The Variety and Quality of a Nation's Exports

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Abstract

Large economies export more in absolute terms than small economies. In this paper we use data on shipments by 121 exporters to 59 importers in 5,000 product categories to ask: *how*? Do big economies export larger quantities of each good (the *intensive* margin), a wider set of goods (the *extensive* margin), or higher quality goods? We find that the extensive margin accounts for about 60% of the greater exports of larger economies. With each category, richer economies export more units at higher prices. We compare these findings to various trade models. Models with Armington national product differentiation do not feature the extensive margin, and incorrectly predict lower prices for the exports of larger economies. Models with Krugman firm-level product differentiation fare better, but must be modified to include quality differentiation to match the price facts. Differences in quality could be the proximate cause of about 10% of country differences in real income per worker, and appear especially important among the richest half of exporters.

1. Introduction

Virtually every theory of international trade predicts that a larger economy will export more in absolute terms than a smaller economy. Trade theories differ, however, in their predictions about how larger economies export more. Models that assume Armington (1969) national differentiation emphasize the *intensive* margin: an economy twice the size of another will export twice as much but will not export a wider variety of goods. Monopolistic competition models in the vein of Krugman (1981) stress the *extensive* margin: economies twice the size will produce and export twice the range of goods. Vertical differentiation models such as Flam and Helpman (1987) feature a quality margin, with richer countries producing and exporting higher quality goods.

These divergent predictions imply very different consequences for welfare. If larger economies intensively export more of each variety, the prices of their national varieties should be lower on the world market. In large-scale CGE models with distinct national varieties, the simulated welfare changes associated with trade liberalization are dominated by such terms of trade effects (see Brown, 1987). In Acemoglu and Ventura (2002), these effects prevent real per capita incomes from diverging across countries with different investment rates. These authors argue that richer countries face lower export prices and that this is the critical force maintaining a stationary world income distribution.[1]

To the extent larger economies export a wider array of goods or export higher quality goods, lower export prices are no longer a necessary consequence of size. Rather than sliding down world demand curves for each variety, bigger economies may export more varieties to more countries. Or they may export higher quality goods at higher prices. If variety and quality margins dominate, then growth and development economists must rely on other forces – such as to technology diffusion and diminishing returns to capital – to tether the incomes of high and low investment economies together. And the welfare effects of trade liberalization could be very different than is typically found in many CGE models.

[1] Davis and Weinstein (2002) build on the Acemoglu and Ventura model in estimating terms-of-trade-driven welfare losses to U.S. natives from migration.

In this paper we use highly detailed U.N. data on exports in 1995 in order to assess the importance of extensive, intensive, and quality margins in trade. The data cover exports from 121 countries to each of 59 importers in over 5,000 six-digit product categories. To check robustness we also examine exports by 124 countries to the U.S. in 1995 in over 13,000 ten-digit product categories. We decompose a nation's exports into contributions from intensive versus extensive margins, and further decompose the intensive margin into price and quantity components. We then relate each margin to country size (PPP GDP) as well as to its components: workers and GDP per worker.

Of special interest are the extensive and quality margins. There are many possible ways to define the extensive margin (counting categories exported, counting categories over a certain size, weighting categories in various ways). We measure the extensive margin in a manner consistent with consumer price theory by adapting the methodology in Feenstra (1994), which appropriately weights categories of goods by their overall importance in exports to a given country. The quality margin is not directly observable, but can be inferred by examining projections of price and quantity on GDP and its components. That is, if large exporters systematically sell high quantities at high prices, this is consistent with these exporters producing higher quality goods.

Our findings are as follows. The extensive margin accounts for about sixty percent of the greater exports of larger economies. The intensive margins are dominated by higher quantities of each good rather than higher unit prices. Richer economies export higher quantities of each good at modestly higher prices, consistent with higher quality. Countries with more workers export higher quantities of each good, but at no higher prices.

These patterns hold for both the U.N. and U.S. datasets. The large extensive margins are inconsistent with Armington models, which do not feature an extensive margin and imply that larger economies face lower export prices. In contrast, Krugman-style models with firm level product differentiation predict that larger economies will produce and export more varieties, consistent with the large extensive margins we find.

Our investigation builds on the empirical work of many predecessors. Feenstra (1994) applied his method to U.S. imports of six manufactured goods and found evidence of substantial import variety growth. Funke and Ruhwedel (2001) found that the variety of both exports and imports are positively correlated with per capita income across 19 OECD countries. Head and Ries (2001)) look for home market effects in U.S. and Canadian trade in order to empirically distinguish increasing returns and national product differentiation models. They find evidence mostly consistent with national product differentiation. By comparison, we examine model implications for extensive (increasing returns) versus intensive (national product differentiation) margins, along with price and quantity effects that each implies. Schott (2002) finds that richer countries export to the U.S. at higher unit prices within narrow categories. Countries more abundant in physical and human capital likewise export a given variety at higher unit prices. Like Schott, we exploit data on export prices in narrow categories by countries of differing income levels. Unlike his study, we examine a broad range of importers and use quantity data along with price data to extract information about quality differences.

The rest of the paper proceeds as follows. In Section 2 we briefly outline the predictions some trade models have for the various margins. We discuss the data we use in Section 3, and this guides how we define the extensive and intensive margins (and the latter's price and quantity components) in Section 4. In Section 5 we present our empirical findings, and in Section 6 we offer conclusions and possible directions for future work.

2. Export Margins in Various Models

In Table 1 we summarize what four trade models predict for the intensive and extensive margins, and for the price and quantity components of the intensive margin. In all of these models, exporter variation in workers and productivity will cause variation in the quantity of output and exports, but along different measurable margins. The predictions for the intensive/extensive margins are stark, and well known, but the price and quantity variations within the intensive margin are more subtle. In the exposition below we describe the implications of the models for prices, and therefore, the value of output for each exporter. Then, a projection of each margin on output, or on output per workers and number of workers, provides information about how well the models describe the data.

To help explain the Table 1 entries, consider the following general environment. Consumers in country m buy from up to J countries in each of I categories of goods. (When we look at the data, we will let I = 5,017 six-digit U.N. Harmonised System codes.) Goods are differentiated both across categories and across producing countries *within* categories. For example, midsize cars and trucks are distinct six-digit categories, but within a category Japanese midsize cars are differentiated from German midsize cars. For simplicity we adopt a Dixit-Stiglitz formulation with a single elasticity of substitution $\sigma > 1$ between goods in different categories and goods from different countries. Consumers maximize utility given by

(1) $$U_m = \left[\sum_{j=1}^{J} \sum_{i=1}^{I} Q_{jmi} N_{jmi} (x_{jmi})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

subject to

(2) $$\sum_{j=1}^{J} \sum_{i=1}^{I} N_{jmi}\, p_{jmi}\, x_{jmi} \leq Y_m .$$

Q_{jmi} is the *quality* of varieties exported by country j to country m in category i.[2] N_{jmi} is the number of symmetric varieties exported from j to m *within* category i. (We assume these are symmetric for simplicity; they are unobserved within six-digit HS categories.) Japan exporting multiple, differentiated midsize car models to the U.S. would be an example of $N_{jmi} > 1$. x_{jmi} is the number of units (quantity) exported from j to m in category i, and p_{jmi} is the price of each of the units. If country m does not buy from country j in category i (say, because j does not produce any varieties in category i), then $x_{jmi} = 0$ and $N_{jmi} = 0$. Y_m is country m's income.

We now explain the entries in Table 1.[3] In doing so we focus on exporter j variation that feeds into proportional variation across all markets m and categories i. That is, market-specific and category-specific proportional constants are omitted. We also express all objects relative to an

[2] We let quality enter the utility function without an exponent so that it is in "price units", i.e., equivalent to a lower price. This is purely a normalization.
[3] We refer the reader to Hummels and Klenow (2002) for a more detailed exposition.

exporter for which the following variables are normalized to 1: I, Q, N, x, p, A (productivity), L (employment), and Y. A and L differ exogenously across countries. We summarize variety within and across categories as $V = NI$ (= 1 in the reference country).

Armington

In Armington's (1969) national differentiation model, each country produces a single variety in each category (V_j = 1 for all j), so there is no extensive margin. Quality likewise does not vary across countries (Q_j = 1 for all j). A country with more workers or higher productivity simply produces more of each variety ($x_j = A_j L_j$). This intensive margin results in lower prices for each variety. The effect on export prices is smaller the larger the elasticity of substitution σ between varieties: $p_j = (A_j L_j)^{-1/\sigma}$. Country j's GDP is $Y_j = p_j\, x_j\, V_j = (A_j L_j)^{1-1/\sigma}$. Taking logs and rearranging, country j's export quantities and prices can be expressed as

(3) $$ln(x_j) = \frac{\sigma}{\sigma - 1} ln(Y_j/L_j) + \frac{\sigma}{\sigma - 1} ln(L_j)$$

and

(4) $$ln(p_j) = \frac{-1}{\sigma - 1} ln(Y_j/L_j) + \frac{-1}{\sigma - 1} ln(L_j).$$

These expressions are the basis of the price and quantity entries in the first row of Table 1. In this Armington world, larger economies intensively export higher quantities at lower prices.[4]

Acemoglu and Ventura

Acemoglu and Ventura (2002) add endogenous capital accumulation and an endogenous number of varieties to the Armington model. They posit constant returns to capital in the production of each variety, and a fixed labor requirement for producing each variety. The number of varieties a country produces is then proportional to its employment ($V_j = L_j$). A country with

[4] An alternative to expression (4) is $ln(p_j) = \frac{-1}{\sigma} ln(A_j) + \frac{-1}{\sigma} ln(L_j)$. For empirical estimation, this expression would allow consistent estimation of the effect of exogenous variables. With (4), in contrast, the effect of employment on prices will be biased downward (upward in absolute terms). Higher L lowers income per worker for a given A, so controlling for Y/L requires a higher A. The coefficient on L in (4) therefore captures the effect on export prices of higher L combined with enough higher A to keep Y/L unchanged. As we discuss below, we focus on (4) because Y/L is directly observable, whereas one must know σ (and quality if it varies across countries) to derive A.

higher productivity (A_j, broadly construed to include physical capital) produces more of each variety ($x_j = A_j$). Higher production of each variety translates into lower prices for each variety: $p_j = (A_j)^{-1/\sigma}$. Country j's GDP is $Y_j = p_j\, x_j\, V_j = (A_j)^{1-1/\sigma} L_j$. Greater Y/L, but not greater L, is associated with producing higher quantities of each variety and selling them at lower unit prices:

(5) $$ln(x_j) = \frac{\sigma}{\sigma-1} ln(Y_j/L_j)$$

and

(6) $$ln(p_j) = \frac{-1}{\sigma-1} ln(Y_j/L_j).$$

The second row of Table 1 summarizes this model's predictions.

Krugman

Krugman (1980, 1981) modeled countries as producing an endogenous number of varieties.[5] With fixed output costs of producing each variety, the number of varieties produced in a country is proportional to the size of the economy ($V_j = Y_j = A_j L_j$). In this simplest Krugman world, all countries export the same quantity per variety ($x_j = 1$ for all j) and export at the same unit prices ($p_j = 1$ for all j). Neither unit prices nor quantity per variety vary with GDP per worker or the number of workers. These results are stated in the third row of Table 1.

Quality Differentiation

Suppose quality varies across countries (Q_j differs across j) but productivity and variety do not ($A_j = 1$ and $V_j = 1$ for all j). Countries with more workers produce more of each variety ($x_j = L_j$). A country's unit prices reflect both the level of employment and the level of quality: $p_j = Q_j(L_j)^{-1/\sigma}$. GDP is $Y_j = Q_j(L_j)^{1-1/\sigma}$. Also, $Y_j/L_j = Q_j(L_j)^{-1/\sigma} = p_j$. Quantity per variety should project on exporter employment but not exporter GDP per worker, and prices for varieties should project on GDP per worker but not employment. These results are shown in the final row of Table 1.

[5] See also Ethier (1979, 1982).

More generally, we can use consumer first order conditions from (1) and (2) to express quality and within-category variety in terms of the observed prices and quantities and the elasticity of substitution between varieties:

(7) $$ln(Q_j) + \frac{1}{\sigma} ln(N_j) = ln(p_j) + \frac{1}{\sigma} ln(N_j x_j).$$

Note that the observed quantities per category are actually Nx, rather than the theoretically ideal x. Also note that quality and within-category variety are isomorphic (up to a scalar) in this expression. We return to this issue when discussing the empirical results.

3. Data Description

We draw export data from two sources. We use worldwide data from UNCTAD's Trade Analysis and Information System (TRAINS) CD-ROM for 1995. The TRAINS project combines bilateral imports data collected by the national statistical agencies of 76 importing countries, covering all exporting countries (227 in 1995). The data are reported in the Harmonized System (HS) classification code at the six-digit level, or 5,017 goods, and include shipment values and quantities. For a subset of these countries (121 of the 227 exporters and 59 of the 76 importers), we have matching employment and GDP data (discussed below). The 59 importers represent the vast majority of world imports, so total shipments for each exporter reported in TRAINS closely approximates worldwide shipments for that exporter.

We also use U.S. data with more product detail from the "U.S. Imports of Merchandise" CD-ROM for 1995, published by the U.S. Bureau of the Census. These data are drawn from electronically submitted Customs forms that report the country of origin, value, quantity, freight paid, duties paid, and HS code for each shipment entering the United States. The ten-digit HS scheme includes 13,386 highly detailed goods categories. The data include all countries shipping to the United States, a total of 222 in 1995. We have employment and output data in 1995 for 124 of these exporters.[6]

[6] The remaining 98, primarily very small or former Soviet-bloc countries, comprise only 5% of U.S. trade in 1995.

In both datasets, we measure prices as unit values (value/quantity). Quantity (and therefore price) data are missing for approximately 16 percent of U.S. observations and 18 percent of worldwide observations for 1995.[7] When the U.S. data include multiple shipments from an exporter in a ten-digit category, we aggregate values and quantities. The resulting prices are quantity-weighted averages of prices found within shipments from that exporter in that category.

Data on national employment and GDP at 1996 international (PPP) prices come from Heston, Summers and Aten (2002). We use PPP GDP, as opposed to GDP at current market exchange rates, to avoid any mechanical association between an exporter's price and GDP through the value of its market exchange rate. All of our empirical results are robust to using GDP valued at market exchange rates instead of PPP exchange rates.

4. Decomposition Methodology

We now construct empirical counterparts to the intensive margin (px), the extensive margin (I), and the price (p) and quantity (x) components of the intensive margin. To do so, we adapt Feenstra's (1994) methodology for incorporating new varieties into a country's import price index when preferences are of the form in our equation (1). Feenstra shows that the import price index is effectively lowered when the set of goods expands.

Instead of comparing varieties imported over time, we compare varieties imported from different exporters at a point in time. In this case, comparing export prices for country j relative to a reference country k requires an adjustment for the size of each exporter's goods set. The appropriate adjustment is the extensive margin. For the case when j's shipments to m are a subset of k's shipments to m, the extensive margin is defined as

$$\text{(8)} \qquad \text{EM}_{jm} = \frac{\sum_{i \in I_{jm}} p_{kmi}\, x_{kmi}}{\sum_{i \in I} p_{kmi}\, x_{kmi}}.$$

[7] The likelihood that quantity data are missing is uncorrelated with aggregate employment and GDP per worker, so our analyses should not be biased by dropping these observations.

This is a cross-exporter analogue of Feenstra's new varieties adjustment to an import price index. I_{jm} is the set of *observable* categories in which country j has positive exports to m, i.e., $x_{jmi} > 0$. (In our empirical implementation the I categories will be 5,017 six-digit U.N. Harmonised System product codes.) Reference country k has positive exports to m in all I categories. EM_{jm} equals country k's exports to m in I_{jm} relative to country k's exports to m in all I categories.

The extensive margin can be thought of as a weighted count of j's categories relative to k's categories. If all categories are of equal importance, then the extensive margin is simply the fraction of categories in which j exports to m. More generally, categories are weighted by their importance in k's exports to m. An advantage of evaluating a category's importance without reference to j's exports is that it prevents a category from appearing important solely because j (and no other country) exports a lot to m in that category.[8]

The corresponding intensive margin compares nominal shipments for j and k in a common set of goods. It is given by

(9) $$\text{IM}_{jm} = \frac{\sum_{i \in I_{jm}} p_{jmi}\, x_{jmi}}{\sum_{i \in I_{jm}} p_{kmi}\, x_{kmi}}.$$

IM_{jm} equals j's nominal exports relative to k's nominal exports *in those categories in which j exports to m* (I_{jm}). The ratio of country j to country k exports to m equals the product of the two margins:

(10) $$\frac{\sum_{i=1}^{I} p_{jmi}\, x_{jmi}}{\sum_{i=1}^{I} p_{kmi}\, x_{jmi}} = \text{IM}_{jm}\, \text{EM}_{jm}.$$

To see a simple example of the intensive versus extensive decomposition, compare German and Belgian exports to the U.S., using k = rest-of-world for the reference country in each case. Given the size of each, it is not surprising that Germany's exports to the U.S. are 6.2 times

[8] A disadvantage is that a country may appear to have a large extensive margin because it exports a small amount in categories in which k exports a lot to m. As we discuss in the next section, we do not find this to be the case empirically.

larger than Belgium's. Some of this comes through a greater number of categories shipped – Germany ships in 79 percent of the 5017 six-digit HS codes, while Belgium ships in 51 percent. Were all categories of equal weight this would yield an extensive margin for Germany that is 1.55 times larger than Belgium's. This leaves an intensive margin for Germany, or exports per category shipped, that is 4 times larger than Belgium's. However, not all categories are of equal weight. Germany ships in categories that are a larger share of rest-of-world exports to the U.S., the numerator in equation (8). Incorporating the weighted counts, Germany's extensive margin is 1.65 times greater than Belgium's, and its intensive margin is 3.75 times larger.

We now turn to decomposing the intensive margin into price and quantity indices. Suppose that quality (Q) and within-category variety (N) vary across categories i for each importer m. This encompasses preferences that place more weight on some goods than others. As a baseline case, assume further that quality and within-category variety do not vary by exporter. (In our empirical analysis, we will test these assumptions.) For this baseline case, Feenstra (1994) derives an exact price index for the intensive margin of country m's imports from j versus k:

(11) $$\mathcal{P}_{jm} = \prod_{i \in I_{jm}} \left(\frac{p_{jmi}}{p_{kmi}}\right)^{w_{jmi}}.$$

In (11), w_{jmi} is the logarithmic mean of s_{jmi} (the share of category i in country j's exports to m) and s_{kmi} (the share of category i in k's exports to m, where $i \in I_{jm}$):

$$s_{jmi} = \frac{p_{jmi}\, x_{jmi}}{\sum\limits_{i \in I_{jm}} p_{jmi}\, x_{jmi}}, \quad s_{kmi} = \frac{p_{kmi}\, x_{kmi}}{\sum\limits_{i \in I_{jm}} p_{kmi}\, x_{kmi}}, \quad w_{jmi} = \frac{\dfrac{s_{jmi} - s_{kmi}}{\ln s_{jmi} - \ln s_{kmi}}}{\sum\limits_{i \in I_{jm}} \dfrac{s_{jmi} - s_{kmi}}{\ln s_{jmi} - \ln s_{kmi}}}.$$

We decompose the intensive margin into the price index (11) and an implicit quantity index: [9]

[9] Feenstra incorporates the extensive margin into a broader price index. The analogue for cross-country exports is

$$\frac{\sum_{i=1}^{I} p_{jmi}\, x_{jmi}}{\sum_{i=1}^{I} p_{kmi}\, x_{kmi}} = \left[\mathcal{P}_{jm}(\mathrm{EM}_{jm})^{-1/(\sigma-1)}\right]\left[\mathcal{X}_{jm}(\mathrm{EM}_{jm})^{\sigma/(\sigma-1)}\right]$$

The first bracketed term is a price index that reflects how higher EM_{jm} lowers the cost of obtaining utility through imports from country j. The second bracketed term is a quantity index incorporating the impact of the lower effective price on demand for country j exports.

(12) $$\mathrm{IM}_{jm} = \mathcal{P}_{jm}\, \mathcal{X}_{jm}$$

Expressions (8) through (12) define our decomposition of country j's exports to a given market m (relative to k's exports to m). To implement the decompositions, we need to choose a reference k. For each market m, we choose $k = W_{-j-m}$, or all exporters to m other than j. In practice this ensures $I_{jm} \subseteq I$, i.e., that country j exports to m in a subset of the categories exported by k to m. For measuring j's extensive margin, it means the importance of different categories is determined by the broadest possible set of other countries. Similarly, for measuring the price and quantity components of the intensive margin, j's prices and quantities are compared to those of all other countries exporting to m.

For our implementation with U.S. data, we employ equations (8) through (12) with the import market m = the U.S.. In the U.N. TRAINS data, we have 59 import markets. We summarize each exporter's margins across all the markets as follows. We first decompose country j's exports to each market $m \subseteq M_{-j}$, where M is the set of countries for which import data are available. We then take the geometric average of country j's decompositions across the M_{-j} markets to get

$$\mathrm{IM}_j = \prod_{m \in M_{-j}} (\mathrm{IM}_{jm})^{a_{jm}} \qquad \mathrm{EM}_j = \prod_{m \in M_{-j}} (\mathrm{EM}_{jm})^{a_{jm}}$$

$$\mathcal{P}_j = \prod_{m \in M_{-j}} (\mathcal{P}_{jm})^{a_{jm}} \qquad \mathcal{X}_j = \prod_{m \in M_{-j}} (\mathcal{X}_{jm})^{a_{jm}}.$$

The weight a_{jm} is the logarithmic mean of the shares of m in the overall exports of j and $W{-}j{-}m$, respectively (normalized so that a_{jm}'s sum to 1 over the set M_{-j}).

5. Empirical Results

For each exporting country, we construct overall exports, the intensive margin, the extensive margin, and the price and quantity components of the intensive margin. We then regress the natural log of each margin on the exporter's log GDP relative to rest-of-world log GDP. Separately, we regress each margin on exporter GDP per worker and log employment, both expressed relative to the rest of the world. The regression samples are cross-sections of exporting countries in 1995.

This approach has two interesting advantages. First, because OLS is a linear operator, the regressions additively decompose the margins along which larger economies export more. Second, by projecting each margin on GDP etc., our conclusions are more robust to measurement error. For example, the level of the extensive margin can be sensitive to the inclusion of very small trade flows that one might argue should rightly be ignored. But a projection of the extensive margin on log GDP is not sensitive to this unless there is a systematic relationship between the measurement error and exporter GDP.[10]

Although we will be comparing our findings to each model's predictions, we are not aiming to formally test each model. The models were deliberately stark and can all be easily rejected. Our goal is instead to identify model ingredients that may help explain the facts. This will hopefully prove useful for future work developing a single model consistent with the facts.

Table 2 presents the extensive and intensive margins in the 1995 U.N. data. This data covers exports by 121 countries to 59 markets in 5,017 categories. Each regression has 121 observations, one for each exporting country. All of the coefficients in this and subsequent Tables are significantly different from zero (p-values below 1%) unless otherwise noted. The first row shows that larger economies – whether measured by GDP per worker, employment, or GDP – export substantially more to the typical market. The second and third rows report that around 40% of this occurs on the intensive margin and the other 60% on the extensive margin. The extensive margin plays a more prominent role for richer economies (66%) than for economies with more workers (57%). The elasticity with respect to overall GDP is tilted toward that with respect to employment because employment varies more than GDP per worker across the 121 countries.

Table 3 breaks the intensive margin into its price and quantity components. Within categories and to a given market, countries with twice the GDP per worker export 32% higher

[10] We experimented with discarding small trade flows, with cutoffs set at various levels in both absolute and percentage of exports terms. These cutoffs did affect the size of extensive margins but did not affect their projection on GDP and its components.

quantities at 11% higher prices. Countries with twice the employment tend to export 34% higher quantities at no higher or lower prices. Economies with twice the GDP export 34% higher quantity at 3% higher prices, not far from the elasticities with respect to employment.

The results in Tables 2 and 3 do not conform to the predictions of any single model in Table 1. This is not surprising given that the models are polar cases. The Armington model has no extensive margin, omitting a channel that constitutes more than half the exports of larger economies. Within the intensive margin, Armington predicts higher quantities per variety and lower prices. Countries with higher GDP do export higher quantities per category, but not nearly to the extent predicted by the model. Just as striking, larger economies do not export their varieties at lower prices. Richer countries export at modestly higher prices, and countries with more workers export at no lower prices. Typical elasticities of substitution estimated at the six-digit level are between five and ten (see Hummels, 1999). The Armington model therefore predicts price elasticities in the range –0.11 to –0.25. The coefficient on GDP per worker is ten standard errors away from this, and the coefficient on employment nine standard errors away.

Like the Armington model, the Acemoglu and Ventura model predicts richer countries will export higher quantities of each variety at a lower price. To match facts about the world income distribution, Acemoglu and Ventura (2002) need the elasticity of substitution to be small (around 2.3), and the elasticity of price with respect to GDP per worker to be large and negative (around –0.7). The data analysis here indicates that the price effects are small and go in the wrong direction. This suggests that diminishing returns and technology diffusion may be needed to ensure a stationary world income distribution.

The Krugman model does feature an extensive margin, but it is larger than that found in the data. The model's predictions for prices and quantities are closer to the data than were the previous models', but discrepancies remain. Richer economies and those with more workers have notably higher export quantities. This could be consistent with the Krugman model if larger economies produce more varieties within a six-digit category. In this case, we would have understated the extensive margin and overstated the quantity component of the intensive margin.

We will argue below that this is a plausible interpretation of our results. One fact difficult for the Krugman framework to explain is the higher price of rich country exports. Quality differentiation would seem to be necessary.

The quality differentiation model has no extensive margin, at odds with the large extensive margins documented in Table 2. But this model has an ingredient which can help explain some of the price and quantity facts in Table 3. By exporting higher quality goods, richer economies can export higher quantities without lowering the prices of their varieties on world markets. The polar version of the model overstates this price margin for richer economies, but fits the price margin for countries with more workers. It understates the quantity margin with respect to GDP per worker, and overstates it with respect to employment.

Putting the polar quality differentiation model aside, how much does quality vary with exporter income? We would like to extract quality from the price and quantity margins using equation (7) above. We cannot disentangle quality from within-category variety, however, unless we have detailed data on the precise number of varieties per good from another source. For an example of this sort of calculation, consider Japanese versus South Korean car exports to the U.S.. In 1995, dollar sales of Japanese models in the U.S. exceeded dollar sales of South Korean models by a factor of 28.[11] Japan exported 56 different car models to the U.S. in 1995, whereas South Korea exported 8 car models.[12] We would attribute 7 of the factor of 28 to more Japanese varieties (a 58% extensive margin in log terms), the remaining factor of 4 to the intensive margin. The average unit price of Japanese models was almost 2.4 times the average unit price of South Korean models ($18,371 vs. $7,768). The number of cars sold per Japanese model exceeded units sold per South Korean model by a factor of 1.7 (38,800 vs. 22,900). Based on these figures, the 42% intensive margin consisted of 26% prices and 16% quantities. Using an elasticity of substitution $\sigma = 5$ and equation (7), we would infer that Japanese models were 2.6 times the

[11] The data is from Ward's Motor Vehicle Facts & Figures. In our calculations below, we include domestic production of models exported to the U.S. in sales of models exported to the U.S..

[12] There are only 7 six-digit categories covering passenger motor vehicles in the U.N. data, so Japan exported at least 8 car models to the U.S. per six-digit car category. This illustrates that a country can be exporting more than one variety to a given market in a six-digit category, i.e., within-category variety.

quality of South Korean models. And we would say Japanese cars had lower quality-adjusted prices (2.6 times the quality for 2.4 times the price), explaining their higher unit sales per model.

Without the necessary data on differentiated models, we cannot do these calculations for all categories of goods. But we can ask what our estimates imply for quality and within-category variety under particular assumptions. We start by supposing that within-category variety does not vary with exporter Y/L or L. Then we can use expression (7), our estimates in Table 3, and estimates of the elasticity of substitution taken from the literature to infer quality variation.[13] Based on estimates in Hummels (1999), we consider $\sigma = 5$ and $\sigma = 10$. These values correspond to markups of 25% and 11%, respectively. We also entertain $\sigma = 2.3$, which is Acemoglu and Ventura's (2002) required value. The top panel of Table 4 reports the implied quality elasticities: countries with twice the Y/L tend to export 14% to 24% higher quality varieties, and countries with twice the L tend to export 4 to 15% higher quality products. Given our construction, quality-adjusted prices must be lower for large economies given their quantity margin is positive. This is in the spirit of the Armington and Acemoglu and Ventura models. At -.14 (standard error .02), however, the quality-adjusted price elasticity with respect to Y/L is a long way from the -0.7 required by Acemoglu and Ventura.

We next suppose that within-category variety varies with exporter size, but quality does not. The middle panel of Table 4 applies (7) to this case. Under the three values for σ, economies with twice the Y/L export 56 to 138% more varieties per category, and economies with twice the L export 34 to 36% more varieties. These elasticities are large compared to the increase in the extensive margin when going from six-digits to ten-digits within the U.S. import dataset.

Finally, suppose both quality and within-category variety are a function of exporter size, but quality-adjusted prices are not. . In this case, observed prices perfectly capture quality variation so the quality elasticities simply equal the price elasticities, as is typically assumed in the literature. If a country's exports are representative of their production, the implication would be that quality differences are the proximate cause of 11% of differences in Y/L across countries.

[13] This assumes the existence of a single elasticity of substitution, whereas this elasticity surely varies by category.

Within-category variety is left to explain the quantity elasticities. As the third panel of Table 4 shows, the implication would be that economies twice the size export about 33% more varieties within categories. In this case, a hybrid of the Krugman model and the quality differentiation model could potentially fit all of the facts.

Robustness Checks

We carried out a number of checks to see if the estimations and calculations in Tables 1-4 are robust to the sample of countries, the sample of goods, and the inclusion of additional covariates. First, we decomposed exports for a sample of 124 countries exporting to the U.S. in 1995. The US data contain more commodity detail, reporting ten-digit HS categories (13,386 categories compared to the 5,017 in the six-digit U.N. data). We estimated that the extensive margin accounts for 53% of the additional exports to the U.S. by larger economies.[14] As in the U.N. data, the extensive margin is more prominent for richer exporters (64%) than for exporters with more workers (47%). Economies with twice the Y/L export 47% higher quantities at 13% higher prices to the U.S. market. Countries with twice the L export 62% higher quantities at 5% lower prices. Overall, exports by 124 countries to the U.S. tell a broadly similar story to the exports by 121 countries to 59 countries.

Returning to the larger set of importers, we split our exporter sample by Y/L, performing the regressions separately for the richest 61 and poorest 60 exporters. The relative importance of the extensive and intensive margins is quite similar for the top and bottom Y/L samples. More interesting is the behavior of the price and quantity margins, as reported in Table 5. Within both samples, countries with higher L export higher quantities per variety with no significant differences in prices. This is very similar to our findings with the pooled sample. Within each sample, however, Y/L has very different coefficients. In the top sample, higher Y/L is associated with higher prices and no greater quantity per variety. In the bottom sample, higher Y/L is associated with higher quantity per variety with no significant differences in prices. These results suggest markedly different patterns of specialization across the samples. In the high Y/L sample we see results consistent with pure quality differentiation – higher prices but no higher quantities per variety. In

[14] When calculated at the six-digit level, the extensive margin accounts for 45% of the total.

the low Y/L sample, we see a story consistent with within-category variety – higher quantity per variety at the same prices.

Our second set of robustness checks examined sensitivity to the goods included in the sample. One possibility is that the models of trade described in Section 3 only apply to differentiated products. Many countries may simply lack the natural resources to export in certain commodity categories. To address this we examined two samples designed to isolate differentiated goods. First, we included only those HS codes that correspond to manufacturing categories, as defined by Standard Industrial Trade Classification categories 5-8, omitting commodity categories 0-4. Second, we included only those HS codes belonging to Rauch's (1999) differentiated products four-digit SITCs. The excluded products are those Rauch classified as reference priced or traded on organized exchanges.[15] Results were similar using either differentiated goods classification scheme.

When looking at differentiated goods only, we found much larger overall export elasticities with respect to Y and Y/L than we found for the entire sample of goods. A likely explanation is that the share of differentiated goods in exports is rising in Y/L, and our elasticity picks this up. However, the contribution of the intensive and extensive margins to the overall export elasticity was very similar to the full sample of goods, as was the contribution of the price and quantity components to the intensive margin.

As another robustness check, we examined decompositions for consumption goods and intermediate plus capital goods separately.[16] Smaller countries may have a narrower range of industries (because of fixed costs of production) and hence have no demand for imports of certain intermediates and capital goods. For example, a country without a steel industry would have no need to import steel-making equipment. On the grounds that people are generalists in consumption (versus specialists in production), this argument has much less force for consumer goods. The results for the consumption goods sample, and for the intermediate plus capital goods sample, were very similar to the full sample of goods.

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[15] The mapping from six-digit HS codes to Rauch's version of four-digit SITCs (revision 2) was not perfect. We could not determine a Rauch classification for about 25% of the 5000 HS categories, so we excluded these as well.
[16] We used the U.N.'s Broad Economic Classification system which provides a split of trade categories into capital, intermediate, and consumption goods.

We also explored the robustness of our results to the inclusion of additional covariates. It may be that certain margins comove with certain factors that contribute to Y/L more than others. Accordingly, we broke Y/L into components: physical capital (K/L), human capital (H/L), and TFP. The relative size of the extensive and intensive margins were very similar for Y/L and each component separately. Point estimates on the price and quantity components did reveal some differences. However, the standard errors on these estimates were quite large, and the differences were not statistically significant.

We next explored whether the results changed when we included measures of trade barriers. For the U.S. dataset, we used (total duties + total freight)/(nominal exports). We then calculated a trade barrier index for each exporter relative to the rest of the world, aggregating over categories in a manner identical to the exporter price indices in equation (11). The coefficient on this barrier index was negative and highly significant in all but the price regressions. Roughly 70 percent of the barrier index's effect on exports was on the intensive margin, and, within that, all on the quantity component. When we added this variable as a control, however, none of the coefficients on Y/L, L, or Y was altered by even one standard error.

For the U.N. countries and categories, data on tariffs and freight costs are not readily available. In their stead we deployed distance to markets as a crude proxy for transport costs. For exporter j, we calculated distance to market m, weighted by m's share of world output in 1995 at market exchange rates, then summed over markets. Including this crude proxy had no material effect on any of the exporter size coefficients.

6. Conclusion

Larger economies export more in absolute terms than smaller economies. In this paper we decompose a country's exports into margins that account for these differences. We analyze the extent to which larger economies export higher volumes of each good (the intensive margin), export a wider set of goods (the extensive margin), and export higher quality goods.

Using 1995 trade data for many countries in many product categories, we find that the extensive margin accounts for 60% of the greater exports of larger economies. Within categories, richer countries export more units at higher prices to a given market, consistent with producing higher quality. Our estimates imply that quality differences could be the proximate cause of around 10% of country differences in real income per worker.

These calculations are useful for distinguishing features of trade models that correspond more or less well to the data. Such distinctions can be extremely important in determining the welfare consequences of access to trade. Armington models of national product differentiation include no extensive margin, and so fail to explain the largest margin by which the exports of large and small economies differ. Because they lack this margin, these models also imply that the greater exports of larger economies will be accompanied by lower export prices. In the Acemoglu and Ventura model (2002), these terms of trade effects result in a stationary world income distribution despite disparate investment rates.

Krugman-style models with products differentiated by firms come closer to fitting the facts on intensive/extensive export margins. To match the positive relationship between prices (and quantities) and exporter income per worker, however, requires modifying these models to include quality differentiation.

We considered only a few models, chosen because they had the clearest predictions for how exports should vary with an economy's size. Other models feature an extensive margin and could perhaps match the facts we have documented. For example, the Ricardian model developed by Eaton and Kortum (2002) predicts variation in the extensive margin as a function of trade barriers and the distribution of productivity. And Kehoe and Ruhl (2002) use a Ricardian model to fit the large extensive component in post-liberalization trade growth (e.g., after NAFTA).[17] Perhaps a Ricardian model could be adapted to also feature covariation between exporter size and the extensive margin. We leave this question for future work.

[17] Hillberry and McDaniel (2002) also document a large extensive margin in post-NAFTA trade growth.

Table 1

Model Predictions for Export Margins

	Intensive (*px*)	**Extensive (*V*)**	**Price (*p*)**	**Quantity (*x*)**
Armington	1	0	-1/(σ-1)	σ/(σ-1)
Acemoglu & Ventura				
Y/L	1	0	-0.7	1.7
L	0	1	0	0
Krugman	0	1	0	0
Quality Differentiation	1	0		
Y/L			1	0
L			0	1

Notes: For discussion of each model, see section 2 in the text. Entries are model predictions for how exports increase with respect to exporter size. A single entry indicates the same elasticity with respect to both *Y/L* (GDP per worker) and *L* (employment).

Table 2

Extensive and Intensive Margins

Independent Variable → **Dependent Variable ↓**	***Y/L***	***L***	Adj. R^2	***Y***	Adj. R^2
Overall Exports	1.26 (0.08)	0.79 (0.05)	0.80	0.91 (0.05)	0.76
Intensive Margin	0.43 (0.05)	0.34 (0.03)	0.59	0.36 (0.03)	0.59
	34%	**43%**		**40%**	
Extensive Margin	0.84 (0.06)	0.45 (0.03)	0.75	0.55 (0.03)	0.67
	66%	**57%**		**60%**	

Notes: All variables are in natural logs. Number of exporting countries = Number of observations = 121. Standard errors are in parentheses. For definitions of each margin see equations (8), (9) and (10). Percentages describe the contribution of each margin to the overall export elasticity. *L* = 1995 Employment in the exporting country relative to the sum of employment in the other 120 exporters. *Y* = 1995 PPP GDP in the exporting country relative to the sum of GDP in the other 120 exporters.

Data Sources: UNCTAD for 1995 exports to 59 countries by 121 countries in 5,017 6-digit categories. Heston, Summers, and Aten (2002) for employment and PPP GDP.

Table 3

Price and Quantity Components of the Intensive Margin

Independent Variable → **Dependent Variable ↓**	***Y/L***	***L***	Adj. R^2	***Y***	Adj. R^2
Prices	**0.11** (0.02)	0.00 (0.01)	0.18	**0.03** (0.01)	0.04
Quantities	**0.32** (0.05)	**0.34** (0.03)	0.53	**0.34** (0.03)	0.54

Notes: All variables are in natural logs. Number of exporting countries = Number of observations = 121. Standard errors are in parentheses. For definitions of the price and quantity components see equations (11) and (12). *L* = 1995 Employment in the exporting country relative to the sum of employment in the other 120 exporters. *Y* = 1995 PPP GDP in the exporting country relative to the sum of GDP in the other 120 exporters.

Data Sources: UNCTAD for 1995 exports to 59 countries by 121 countries in 5,017 6-digit categories. Heston, Summers, and Aten (2002) for employment and PPP GDP.

Table 4

What Prices and Quantities Imply for Quality, Quality-Adjusted Prices, and Within-Category Variety

		σ	*Y/L*	*L*
If All Quality	Quality	2.3	.24	.15
		5	.17	.07
		10	.14	.04
	Prices - Quality	2.3	-.14	-.15
		5	-.06	-.07
		10	-.03	-.03
If All Variety	Variety	2.3	.56	.34
		5	.85	.35
		10	1.38	.36
	Prices - Quality	NA	.11	.00
Some of Each	Variety (= Quantity)	NA	.32	.34
	Quality (= Price)	NA	.11	.00

Notes: Entries in the last two columns are elasticities with respect to *Y/L* and *L*. These are based on estimates in Table 3 and equation (7). σ = the elasticity of substitution between different varieties. NA means independent of σ. *L* = 1995 Employment in the exporting country relative to the sum of employment in the other 120 exporters. *Y* = 1995 PPP GDP in the exporting country relative to the sum of GDP in the other 120 exporters.

Data Sources: UNCTAD for 1995 exports to 59 countries by 121 countries in 5,017 6-digit categories. Heston, Summers, and Aten (2002) for employment and PPP GDP.

Table 5

Prices and Quantities: Top vs. Bottom Y/L

Sample	Independent Variables → / Dependent Variable ↓	*Y/L*	*L*	Adj. R^2
Richest 61 countries	Prices	**0.41**	0.00	0.39
		(0.07)	(0.02)	
	Quantities	0.00	**0.37**	0.58
		(0.18)	(0.04)	
Poorest 60 countries	Prices	-0.05	-0.02	0.03
		(0.03)	(0.02)	
	Quantities	**0.39**	**0.33**	0.44
		(0.12)	(0.05)	

Notes: All variables are in natural logs. Standard errors are in parentheses. For definitions of the price and quantity components see equations (11) and (12). *L* = 1995 Employment in the exporting country relative to the sum of employment in the other 120 exporters. *Y* = 1995 PPP GDP in the exporting country relative to the sum of GDP in the other 120 exporters.

Data Sources: UNCTAD for 1995 exports to 59 countries by 121 countries in 5,017 6-digit categories. Heston, Summers, and Aten (2002) for employment and PPP GDP.

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