \hat{x}_{ij}}}{e^{\delta \hat{x}_{ij}} - 1}\right]. \tag{33}$$

The gravity parameter $\frac{\lambda}{2}$ is the effect at the intensive margin, not accounting for MR. The first square bracket is the adjustment for MR. The second square bracket, which exceeds unity, is the amplification brought about by allowing for the effect at the extensive margin. Note that ignoring this term gives the intensive margin provided we have controlled for w_{ij} in estimation in our heterogeneous firm model. If we have not controlled for firm selection and we estimate a homogeneous firms model, then the firm and country-level response is the same: in this case there is no firm entry or exit into overseas markets and all firms experience the same trade elasticity.

In the heterogeneous model, the $\hat{\lambda}$ coefficient on $(L_i + L_j)$ still forms the approximate intensive margin change for an average-size country, while $\hat{\lambda}\frac{\delta e^{\delta \hat{x}_{ij}}}{e^{\delta \hat{x}_{ij}} - 1}$ gives the approximate extensive margin change for an average-size country. The overall bilateral country-level effect for an average-size country is therefore

$$\overline{\left.\frac{\partial m_{ij}}{\partial L_j}\right|_{\text{hetero.}}} \approx \hat{\lambda} \left[1 + \frac{\delta e^{\delta \hat{x}_{ij}}}{e^{\delta \hat{x}_{ij}} - 1}\right]. \tag{34}$$

5 Estimation

To place our model in a stochastic framework, we allow for measurement error in the reporting/recording of trade flows and unobserved trade costs. A necessary condition for consistent estimates is that the error term is Independently and Identically Distributed (IID). This section will discuss potential reasons why the IID assumption might not hold. It also discusses the dropping of high-income exporters from our sample.

5.1 Endogeneity bias

The IID assumption rules out reverse causation. There is ambiguity regarding the relationship between logistics and trade. Our theoretical framework describes a unidirectional impact of improved logistics on exports. However, it may be that higher trade volumes stimulate the construction of new infrastructure and the introduction of more efficient clearance technologies: the marginal value of investments in trade facilitating measures may be higher if exports are high, while some aspects of the logistics technology are subject to scale economies and thus only worthwhile at very high volume. This could cause an upward bias in the estimated coefficient. On the other hand, high trade volumes may increase the strain on the system, leading to queues at the border and longer customs processing times (Djankov et al, 2010), and causing downward bias in the estimates. The instrumental variables (IV) specifications we include provide a check for robustness. For effective IV estimation, we need instruments that have explanatory power (they are sufficiently correlated with logistics) but are exogenous (uncorrelated with exports except through logistics). While explanatory power can be checked by examining the first-stage IV regression for logistics, the validity of the instrument is ultimately not testable. We tried a number of plausible candidates.

5.2 Omitted multilateral resistance terms

While we have emphasised the importance of multilateral resistance for comparative statics, it can have an effect on estimation. If we have the bilateral trade cost variables but omit their multilateral resistance analogues, these terms would be in the error term. By construction, this would make the error term correlated with the regressors, would invalidate IID and lead to biased estimates of the coefficients. We construct multilateral resistance terms for all bilateral variables and include importer-equivalents for all country-specific variables. Following Baier & Bergstrand (2009,2010), we perform estimation with the equality restrictions implied by (30) imposed. For example, we include the sum of exporter and importer logistics as a single variable and include $d_{ij} - MR_{ij}^{\text{dist}}$ as a single variable. Furthermore, we construct the MR terms by taking simple averages, which assumes $s = 1/n$ for all countries (see Appendix A.2). Melitz (2008) also uses simple averages and applies it to the context of both bilateral and country-specific variables.[21] We emphasize that taking the simple mean is for the purposes of estimation and not comparative statics (see Baier & Bergstrand, 2010).

5.3 Firm-heterogeneity

The heterogeneous firms model also indicates potential violation of the IID assumption. Leaving out the control for the proportion of firms exporting would lead to omitted variables bias. Furthermore, the model suggests how country-selection into trade is a function of the variables of interest and a potential source of sample selection bias. To address these issues and implement the heterogeneous firms model, a two-step procedure is needed.

In the first stage, we estimate a probit model for the probability that country j exports to i, denoted ρ_{ij}. Letting T_{ij} be unity when exports from j to i are observed and zero otherwise, we write

$$\rho_{ij} = \Pr(T_{ij} = 1|\text{Observables,unobservables}). \tag{35}$$

Predicted values of ρ_{ij} are used to generate normalized predicted values for z_{ij}, $\hat{z}_{ij}$ (cf. equation (23)). The predicted probability $\hat{\rho}_{ij}$ can be used to estimate the inverse Mills ratio $\hat{\eta}_{ij}$, which controls for the *country* selection effect. Furthermore, HMR show how $\hat{z}_{ij}$ and $\hat{\eta}_{ij}$ can be used to account for *firm* selection. Define the *propensity to export* $\widehat{x}_{ij} \equiv \hat{z}_{ij} + \hat{\eta}_{ij}$, which is a positive function of ρ_{ij}. This is an estimate of the latent variable z_{ij} as a function of both observable and (an estimate of) unobservable trade frictions. As above, attaching a Pareto distribution to firm productivities allows us to map $\widehat{x}_{ij}$ to a consistent estimate of the number of firms profitable enough to export. We include this $\widehat{w}_{ij} = \ln(e^{\delta\widehat{x}_{ij}} - 1)$, together with $\hat{\eta}_{ij}$, in the second stage of our regression, modifying (29) to yield

$$m_{ij} = \psi + \beta_y (y_i + y_j) - \gamma \left(d_{ij} - MR_{ij}^{dist}\right) + \frac{\lambda}{n}(L_i + L_j) + \kappa MR_{ij}^{f} + \ln\left(e^{\delta\hat{x}_{ij}} - 1\right) + \beta_\eta \hat{\eta}_{ij}. \tag{36}$$

We estimate this second stage using non-linear least squares and use bootstrapped standard errors to allow for the fact that we have generated regressors in the second stage.[22] The first stage and homogeneous goods models use standard errors clustered by country-pair. For reliable identification, we need to have one variable in the probit equation that is not in the second stage. Our theoretical framework suggests variables that affect a firm's fixed costs (f_{ij}) of exporting but not its variable costs.

Our first-stage probit only differentiates between zeros and ones and ignores the missing observations. Baranga (2009) suggests this may induce further selection bias. Addressing these concerns, we also ran specifications in which we estimated a preliminary probit for missing variables. Including an analogous

[21] We thank an anonymous referee for the reference. Melitz's derivation of MR terms in the country-specific case is similar to ours (cf Melitz's equation 7 and footnote 10) but not exactly the same. This is in part due to differences in treatment of the country-specific variable when $i = j$.

[22] We perform 50 replications. Furthermore, we reject draws that spawn theoretically illegitimate values for $\widehat{x}_{ij}$ and $\hat{\eta}_{ij}$.

inverse Mills ratio in the "first-stage" probit for positive trade yielded a coefficient of virtually zero with a p-value of close to unity. This suggests ignoring missing values is not an issue for our data. Results are available on request.

6 Results

This section discusses the estimation results. In a homogeneous-firm setting, we start with benchmark specifications. We discuss the impact of MR on the estimates and then we assess potential endogeneity. Thereafter, in a heterogeneous-firm setting, we show the results of our two step procedure. The results in this section estimate trade flows using developing countries. It is quite plausible that the logistics issues faced by richer exporters differ from those faced by poorer exporters such that the gravity parameter λ may differ. Nonetheless, we explore the implications of estimation based on the fuller sample in Appendix A.3. As discussed there, we were not satisfied with the extent to which an interaction between logistics and a developing country dummy captured differences by income group. More importantly, our results were not as reliable or robust when estimated on the full sample, especially when trying to employ IV methods or the HMR procedure. It is important to stress that, although we estimate trade flows using developing countries only, we calculate multilateral resistance terms by summing over all 116 countries and perform comparative statics accordingly.[23]

Homogeneous firms In Table 2, column 1 presents a standard augmented gravity model. The signs of the coefficients are as one would expect. In particular, the international logistics coefficient (on $L_i + L_j$) is significant with a value of 0.606. To get a sense of magnitude, we calculate the effect on exports of a one standard deviation rise in the ILI. This modest 0.4 unit rise would for example put Rwanda's logistics on a par with nearby Tanzania's, make Bulgaria's like Romania's or place Brazil just above Argentina. Such a rise would raise exports $e^{0.6^{*}0.4} - 1 = 27\%$. Alternatively, we can use the coefficients on logistics and distance to calculate this is equivalent to a reduction in distance of $\frac{\hat{\lambda}}{\gamma}^{*}0.4 = 17\%$. In column 2, we add a full set of controls for MR for each bilateral variable - d_{ij} is replaced with $\left(d_{ij} - MR_{ij}^{dist}\right)$ for example - and the logistics coefficient is 0.597. More generally the coefficients are quite similar. While the influence of MR on estimation is negligible in this case, we will see later that its comparative static impact will be very important.

Column 3 presents the second stage of a two-stage-least-squares estimation by instrumental variables, where the first stage has the number of procedures needed to start a business in the *importer* instru-

[23] For comparative statics, a prior version of this paper multiplied by only the 88 countries for which we estimate trade flows. We are grateful to an anonymous referee for pointing out it is more appropriate to proxy for the whole world with the full sample of countries in our dataset.

Anderson & van Wincoop (2003) have a two-country model as well as a multi-country model. In the former, they use only US and Canada information. In the latter, they estimate bilateral trade flows using only Canadian Provinces and US states but include data from another twenty industrial countries in their system of price equations. Our approach here is analogous to their multi-country model.

menting for logistics ($L_i + L_j$). A priori, we expect this to be correlated with our logistics variable, because both variables (specifically, the importer component of logistics) share common institutional bureaucratic features. Furthermore, while the exporter's business start-up procedures may or may not be correlated with exports, there is no good reason to believe the importer's business start-up procedures should be directly related to the exporter's exports. In the first stage, the instrument was significant with a p-value of less than 0.0015 (using a t-test or F-test). There is only one instrument so no overidentifying restriction to test.[24] The coefficient on logistics in column 3 is 0.437, which is a bit lower than in column 3, but the specification was deemed insignificantly different by a Hausman test.

We also have a specification where we have the sum of procedures in both exporter and importer as one instrument and their product as another. Both variables have explanatory power in the first-stage and the overidentification test was insignificant (with a p-value of 0.17). Thus, conditional on one of these instruments being valid, we can legitimately exclude both. This condition cannot be tested, but our regression of the residuals on the exogenous variables yielded individually and jointly insignificant terms. This generates a coefficient of 0.697 on logistics, which was also deemed insignificantly different by a Hausman test.[25]

The evidence is against the OLS coefficient being incorrectly estimated due to endogeneity. Column 4 produces an insignificantly lower estimate, while column 5 represents estimates which were insignificantly higher. We prefer to use the column 2 estimates, which lie inbetween, for the homogeneous firm comparative static exercise we will perform later. However, we also need to take into account another source of bias, namely firm heterogeneity and country selection.

Heterogeneous firms In Table 3, we produce the results which account for firm- and/or country-selection. In column 1, the probit model yields all the expected signs. We note logistics affects the probability that a country exports, which in our framework means logistics affect fixed costs. In particular, we note that the Samecountry variable is also significant.

In column 2, we present the second stage of the Heckman two-step procedure, where we have excluded the Samecountry variable.[26] The logistics coefficient is somewhat higher than in Table 2. Analogous to HMR, this is because failure to account for country selection induces a negative correlation between logistics quality and the error term, because a low logistics quality means that unobserved trade frictions must be low on average for countries to be observed as trading pairs. This in turn induces a downward

[24] We ran an alternative specification in which we include both importer and exporter procedures as separate instruments. This produces a coefficient of 0.49. Informatively, an auxilliary regression of the residuals found that the exporter logistics variable is significant while the importer's was not.

[25] We experimented with alternative variables and functional form, including the importer's documentation for imports, the importer's documentation for exports, the importer's costs of starting a business, the importer's duration in days of starting a business and combinations thereof. These tended to produce significant coefficients in residuals regressions and/or significant overidentification tests as well as instances of insufficient explanatory power in the first stage.

[26] We also ran a just-identified model with all first-stage variables included in the second stage. The results were very similar. We also attained similar results using the number of regulations in the first stage probit and excluding those from the second stage.

bias in the homogeneous logistics coefficient. However, the Inverse Mills Ratio is insignificant, which suggests that country-selection is not an important issue in our application.

In column 3, we implement the full HMR procedure to account for both country- and firm-selection. When accounting for both firm and country selection, it becomes especially important to exclude a variable from the second stage. Economically, this is a variable which affects the fixed costs of exporting, but not the variable costs (Helpman, Melitz & Rubinstein, 2008). We omit the Samecountry variable but preserve the MR component to be consistent with the theoretical specification (equation 36).[27] This specification assigns low coefficients to logistics and distance but a high estimated δ. This would indicate that the influence of logistics is only through the extensive margin. However, as in column 2, the Inverse Mills Ratio is still insignificant, so the next two specifications countrol for firm-selection but not country-selection.

In column 4, we follow Manova (2008) by excluding no explanatory variables from the second stage but dropping the Inverse Mills Ratio. This produces a logistics coefficient of 0.489 and a δ of 0.307. Excluding the Samecountry variable from column 5, the logistics coefficient is 0.445 and δ is 0.416.[28] Column 5 is our preferred specification but we stress that, provided we exclude the Inverse Mills Ratio, our results are not materially affected by the choice of exclusion variable, for example religious similarity or the number of procedures or days needed to start a business as used by HMR. Column 5 implies a one standard deviation improvement in the ILI is equivalent to a 14% reduction in distance.[29]

Consistent with HMR, allowing for firm heterogeneity produces lower coefficients. Comparing our two benchmarks for example, the homogeneous coefficient (column 2 of Table 2) is 0.597 while the firm-level coefficient (column 5 of Table 3) is 0.445. However, this does not mean that the *country-level* effect is smaller.

Table 4 in fact demonstrates much higher bilateral country-level effects, which are calculated for each country-pair by allowing for the extensive margin (cf. equation (34)). For reference, the first column presents values from the homogeneous firms model. This is followed by the firm-level coefficient from our preferred heterogeneous firms model. The subsequent values reveal substantial variation in the extensive margin and hence the country-level effect; for example the standard deviation is 0.147. We see that even the minimum value of 0.648 is greater than that implied by the homogeneous model. Therefore, the homogeneous firm model has in this application underestimated the country-level effect of logistics

[27] Excluding the MR component made no difference. Furthermore, as done by HMR, we attempted specifications which exclude religious similarity or the procedures or days needed to start a business. The specifications yielded a large significantly negative Inverse Mills Ratio, a GDP coefficient well below unity and a positive distance coefficient. These all suggest excluding these variables from the second stage is not appropriate for our dataset. We also attempted export documentation and/or import documentation in the importer and/or exporter, or combinations theoreof. While these are a priori highly plausible candidates for fixed but not variable trade costs, the results suggested they are not reliable identifying variables.

[28] We do not discuss the significance of this variable because it must be non-zero for a well-defined gravity model, so it cannot be zero under the null hypothesis. Furthermore, the term $\ln(e^{\delta \hat{x}_{ij}} - 1)$ is only the $ij-$specific compnent of ω. The rest of it is subsumed in the constant.

[29] Because all trade costs are equally affected by firm heterogeneity and multilateral resistance, we still calculate this by taking the quotient of the logistics and distance coefficients.

for all countries. The source of variation across country-pairs and hence across income-groups is driven by variations in the extensive margin. Differentiation of (34) with respect to $\hat{x}_{ij}$ would show that the extensive margin effect is higher for countries with a lower value of $\hat{x}_{ij}$, which implies the extensive margin effect is higher for those who tend to have a lower proportion of firms exporting. This in turn implies, for example, that more distant countries with lower logistics quality would have a bigger increase in bilateral exports, ceteris paribus.

The average country-level effect of 0.882 on bilateral trade is almost 50% higher than that implied by the homogeneous firms model. It also suggests that the country-level effect is on average half due to the intensive margin and half due to the extensive margin. In other words, approximately half the country-level effect is due to new firms entering the export market.

7 Simulations: total country-level exports

To understand the effects of logistics on a country's total exports in the heterogeneous goods model, we must aggregate over the bilateral elasticities calculated in Table 4. It is also about time we recognized the importance of MR more explicitly by factoring in the actual size of the country. The distribution of world GDP is highly skewed. China accounts for about 5% of world output. This is about the same as the next three biggest developing countries combined (Brazil, India and Mexico). This 10% share exceeds that of the other 84 developing countries in our sample! Mean GDP is about seven times as big as the median and, in our full sample, the world mean for non-African countries is almost *forty* times as big as that for African countries.

Because of multilateral resistance, this extreme skewness means the effect on a particular country or subset of countries can be very different to the average. We illustrate the importance of this issue in a homogeneous setting before performing the aggregation necessary if firms are heterogeneous. We do not allow for country-level entry in the simulations. HMR attribute very little of the rise in international trade to the formation of new bilateral relationships. Furthermore, the Inverse Mills Ratio was insignificant in our application.

Homogeneous firms To calculate the effect for a particular country j, equations (31) and (30) imply that we multiply the logistics coefficient by n to get λ and then multiply that by $s_j(1-s_j)$. Using the estimate $\frac{\lambda}{n} = 0.597$ and $n = 116$ gives $\lambda \approx 69$. China's share of world GDP is 5.34% so its value of $s_j(1-s_j)\lambda = 3.5$. Table 5 has the (semi-)elasticities for all 88 developing countries. China's value is at the top left. As we move down, we see the steep fall in size as measured by the share of world GDP. As a result, the homogeneous elasticities fall dramatically. Many semi-elasticities are less than 1%; the bottom right produces elasticities of less than 0.1%. Clearly, the elasticity depends on whether you are the Comores or China. Calculating this for all 88 exporters, we average over these to get the mean elasticity of 0.16. This value, which we call the "typical" elasticity, is about a quarter of that for a country of average-size $\frac{1}{n}$. Argentina's share of GDP is only slightly higher than the average (1/116) and its comparative static effect is accordingly only slightly higher than that given by the homogeneous coefficient. China's elasticity is more than twenty times bigger than the typical elasticity. Similarly, Brazil, India and Mexico all have elasticities more than double those implied if we ignore MR. On the other hand, 82 out of 88 countries are below average, so ignoring MR typically overestimates the elasticity and sometimes does so by a large amount. While this calls for estimation of elasticities at a country-level, we are not necessarily saying that $\hat{\lambda}$ is inappropriate: by implicitly giving a greater weighting to bigger countries, it may be a good summary measure.

Heterogeneous firms For each exporter, the elasticity varies by importer when firm heterogeneity is included. Therefore, for each exporter, we sum the bilateral response over all its importers, weighting by the level of exports:[30]

$$\frac{\partial m_j}{\partial L_j} = \frac{1}{\sum\limits_l M_{lj}} \sum_l \left[M_{lj} \frac{\lambda}{n} \left(1 + \frac{\delta e^{\delta \hat{x}_{lj}}}{e^{\delta \hat{x}_{lj}} - 1} \right) \right]. \tag{37}$$

The average-size *total country* response is 0.766, which is higher than the homogeneous firms benchmark that did not account for MR in estimation (0.606). The value of 0.766 implies a one standard deviation improvement in the ILI would raise exports by $e^{0.297} = 36\%$. To incorporate MR fully in comparative statics, we follow analogous procedures to before and compute

$$\xi_j = s_j (1 - s_j) \frac{\partial m_j}{\partial L_j}$$

ξ_j is a key object of interest and forms the basis for our main substantive result. We expect bigger exporters to have smaller elasticities in general because they have a lower extensive margin effect, but this effect is empirically dominated by the MR effect. Overall, the biggest countries have the biggest elasticities, which would be true for all country-specific determinants of trade costs, not just logistics.

Alongside the homogeneous model elasticities, Table 5 presents the heterogeneous model elasticity for each country with respect to an improvement in its own logistics. The average value of ξ_j across 88 exporters is 0.185, which implies a one standard deviation rise in a country's ILI would raise exports by 7.67% or about 8%. Recall that such an improvement would place Brazil on a par with Argentina next door. Brazil's size means its calculated response of 84% is more than triple the benchmark of 27%. More dramatically, Rwanda's small size means its trade response of 0.028% would be barely one per cent of the benchmark.

By way of summary, we make two final comparisons using estimates we have already presented. Our

[30] We did this with actual trade flows but predicted trade flows produced similar results.

final estimate of the response to a one standard deviation improvement in logistics quality for a country of average size is 36%. This is somewhat higher than the 27% response implied by our benchmark model in column 1 of Table 2. However, this masks the huge variation in response by country and, due to the skewed distribution of country size, is not typical. Averaging over each country-level response, our measure of the typical response is only 7.67%, which is about one quarter of the effect implied by the benchmark. This difference is an order of magnitude greater than the estimation issues with which empirical economists are typically concerned.

8 Concluding discussion

We have seen consistent evidence that an exporter's logistics increase exports. Our preferred heterogeneous specification indicates that the elasticity of total exports with respect to a change in logistics for a country of average size is 0.74. However, most countries are much smaller than the average, so most countries have much smaller effects. After calculating elasticities for all countries, the typical (mean) elasticity is only 0.185. This implies a one standard deviation improvement in logistics would raise exports by 8%.

By contrast, the benchmark linear model would have produced estimates of 27% – a five-fold exaggeration. The exaggeration for Rwanda would have been 100-fold, for example. The chief reason for these exaggerations is that standard methods ignore the general equilibrium effects operating through multilateral resistance, which are stronger for smaller countries and hence dampen their trade responses by more. In contrast, a handful of large countries have elasticities that are much higher than that given by the benchmark. To be clear, our critique focusses on the comparative static impacts on trade. Statements about one transport cost expressed in other trade cost equivalents are generally still valid because MR affects all trade costs equally.

One of our key results is that economically small countries have small export elasticities. When evaluating the case for logistics upgrades, this result should be considered alongside the costs of improving logistics, which are also likely to increase with country size. Upgrading international logistics for the whole of Brazil requires far more resources than upgrading in Rwanda.[31] This is an important factor in the context of broader evaluations of net welfare gains and evaluations of aid-for-trade on a country-by-country basis.

While we have emphasised the importance of multilateral resistance for individual country responses, a summary view is arguably better captured by the elasticity for the average-size country, where bigger countries are implicitly given a bigger weighting. Here, it is important to stress that allowing for firm

[31] Furthermore, the functional form we have chosen does not readily allow for decreasing returns, nor does it allow for variations in the gravity parameter $\hat{\lambda}$.This is standard in the literature. However, this parameter may vary across countries because the products they export may differ (Djankov et al, 2010) or because the elasticity of substitution is not constant. Even so, it would take very large variations in $\hat{\lambda}$ to extinguish the relationship between size and the general equilibrium response. More generally, a proper evaluation of welfare gains and losses would be needed.

heterogeneity generates a higher trade response. A one standard deviation improvement gives a trade response of 36% for an average-size country, which is higher than given by the benchmark. For any country, such an improvement is equivalent to a 14% reduction in distance. Nonetheless, the cross-country variation in trade responses is overwhelmingly driven by differences in multilateral resistance.

Our study has been of a unilateral improvement by a country, but a global analysis requires an investigation of multilateral improvements. Wilson et al (2005) simulate the effect of bringing all countries with below-average measures of trade facilitation half way up to the global average. Such a simulation is beyond the scope of this paper, but one that takes proper account of firm heterogeneity and especially MR would be an informative enterprise.

A Appendix

A.1 Deriving equation 11

Trade balance requires $Y_j = \sum_i M_{ij}$, so summing both sides of (9) yields

$$\frac{Y_j}{\sum_i \left[\frac{t_{ij}}{P_i}\right]^{1-\sigma} Y_i V_{ij}} = \left(\frac{1}{\alpha}\right)^{1-\sigma}$$

which we use in (9) to give

$$M_{ij} = \frac{Y_i Y_j}{Y}\left[\frac{t_{ij}}{P_i P_j}\right]^{1-\sigma} V_{ij}$$

where $P_j^{1-\sigma} = \sum_i \left[\frac{t_{ij}}{P_i}\right]^{1-\sigma} s_i V_{ij}$.

A.2 Simplifying $MR_{ij}^{\text{logistics}}$

When $s_i = 1/n$,we have

$$\begin{aligned}
MR_{ij}^{\text{logistics}} &\equiv \sum_l s_l \sum_{h\neq l} s_h(L_l + L_h) - \sum_{h\neq i} s_h(L_i + L_h) - \sum_{l\neq j} s_l(L_l + L_j) \\
&= \frac{1}{n}\frac{1}{n}\sum_l \sum_{h\neq l} L_l + \frac{1}{n}\frac{1}{n}\sum_l \sum_{h\neq l} L_h - \frac{1}{n}\sum_{h\neq i} L_h - \frac{1}{n}\sum_{l\neq j} L_l - L_j\left(1-\frac{1}{n}\right) \\
&\quad -L_i\left(1-\frac{1}{n}\right) \\
&= -\frac{2}{n}\overline{L} - (L_i + L_j)\left(\frac{n-2}{n}\right)
\end{aligned}$$

where $\overline{L} = \frac{1}{n}\sum_l L_l$.

A.3 Dropping high-income exporters

We are interested in the less developed countries. Nonetheless, we explore the implications here of performing estimates on the full sample and including a dummy for developing countries. Theoretically, if we want to capture a different effect of a trade friction on a developing versus rich country, our equation becomes

$$m_{ij} = \psi + y_i + y_j - \gamma d_{ij} + \frac{\lambda}{2}(L_i + L_j) + \frac{\lambda'}{2}\left(D^i L_i + D^j L_j\right) + w_{ij} + \ln\left(P_i P_j\right)^{\sigma-1}, \tag{38}$$

where $D^k = 1$ if country k is 'developing', and λ' is the additional logistics coefficient. Analogous to $MR_{ij}^{\text{logistics}}$, when $s_i = 1/n$, the MR effect of the dummies is captured by

$$\begin{aligned}
MR_{ij}^{D} &= \sum_l s_l \sum_{h\neq l} s_h(D^l L_l + D^h L_h) - \sum_{h\neq i} s_h(D^i L_i + D^h L_h) - \sum_{l\neq j} s_l(D^l L_l + D^j L_j) \\
&= \frac{1}{n}\frac{1}{n}\sum_l \sum_{h\neq l} D^l L_l + \frac{1}{n}\frac{1}{n}\sum_l \sum_{h\neq l} D^h L_h - \frac{1}{n}\sum_{h\neq i} D^h L_h - \frac{1}{n}\sum_{l\neq j} D^l L_l \\
&\quad -D^j L_j\left(1-\frac{1}{n}\right) - D^i L_i\left(1-\frac{1}{n}\right) \\
&= -\frac{2}{n}\overline{DL} - \left(D^i L_i + D^j L_j\right)\left(\frac{n-2}{n}\right)
\end{aligned}$$

where $\overline{DL} = \frac{1}{n}\sum_l D^l L_l$. Then, as above,

$$m_{ij} = \psi + y_i + y_j - \gamma\left(d_{ij} - MR_{ij}^{\text{dist}}\right) + \frac{\lambda}{n}(L_i + L_j) + \frac{\lambda'}{n}\left(D^i L_i + D^j L_j\right) + w_{ij} + \kappa MR_{ij}^{f}. \tag{39}$$

A priori, we have technical econometric concerns regarding high-income exporters. First, as part of the HMR procedure, very high values of $\hat{\rho}_{ij}$ can be predicted for many country pairs such that they are practically indistinguishable from unity and from one another. HMR truncate the values of $\hat{\rho}_{ij}$ that are greater than 0.9999999 at that value. As a result, there is a mass of estimates of η_{ij} and z_{ij} at a particular value. Baranga (2009) notes that a seemingly innocuous truncation can have a very big impact on estimates of δ. He speculates this may have been done to ensure $\hat{\delta}$ comfortably exceeds zero, which is required for a well-defined gravity model. Preliminary analysis revealed that all our predicted values above 0.9999999 were generated by high-income exporters and that high-income countries generally generated high predicted probabilities. Rather than being stuck with indistinguishable values or truncating arbitrarily, we remove a well defined group of countries, namely high-income exporters. Second, including logistics and its interaction with the income level means we have two potentially endogenous variables for which instruments must be found. This places a greater demand on the instrumentation procedure.

Turning to the results, Column 1 of Table A2 presents the OLS results for a homogeneous firms model with MR controls. It now includes a dummy equal to one if the exporter is classified as a high income country and an interaction between logistics and income level which applies only to developing countries as in equation (39). This produces a higher logistics coefficient than the analogous estimate in Table 2 together with insignificant estimates for the income dummy and interaction. The insignificance may be due to high multicolinearity - the variance inflation factors for the income dummy and the interaction are 118 and 72 respectively - but could imply that income level makes no difference. However, the coefficient is different to that for developing countries estimated alone. This may be in part to different coefficient estimates for the other trade costs variables. In other words, fully isolating separate developing country effects may require a number of interactions with income for a large number of trade cost variables and not just logistics. IV estimates are unreliable. Using the sum of start-up procedures in both exporter and importer as one instrument and their product as another - as done before - yields very poor identification of the coefficients of interest. They are all individually insignificant, but the.coefficients imply logistics quality reduces exports in rich countries and has a huge positive impact on developing country exports.

Moving onto the heterogeneous firms model, we present two estimates where the bilateral component of the Samecountry variable is excluded. Column 4 controls for country and firm selection. The estimates implied for developing countries are individually insignificant but jointly significant at the 5% level. Compared to the specification controlling for country and firm selection for developing countries, this assigns a relatively greater role to the intensive margin and a smaller role to the extensive margin. As was the case for developing countries only, specifications controlling for country and firm selection were not robust to the choice of excluded variable. Unlike the developing country estimates, there is a large and negatively significant IMR term. Therefore, it is not entirely surprising that attempting to control only for firm-selection yields nonsensical results. Most importantly, it produces a negative delta term, which is theoretically inconsistent and precludes the calculation of country-level comparative statics.

While we ave provided estimates based on the exclusion of the Samecountry variable for consistency and brevity, we stress that these results are representative of a range of alternative specifications, including those which exclude the bilateral component of the trade cost, alternative excluded variables and specifying a reduced-form interaction of $D^j(L_i + L_j)$ instead of our theoretically derived estimates and specifications which exclude the high_income dummy to reduce colinearity. We also tried a number of alternative instrument combinations and functional forms for the IV estimates. These consistently yielded poorly identified results as well as negative delta coefficients or IMR terms.

We additionally estimated specifications on the full sample without the income dummy or interactions. The results were more plausible for the IV estimates but equally untrustworthy for the heterpgeneous firms models. Furthermore, the OLS coefficient on logistics (0.876) was higher than that for the analogous developing country estimate.

References

Anderson, J. (1979), 'A Theoretical Foundation for the Gravity Equation', *American Economic Review* **69**(1), 106–116.

Anderson, J. & van Wincoop, E. (2003), 'Gravity with Gravitas: A Solution to the Border Puzzle', *American Economic Review* **93**(1), 170–192.

Anderson, J. & van Wincoop, E. (2004), 'Trade Costs', *Journal of Economic Literature* **42**, 691–751.

Arvis, J., Mustra, M., Panzer, J., Ojala, L. & Naula, T. (2007), 'Connecting to Compete: Trade logistics in the global economy', *The World Bank* .

Baier, S. & Bergstrand, J. (2009), 'Bonus Vetus OLS: A Simple Method for Approximating International Trade-cost Effects Using the Gravity Equation', *Journal of International Economics* **77**(1), 77–85.

Baier, S. & Bergstrand, J. (2010), Approximating general equilibrium impacts of trade liberalizations using the gravity equation: Applications to nafta and the european economic area, *in* S. Brakman & P. van Bergeijk, eds, 'The Gravity Model in International Trade: Advances and Applications', Cambridge University Press.

Baranga, T. (2009), 'Unreported Trade Flows and Gravity Equation Estimation', *mimeo* .

Behar, A. & Nelson, B. D. (2009), 'Trade Flows, Multilateral Resistance and Firm Heterogeneity.', *Department of Economics Working Paper Series, University of Oxford* .

Behar, A. & Venables, A. (2011), Transport costs and international trade, *in* A. de Palma, R. Lindsey, E. Quinet & R. Vickerman, eds, 'Handbook of Transport Economics', Edward Elgar.

Bergstrand, J. (1985), 'The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence', *The Review of Economics and Statistics* pp. 474–481.

Bergstrand, J., Egger, P. & Larch, M. (2007), 'Gravity Redux: Structural Estimation of Gravity Equations with Asymmetric Bilateral Trade Costs', *mimeo* .

Bernard, A., Jensen, J., Redding, S. & Schott, P. (2007), 'Firms in International Trade', *The Journal of Economic Perspectives* **21**(3), 105–130.

Chaney, T. (2008), 'Distorted Gravity: The Intensive and Extensive Margins of International Trade', *American Economic Review* **98**(4), 1707–1721.

Clark, X., Dollar, D. & Micco, A. (2004), 'Port Efficiency, Maritime Transport Costs, and Bilateral Trade', *Journal of Development Economics* **75**(2), 417–450.

Djankov, S., Freund, C. & Pham, C. (2010), 'Trading on Time', *The Review of Economics and Statistics* **92**(1), 166–173.

Feenstra, R. (2004), *Advanced International Trade: Theory and Evidence*, Princeton University Press.

GrowthCommission (2008), 'The Growth Report: Strategies for Sustained Growth and Inclusive Development', *Commission on Growth and Development Final Report, Washington, DC* .

Helpman, E., Melitz, M. & Rubinstein, Y. (2008), 'Estimating Trade Flows: Trading Partners and Trading Volumes', *Quarterly Journal of Economics* **123**(2), 441–487.

Helpman, E., Melitz, M. & Yeaple, S. (2004), 'Export Versus FDI with Heterogeneous Firms', *American Economic Review* **94**(1), 300–316.

Huchet-Bourdon, M., Lipchitz, A. & Rousso, A. (2009), 'Aid for Trade in Developing Countries: Complex Linkages for Real Effectivenes', *African Development Review* .

Hummels, D. (2001), 'Time as a Trade Barrier', *GTAP Working Papers* .

Limao, N. & Venables, A. (2001), 'Infrastructure, Geographical Disadvantage, Transport Costs, and Trade', *The World Bank Economic Review* **15**(3), 451.

Manova, K. (2008), 'Credit Constraints, Heterogeneous Firms, and International Trade'.

McCallum, J. (1995), 'National Borders Matter: Canada-US Regional Trade Patterns', *American Economic Review* **85**(3), 615–623.

Melitz, J. (2008), 'Language and Foreign Trade', *European Economic Review* **52**(4), 667–699.

Melitz, M. (2003), 'The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity', *Econometrica* **71**(6), 1695–1725.

Nordås, H. & Piermartini, R. (2004), 'Infrastructure and Trade', *World Trade Organisation, Staff Working Paper ERSD-2004-04* .

Portugal-Perez, A. & Wilson, J. S. (2010), 'Export Performance and Trade Facilitation Reform : Hard and Soft Infrastructure', *Policy Research Working Paper Series, The World Bank* .

Tinbergen, J. (1962), *Shaping the World Economy: Suggestions for an International Economic Policy*, The Twentieth Century Fund, New York.

Wilson, J., Mann, C. & Otsuki, T. (2005), 'Assessing the benefits of trade facilitation: A global perspective', *The World Economy* **28**(6), 841–871.

	Statistic	LPI	ILI
High Income	Mean	3.74	3.84
	std dev	0.34	0.32
Middle and Low Income	Mean	2.49	2.61
	std dev	0.39	0.40

Table 1: Summary Statistics for logistics indices. LPI is World Bank Index. ILI is our own summary measure of the components affecting international logistics. Authors' Calculations

Dependent variable: bilateral exports	1 OLS	2 OLS MR	3 IV 1	4 IV 2
GDP	0.987***	0.922***	0.951***	0.904***
	[0.0161]	[0.0157]	[0.0274]	[0.0295]
Logistics (ILI)	0.606***	0.597***	0.437**	0.697***
	[0.0566]	[0.0556]	[0.138]	[0.151]
Distance	-1.437***	-1.467***	-1.456***	-1.474***
	[0.0437]	[0.0496]	[0.0500]	[0.0501]
Border	1.491***	1.071***	1.066***	1.074***
	[0.166]	[0.176]	[0.176]	[0.176]
Colony	0.653***	0.501***	0.491***	0.508***
	[0.116]	[0.133]	[0.134]	[0.134]
Language	0.651***	0.646***	0.648***	0.645***
	[0.0769]	[0.0956]	[0.0956]	[0.0955]
Samecountry	0.403*	0.398	0.416*	0.387
	[0.227]	[0.243]	[0.244]	[0.243]
Religion	0.122	0.826***	0.820***	0.829***
	[0.107]	[0.143]	[0.142]	[0.143]
Landlocked	-0.752***	-0.648***	-0.635***	-0.656***
	[0.0651]	[0.0653]	[0.0657]	[0.0659]
Island	-0.00127	-0.410***	-0.393***	-0.421***
	[0.0702]	[0.0694]	[0.0700]	[0.0697]
Constant	-24.11***	-33.18***	-33.66***	-32.89***
	[0.695]	[0.602]	[0.704]	[0.724]
N	6939	6939	6939	6939
adj. R-sq	0.593	0.589	0.588	0.589

Table 2: Gravity regression results for homogenous firm model. Significance levels: * p<0.01, ** p<0.05, *** p<0.01. Std errors in brackets. Logistics is significant in all columns and robust to the inclusion of controls or the use of instrumental variables. Column 1 will serve as the benchmark. Column 2 includes MR terms. Columns 3 (1 instrument) and 4 (2 instruments) give insignificantly different coefficients either side of the OLS coefficient.

	1	2	3	4	5
Dependent variable: bilateral exports	Probit	Country	Country, firm	Firm 1	Firm 2
GDP	0.244***	0.941***	0.679***	0.868***	0.840***
	[0.00937]	[0.0183]	[0.135]	[0.0477]	[0.0462]
Logistics (ILI)	0.483***	0.636***	0.123	0.489***	0.445***
	[0.0342]	[0.0704]	[0.273]	[0.105]	[0.0948]
Distance	-0.635***	-1.520***	-0.842**	-1.314***	-1.270***
	[0.0374]	[0.0463]	[0.365]	[0.141]	[0.128]
Border	0.175	1.162***	0.881***	1.020***	1.059***
	[0.175]	[0.163]	[0.215]	[0.172]	[0.184]
Colony	0.152**	0.563***	0.365**	0.478***	0.499***
	[0.0689]	[0.146]	[0.160]	[0.121]	[0.143]
Language	0.418***	0.680***	0.247	0.550***	0.527***
	[0.0598]	[0.0944]	[0.254]	[0.112]	[0.115]
Samecountry	0.489**		-4.123***	0.281	-3.961**
	[0.196]		[1.367]	[0.258]	[1.566]
Religion	0.316***	0.853***	0.541***	0.759***	0.751***
	[0.0865]	[0.141]	[0.204]	[0.167]	[0.146]
Landlocked	-0.121***	-0.657***	-0.523***	-0.622***	-0.603***
	[0.0296]	[0.0582]	[0.105]	[0.0796]	[0.0791]
Island	0.0685*	-0.408***	-0.522***	-0.427***	-0.477***
	[0.0404]	[0.0667]	[0.0688]	[0.0651]	[0.0737]
Constant	-13.32***	-34.38***	-19.05***	-29.45***	-27.94***
	[0.385]	[0.982]	[7.344]	[2.425]	[2.303]
Inverse Mills Ratio		0.273	-0.725		
		[0.229]	[0.585]		
Delta			1.053*	0.307	0.416*
			[0.558]	[0.241]	[0.225]
N	9350	6939	6939	6939	6939
adj. R-sq		0.589	0.589	0.589	0.589

Table 3: Gravity regression results for heterogeneous firm model. Significance levels: * p<0.01, ** p<0.05, *** p<0.01. Std errors in brackets (bootstrapped in columns 2-5). Column 1 is the probit estimate. Column 2 controls for country selection (only) using the Heckman 2-step model. Column 3 follows the HMR procedure with the exclusion of the bilateral component of the same country variable (the MR component is included). Column 4 follows Manova (2008) by not excluding any trade cost variables but excludes the Inverse Mills Ratio. Column 5 excludes the bilateral component of the same country variable and the Inverse Mills Ratio; it is the basis for the country-level simulations.

		Country Level						
Homogeneous	Firm-level	mean	p25	p50	p75	sd	min	max
0.597	0.445	0.882	0.770	0.855	0.971	0.143	0.648	1.522

Table 4: Summary statistics for bilateral export responses to improved logistics. The homogeneous statistic refers to the ILI coefficient in column 2 of Table 2. Other statistics derived from column 5 of Table 3.

Exporter	Share	Homogeneous	Heterogeneous
China	5.34%	3.50	3.93
Brazil	1.90%	1.29	1.53
India	1.82%	1.24	1.45
Mexico	1.81%	1.23	1.35
Russian	0.99%	0.68	0.81
Argentina	0.89%	0.61	0.72
Turkey	0.70%	0.48	0.56
Indonesia	0.59%	0.41	0.47
Poland	0.56%	0.39	0.44
South Africa	0.45%	0.31	0.37
Thailand	0.45%	0.31	0.35
Iran	0.38%	0.26	0.31
Egypt	0.35%	0.24	0.29
Venezuela	0.37%	0.26	0.29
Malaysia	0.32%	0.22	0.25
Colombia	0.28%	0.19	0.22
Pakistan	0.26%	0.18	0.22
Chile	0.27%	0.18	0.22
Philippines	0.26%	0.18	0.21
Algeria	0.19%	0.13	0.16
Peru	0.18%	0.13	0.15
Bangladesh	0.17%	0.12	0.14
Nigeria	0.16%	0.11	0.13
Hungary	0.16%	0.11	0.13
Romania	0.14%	0.10	0.11
Vietnam	0.13%	0.09	0.10
Morocco	0.12%	0.08	0.10
Tunisia	0.07%	0.05	0.06
Syrian	0.06%	0.04	0.05
Uruguay	0.06%	0.04	0.05
Dominican	0.06%	0.04	0.05
Lebanon	0.06%	0.04	0.05
Guatemala	0.06%	0.04	0.05
Sri Lanka	0.06%	0.04	0.05
Ecuador	0.06%	0.04	0.05
Costa Rica	0.05%	0.04	0.04
Sudan	0.05%	0.03	0.04
Bulgaria	0.05%	0.03	0.04
Kenya	0.04%	0.03	0.04
Angola	0.04%	0.03	0.04
Tanzania	0.04%	0.02	0.03
Panama	0.04%	0.03	0.03
El Salvador	0.04%	0.03	0.03
Yemen	0.04%	0.02	0.03
Cameroon	0.03%	0.02	0.03
Jordan	0.03%	0.02	0.03
Cote d'Ivoire	0.03%	0.02	0.03
Ethiopia	0.03%	0.020	0.026
Bolivia	0.03%	0.019	0.023
Uganda	0.02%	0.015	0.021
Jamaica	0.02%	0.017	0.021
Paraguay	0.02%	0.017	0.021
Ghana	0.02%	0.013	0.017
Honduras	0.02%	0.014	0.016
Senegal	0.02%	0.011	0.015
Nepal	0.02%	0.012	0.015
Mozambique	0.02%	0.011	0.015
Mauritius	0.02%	0.011	0.014
Gabon	0.02%	0.011	0.014
Zimbabwe	0.02%	0.011	0.014
Cambodia	0.01%	0.010	0.012
Albania	0.01%	0.009	0.011
Madagascar	0.01%	0.009	0.011
Zambia	0.01%	0.008	0.011
Nicaragua	0.01%	0.009	0.011
Guinea	0.01%	0.007	0.010
Burkina	0.01%	0.007	0.010
Mali	0.01%	0.006	0.010
Haiti	0.01%	0.007	0.009
P. New Guinea	0.01%	0.007	0.009
Benin	0.01%	0.005	0.008
Chad	0.01%	0.005	0.007
Rwanda	0.01%	0.005	0.007
Niger	0.01%	0.004	0.006
Lao	0.01%	0.005	0.006
Malawi	0.01%	0.004	0.006
Togo	0.00%	0.003	0.004
Mauritania	0.00%	0.003	0.004
Sierra	0.00%	0.002	0.004
Mongolia	0.00%	0.002	0.003
Burundi	0.00%	0.002	0.002
Guyana	0.00%	0.001	0.002
Djibouti	0.00%	0.001	0.002
Gambia	0.00%	0.001	0.002
Liberia	0.00%	0.001	0.001
Solomon	0.00%	0.001	0.001
Guinea-Bissau	0.00%	0.000	0.001
Comoros	0.00%	0.000	0.001
MEAN	0.23%	0.16	0.18

Table 5: Country-level elasticities after accounting for Multilateral Resistance. Elasticities for each country assume that only that country improves its international logistics quality by one unit.

APPENDIX TABLES

Country	ILI	LPI	Country	ILI	LPI	Country	ILI	LPI
Rwanda	1.90	1.77	Gambia	2.52	2.52	Saudi Arabia	3.14	3.02
Djibouti	1.99	1.94	Malawi	2.52	2.42	Indonesia	3.17	3.01
Sierra	2.04	1.95	Egypt	2.52	2.37	Poland	3.19	3.04
Gabon	2.10	2.10	Morocco	2.53	2.38	Turkey	3.26	3.15
Albania	2.11	2.08	Iran	2.55	2.51	Hungary	3.26	3.15
Chad	2.11	1.98	P. New Guinea	2.55	2.38	Czech Rep.	3.28	3.13
Niger	2.14	1.97	Ethiopia	2.56	2.33	Israel	3.34	3.21
Solomon Islands	2.16	2.08	Angola	2.59	2.48	Chile	3.40	3.25
Guyana	2.18	2.05	Bangladesh	2.60	2.47	China	3.42	3.32
Algeria	2.20	2.06	Uganda	2.61	2.49	Thailand	3.43	3.31
Tanzania	2.20	2.08	Cambodia	2.61	2.50	Greece	3.52	3.36
Mauritius	2.25	2.13	Uruguay	2.62	2.51	Portugal	3.57	3.38
Syrian	2.26	2.09	Benin	2.63	2.45	South Korea	3.61	3.52
Burundi	2.26	2.29	Honduras	2.63	2.50	Spain	3.61	3.52
Mongolia	2.26	2.08	Colombia	2.63	2.50	Malaysia	3.63	3.48
Togo	2.28	2.25	Paraguay	2.64	2.57	South Africa	3.66	3.53
Nepal	2.29	2.14	Costa Rica	2.68	2.55	Italy	3.68	3.58
Ghana	2.31	2.16	Guatemala	2.70	2.53	France	3.85	3.76
Nicaragua	2.31	2.21	Ecuador	2.71	2.60	New Zealand	3.87	3.75
Haiti	2.31	2.21	Cameroon	2.72	2.49	United States	3.89	3.84
Lao PDR	2.36	2.25	Venezuela	2.72	2.62	Finland	3.91	3.82
Burkina Faso	2.38	2.24	Pakistan	2.73	2.62	Norway	3.92	3.81
Mozambique	2.38	2.29	Kenya	2.74	2.52	Australia	3.94	3.79
Madagascar	2.39	2.24	Brazil	2.78	2.75	Belgium	3.96	3.89
Jamaica	2.40	2.25	Mauritania	2.78	2.63	Denmark	3.98	3.86
Senegal	2.40	2.37	El Salvador	2.83	2.66	Canada	4.04	3.92
Guinea-Bissau	2.41	2.28	Sudan	2.84	2.71	Ireland	4.06	3.91
Yemen	2.41	2.29	Philippines	2.87	2.69	United Kingdom	4.08	3.99
Cote d'Ivoire	2.44	2.36	Guinea	2.88	2.71	Japan	4.09	4.02
Russian Fed.	2.44	2.37	Peru	2.91	2.77	Switzerland	4.10	4.02
Bolivia	2.46	2.31	Tunisia	2.92	2.76	Hong Kong	4.10	4.00
Mali	2.46	2.29	Mexico	3.01	2.87	Austria	4.16	4.06
Zimbabwe	2.46	2.29	Jordan	3.01	2.89	Germany	4.16	4.10
Lebanon	2.48	2.37	Jordan	3.02	2.89	Sweden	4.18	4.08
Zambia	2.50	2.37	Bulgaria	3.04	2.87	Netherlands	4.25	4.18
Comoros	2.51	2.48	Romania	3.05	2.91	Singapore	4.28	4.19
Nigeria	2.51	2.40	Kuwait	3.08	2.99			
Liberia	2.51	2.31	Vietnam	3.09	2.89			
Sri Lanka	2.51	2.40	Argentina	3.10	2.98			
Dominican Rep.	2.52	2.38	India	3.14	3.07			

Table A1: Logistics Performance Index (LPI) and International Logistics Index (ILI) by country.

	1	2	3	4
Dependent variable: bilateral exports	OLS MR	IV	Country, firm	Firm
GDP	0.866***	0.245	0.689***	0.933***
	[0.0123]	[1.100]	[0.118]	[0.0362]
Logistics (ILI)	0.840***	-1.119	0.282	1.203***
	[0.0864]	[5.462]	[0.466]	[0.183]
Logistics_developing	0.158	8.369	0.347	-0.0744
	[0.102]	[16.77]	[0.252]	[0.144]
Distance	-1.363***	-1.418***	-0.979***	-1.588***
	[0.0372]	[0.112]	[0.294]	[0.101]
Border	0.795***	0.840***	0.718***	1.027***
	[0.149]	[0.257]	[0.202]	[0.164]
Colony	0.300***	0.375*	0.23	0.414***
	[0.116]	[0.216]	[0.151]	[0.127]
Language	0.713***	0.798***	0.449**	0.835***
	[0.0726]	[0.195]	[0.194]	[0.0723]
Samecountry	0.633***	0.521	-3.901***	-3.683***
	[0.226]	[0.380]	[1.215]	[1.329]
Religion	0.634***	0.528**	0.409**	0.740***
	[0.111]	[0.261]	[0.180]	[0.0894]
Landlocked	-0.550***	-0.26	-0.477***	-0.564***
	[0.0498]	[0.582]	[0.0601]	[0.0534]
Island	-0.400***	0.0931	-0.483***	-0.410***
	[0.0484]	[1.067]	[0.0599]	[0.0533]
High_income	0.44	26.63	1.062	-0.376
	[0.369]	[54.68]	[0.871]	[0.513]
Constant	-32.56***	-36.88***	-21.42***	-34.88***
	[0.492]	[9.049]	[6.393]	[1.800]
Inverse Mills Ratio			-1.079**	
			[0.479]	
Delta			0.584	-0.382**
			[0.474]	[0.162]
N	10057	10057	10057	10057
adj. R-sq	0.679	0.324	0.68	0.68

Table A2: Gravity regression results for full sample of countries. Significance levels: * p<0.01, ** p<0.05, *** p<0.01. Std errors in brackets (bootstrapped in columns 3-4). Column 1 is estimated by OLS. Column 2 uses two instruments. Column 3 follows the HMR procedure with the exclusion of the bilateral component of the same country variable (the MR component is included). Column 4 excludes the bilateral component of the same country variable and the Inverse Mills Ratio.