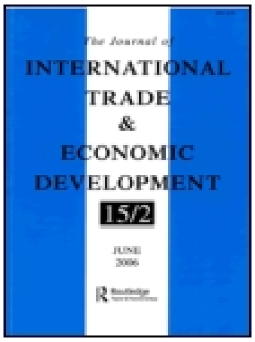

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The role of endowments, technology and size in international trade: new evidence from product-level data

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ABSTRACT

Using product-level trade data, we empirically investigate the export patterns of more than 150 countries in their exports to the USA, Brazil, India, and Japan. We document strong evidence that exporters specialize according to their relative factor endowments, technology, and economic size. More developed, capital abundant countries are found to export products of higher unit values and a wider range of products to developed, emerging and developing markets. More developed, economically larger, and technologically advanced countries are also the major exporters of new products, spanning a wide range of product categories with high unit values. Our findings provide important insights into the macro phenomenon that a large proportion of the global trade takes place among developed economies, and that the latter are also major exporters to developing markets.

KEYWORDS New products; product specialization; unit value

JEL CODES F20, F14

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1. Introduction

International trade has been characterized by a robust regularity. On one hand, the majority of the world's trade takes place among developed economies (the North), which are also the most important exporters to the developing economies (the South). On the other hand, poor and developing exporters trade disproportionately less not only among themselves but also with developed countries.

The primary objective of this paper is to examine whether the conventional patterns in North–North, North–South, and South–South trades exist in product-level data. To our knowledge, very few empirical studies have hitherto undertaken analogous investigations using disaggregate information. To exemplify the product categories and characteristics that we have in mind for our exploration, take televisions. We seek to answer whether the North, compared to the South, exports higher quality televisions (i.e., large-screen high-definition LCD televisions *vs.* small-screen black-and-white televisions) within the same product category (i.e., televisions), and whether or not the exporters

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of the North export a larger quantity and/or a larger range of LCD televisions due to their larger economic size. In addition, we ask whether or not the technology and the size of the economies of the North also give them a comparative advantage in new products, be it a completely new type of broadcast receiver or a new product that is unrelated to broadcasting.

We are motivated by the fact that inspecting the data at a finer level could inform us about the formation of aggregate North–North, North–South and South–South trade flows. To this end, our study focuses on explaining the export patterns of more than 150 countries to four major markets in the North (the USA and Japan) and the South (Brazil and India). Specifically, we investigate the role played by endowments, technology, and economic size in three components of the volume of trade – the unit value, range, and quantity – of exported *existing* and *new* products. Altogether, technology, endowment, and size underlie the unit value of exports as well as the intensive margin (i.e., the range and quantity of existing products) and the extensive margin (i.e., the range and quantity of new products) of trade.[1]

Our analysis is guided by the theoretical framework of Zhu and Trefler (2005) and Zhu (2005), which combines both Ricardian and Heckscher–Ohlin properties. Our empirical set-up closely follows the seminal paper by Schott (2004), who analyze the role of factor endowments and technology in product specialization in imports into the USA. In particular, we extend Schott's analysis in four different directions. First, we investigate the patterns of specialization in imports into not only the USA, but also three major trade players representing the North and the South: Japan, Brazil, and India. As such, we look for patterns that are more likely to characterize world trade more generally. Second, we examine not only the role of factor endowments and technology as did Schott (2004), but also that of economic size in product specialization. The role of economic size has especially been unexplored in this particular setting. Third, we explore in detail the question of whether exports from particular cones exhibit differences in specialization patterns, that is, single- and double-sourced products. Single-sourced products are defined as those that are exported exclusively by countries belonging to *one* of the following three cones: low-wage, middle-wage, or high-wage countries. Double-sourced products are those that are exported *simultaneously* by countries belonging to two cones: low-wage and middle-wage cone, or middle-wage and high-wage cone. Multiple-sourced products are defined as those that are exported simultaneously by countries belonging to all three cones.[2] Fourth, we also investigate the extent to which endowments, technology, and economic size determine the ranges of *existing* and *new* exported products. Thus, we contribute to the growing literature on *new* products (see Feenstra and Rose 2000; Klinger and Lederman 2004; Xiang 2005, 2007, 2014), which is essential for understanding the formation of trade flows across the North and the South. It must be noted that we examine new products only with the US imports data, given that the disaggregated data needed to identify these products are reliably available only for US imports.[3]

Our paper is also linked to those of Hummels and Klenow (2005), Hallak (2006, 2010), Khandelwal (2010), Hallak and Schott (2011) and Feenstra and Romalis (2014), who study product quality in bilateral trade flows. We stress that our paper, while offering insights on product quality based on the imperfect measure of unit value, focuses primarily on the determinants of the extensive and intensive margins of trade in studying the formation of global trade flows.[4]

Our empirical analysis, featuring a battery of intuitive robustness checks, yields important results. First, economically larger countries export larger quantities of a product and a greater range of products. Second, more capital-abundant and more technologically advanced countries export products of higher unit values. These two results are found irrespective of the development level of the importer. Third, more developed countries are the major exporters of *new* products to the USA, a developed market, and the trade in these products spans a wide range, with high unit values. Taken together, these findings shed strong light on the macro regularity that a large proportion of world trade occurs among the North and that the latter are also major exporters to the South.

The paper is organized as follows. Section 2 presents a brief two-factor, three-country model, with predictions on the unit value, quantity, and range of existing and new products. Section 3 discusses the data and Section 4 the results. Section 5 concludes the paper.

2. Product specialization in an extended theoretical framework

We adapt the two-country model developed by Zhu and Trefler (2005) and Zhu (2005) as a theoretical guide to our empirical implementation. These models combine both Ricardian and Heckscher–Ohlin properties in a unified framework.[5] There are three countries, *Advanced*, *Emerging*, and *Developing*, which are assumed to be sufficiently different from each other in capital and labor endowments.[6] We also assume that there is a continuum of products, which are ranked in increasing order in terms of their capital intensity, and are accordingly indexed by z $(0 < z < 1)$.

We denote *Advanced*, *Emerging*, and *Developing* countries by h (high capital–labor ratio), m (medium capital–labor ratio), and d (low capital–labor ratio), respectively. If standard assumptions of the Heckscher–Ohlin model hold under autarky, country *Advanced* must have the highest wage (w) to capital rental (r) ratio: $(w^h/r^h) > (w^m/r^m) > (w^d/r^d)$. Figure 1, which displays the unit cost curves of the three countries, illustrates their trade patterns under complete specialization: country *Advanced*, which has the highest capital–labor ratio, has a comparative advantage in the most capital-intensive products defined by Z^M1, and similarly, country *Developing* has a comparative advantage in the least capital-intensive products defined by $0Z^D$.

Note that a product is associated with a unique production function or a unique capital–labor ratio at a given wage-rental rate. Since product-level data actually aggregate products with a similar end-use, rather than those with similar production techniques, it is important to distinguish between product categories in the data and those products whose definitions are consistent with our theoretical model. This can be illustrated easily in Figure 1, which shows in parentheses how the products are actually classified in the data.[7] Products z^1, z^3, and z^7 are all classified as product category B in the data even though their production requires different capital intensity. As an example, we can think of them as black-and-white TVs, colored TVs, and LCD TVs.[8] Thus, the countries *Advanced*, *Emerging* and *Developing* will theoretically specialize in producing and exporting the product category B with production techniques which are commensurate with their endowments. Country *Advanced* is likely to produce and export the items of higher capital intensity and more advanced technology within product category B (i.e., LCD TVs) than those produced by countries *Emerging* and *Developing*.[9] Figure 1 also shows that countries *Emerging* and *Advanced* specialize in products z^2 and z^6, respectively, which are classified as two different product categories in the data, D and C.[10] It is

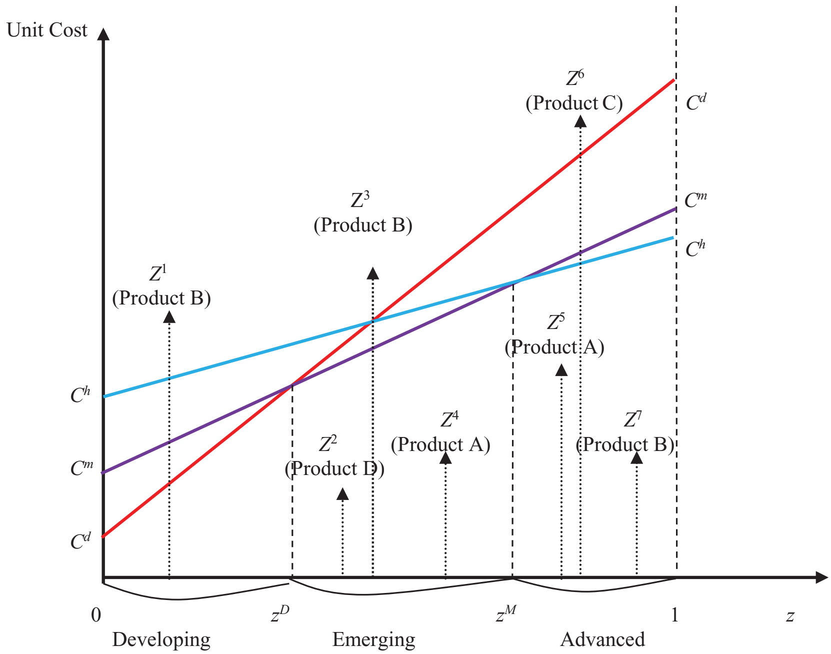

Figure 1. The Ricardian and Heckscher-Ohlin model with complete specialization.

only in such cases, i.e., when product categories are produced by distinct diversification cones, that we can observe the pattern of specialization in the data without having to look at the unit values. In this case, we can examine whether the production of product category C requires a higher capital–labor ratio and/or more advanced technology than that of product category D.[11]

There are several straightforward extensions of the theoretical framework. The first extension is the size effect. It is evident that resource limitations could put constraints on the amount of production and the range of products that can be produced. In other words, all else being equal, larger exporters have, on average, a larger range of products or/and more quantity of a product.[12] It is worth noting that in Figure 1, all three countries specialize in an infinite number of products independently of the size of their economies (i.e., L and K). Although this assumption helps with tractability, it is clearly not consistent with the real world, where the number of products is not infinite. Note that while the number of products that the countries *Developing*, *Emerging* and *Advanced* can specialize is graphically represented by three segments $0Z^D$, $Z^D\, Z^M$, and Z^M1, which correspond to an infinite number of products, we can think of these segments as the *potential* number of products that each country can produce given its *unlimited* resources *and* the absence of new products. In other words, the segments of specialization include products that each country cannot produce due to its limited resources as well as new products that arrive later in the market. Since it is appropriate to assume that the constant-returns-to-scale production of most products can only start after certain levels of K and L, it is straightforward to show that a small economy, which is exactly similar to the USA in terms of its relative factor endowments and technologies but is one thousand times smaller than the USA, must specialize in a smaller number of products than does the USA.

Second, like Zhu and Trefler (2005), we can incorporate into the framework another source of comparative advantage, Ricardian technology differences, by assuming that for *any common set of factor prices* (*w*, *r*), country *Advanced* will have a lower marginal cost in the production of skill-intensive products.[13] Technology will affect the volume of trade via its impact on the unit value and the range of products a country can produce. Countries that are technologically more advanced will produce products of higher unit values and/or a larger range of products.[14]

As a third extension, we can take into account the fact that *new* products enter the market continuously. New products are created to meet new customer needs and wants. New product development *generally,* though not exclusively, goes through a series of stages that are intensive in capital, research, skill and technology. According to Koren et al. (2007), these stages are time consuming and expensive, and may involve idea generation and screening, idea development and testing, business analysis, market testing, technical implementation and commercialization. Consequently, *most* of the new products can be assumed to be capital and technology intensive, and thus, the new products mostly fall in segment $Z^M 1$ specialized by country *Advanced*. Note that there are still some new products that are labor intensive and can be produced by countries *Developing* and *Emerging*.

Finally, we can consider a world which consists not of three countries, but rather of three groups of countries: developing, emerging, and advanced *groups* of countries. If the countries in each group are similar enough in their relative capital–labor endowments and each of the three groups is dissimilar enough in the same, then there will be three cones of diversification within which countries will produce similar sets of products, but export products for which they have a comparative advantage. The same prediction applies across different cones, with the only difference being that countries belonging to different cones will produce different products.

Figure 2 presents the celebrated Learner-Pearce diagram, illustrating the case of the multi-country model with three diversification cones. Specifically, it depicts the case of seven products, two factors (capital and labor) and six countries. The products (z^1 to z^7) are ordered by their degree of relative capital intensity, where product 7 is the most capital intensive and product 1 is the least capital intensive. The arrows represent the factor endowment vectors of six countries.[15] Note that the six products are classified in 4 product categories A, B, C, and D in the data. Figure 2 shows that *Advanced* countries 1 and 2 have a comparative advantage in the most capital-intensive goods z^5, z^6, and z^7, while *Developing* countries 5 and 6 have a comparative advantage and specialize in the most labor-intensive goods z^1 and z^2. In our empirical analysis, product category A corresponds to the multiple-sourced products while product categories D and B correspond to double-sourced and single-source products, respectively.

In sum, this paper empirically explores the following two hypotheses concerning the relationship between the quality, the quantities and the range of exported products and new products, on one hand, and the characteristics of exporters, on the other:

Hypothesis 1: *Within a product category, more capital abundant and more technologically advanced countries export products and new products of higher unit values.*

Hypothesis 2: *Other things being equal, larger countries export a larger range of products and new products and more quantities of these products. More capital abundant countries and more technologically advanced countries export a larger range of products and new products.*

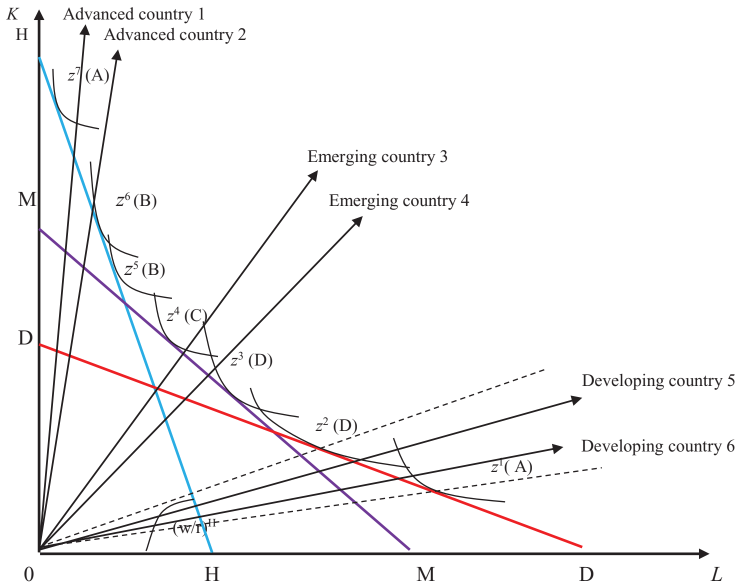

Figure 2. Learner–Pearce diagram for multiple cones with complete specialization.

3. Data

The US product-level import data for 1972–2004 are compiled from Feenstra (1996). The Brazilian, Indian, and Japanese product-level import data, available from 1989 to 2004 and grouped according to HS 2 classifications at six-digit level, are obtained from the United Nations Commodity Statistics Trade Database. It is important to point out that the data used in our paper are huge and their construction requires extensive work. For example, the full sample of US import data at 8-digit and 10-digit levels of disaggregation has more than 5 million observations while the samples of Brazil's, India's, and Japan's import data at six-digit level of disaggregation have approximately 0.3–0.5 million observations. While it is preferable to use a sample including more importers look for patterns of product specialization in world trade in general it is less so for our practical purpose given the extremely extensive data work and analysis. The selection of the USA is explained by the fact that US import data are the most detailed data of the four countries and are disaggregate enough for our purpose of accurately identifying the new products. The selection of Brazil, India and Japan for our analysis is due to the fact that they are large importing markets for many countries at different levels of development *and* are representative of emerging, developing and advanced economies, respectively. We choose to focus on India instead of China in our analysis because the two countries can be considered to be two similar developing economies but China's import data are available only from 1992 in UN Comtrade Database.[16]

There are more than 150 exporters to each of the four markets.[17] All of the data correspond to four SITC 2 manufacturing industries (one-digit SITC 2 = 5, 6, 7, and 8). We compute the unit value of product p from country c in year t by dividing the import value by the import quantity. The range of products a country exports is equal to the total number of products exported by country *c* in year *t*. The import data of the USA, Brazil, India, and Japan are the before-tariff values of imports.

As mentioned, we examine the new products using the data of new products imported by the USA for the 1989–2001 period. Xiang (2005) reliably identified and compiled the data on new products by carefully comparing the product listings of the 1987 and 1972 Standard Industrial Classification manuals. Xiang considers the new entries that appeared in the list as candidates for new products, and then match them with US import data after checking for measurement errors (e.g., name changes).[18]

We use the number of patents granted by the USA to foreign countries, obtained from Hall, Trajtenberg, and Jaffe (2001), to measure the level of technology in the latter. Data on capital stock per worker are available from the Penn World Table. [19] The data on GDP, GDP per capita, and population of exporters come from the World Development Indicators. GDP, population, and labor force are used as proxies for economic size, while GDP per capita is used as another proxy for the level of technology and capital abundance. See Appendix 1 for the summary statistics of the main variables.

4. Empirical analysis

4.1. Factor endowments, technology, and the unit values of exports

It is important to stress here that our main goal is to examine the determinants of the unit value of exports for exporters that belong to different cones of diversification. If one is strictly interested in the patterns of specialization along the quality dimension, then the unit value is not a perfect measure of quality. In this respect, studies by Khandelwal (2010), Hallak and Schott (2011), and Feenstra and Romalis (2014) are major developments to estimate the quality of exported products. Our benchmark analysis does not adopt their approach for one main reason. A sample with a large number of exporting countries is essential for studying product specialization within and across different cones, and the unit value can be computed readily for such a sample from available data. The application of methods in the aforementioned papers involves an evident trade-off related to substantial reduction in the number of exporters, due to data limitations.[20] Nevertheless, we will make some digression below and perform several rigorous robustness checks relating to the definition of product quality.

As emphasized in Section 1, product specialization takes place not only across the cones of diversification, but also within each cone. Hence our analysis is with respect to multiple-sourced, double-sourced, and single-sourced products. Our analysis excludes double-sourced products that are exported to a market simultaneously by low-wage and middle-wage countries, as well as single-sourced products that are exported exclusively by either low-wage or middle-wage countries because the number of those double-sourced and single-sourced products is negligible (see Schoot 2004; Pham 2008).[21]

We define the three cones of diversification based on low-, middle-, and high-wage trading partners of the USA, Brazil, India, and Japan; specifically, whether the GDP per capita of these trading partners lies in the 0th to 30th, 30th to 70th, or 70th to 100th percentiles of the global distribution of GDP per capita, respectively. While this classification is far from perfect, it is adopted by studies such as Schott (2004).

There are evident advantages of using GDP per capita in classifying countries into groups belonging to different diversification cones. First, the data on GDP per capita are available for a large number of countries and years. Second, GDP per capita of exporters is strongly correlated with their capital stock per worker and the level of development and technology. The extent to which exporters are similar or different in these factors determines whether or not they belong to a diversification cone.[22] Schott (2003) found evidence for the two-cone model using a more sophisticated method of cone identification.[23] Yet, Schott used only a sample of 45 countries, which is much smaller than the sample of more than 150 exporters utilized in our study. Since a more complicated way of identifying cones requires considerably more data, we instead choose to perform later a number of robustness checks to see whether or not our results are sensitive to different cutoffs that delimit the three wage cohorts.

Consistent with the assumption that, within a given product category, several varieties with higher unit values, which have higher capital–labor requirements and/or higher skill intensities, will be produced, our theoretical framework predicts that capital-abundant and more technologically advanced countries will export products of higher unit values. Following Schott (2005), we estimate the relationship between the unit values of multiple-, double-, and single-sourced products and factor endowment variables using the following regressions:

$$\log(\mathrm{UV}_{\mathrm{pct}}) = \alpha_{\mathrm{pt}} + \delta \log\left(\mathrm{GDPC}_{\mathrm{ct}}\right) + \varepsilon_{\mathrm{pct}}, \tag{1}$$

$$\log(\mathrm{UV}_{\mathrm{pct}}) = \alpha_{\mathrm{pt}} + \delta \log\left(\mathrm{Endowment}_{\mathrm{ct}}\right) + \varepsilon_{\mathrm{pct}}, \tag{2}$$

where $\mathrm{UV}_{\mathrm{pct}}$ is equal to the value of exports of product *p* by country *c* at time *t*, divided by the quantity, and GDPC denotes GDP per capita, and $\mathrm{Endowment}_{\mathrm{ct}}$ stands for capital stock per labor for (exporting) country *c* at time *t*. Note that Schott (2005) applied regressions 1 and 2 to the group of multiple-sourced products only using the US import data. We include α_{pt} in the model to capture the factors that are specific to both time *and* products and that explain the differences in the unit values of exported products. For example, α_{pt} explains the difference between the unit value of one kilogram of sugar exported by Vietnam to the USA and the unit value of one liter of wine exported by Australia to the USA. The effects of factors such as GDP per capita and capital stock per labor, which are specific to exporter *c* at time *t* on the unit values of a product that is exported by different countries, are captured by the coefficient estimate of δ.[24] Note that the inclusion of α_{pt} eliminates all the omitted variable bias due to the potential correlation between $\mathrm{GDPC}_{\mathrm{ct}}$ (or $\mathrm{Endowment}_{\mathrm{ct}}$) and unobservable *product-year specific* factors of $\varepsilon_{\mathrm{pct}}$. Since the dependent variable, i.e., the unit value of exported products $\mathrm{UV}_{\mathrm{pct}}$, is computed at the product level while our main explanatory variables of interest, i.e., $\mathrm{GDPC}_{\mathrm{ct}}$ and $\mathit{Endowment}_{\mathrm{ct}}$, are computed at the country level, endogeneity due to reverse causality is unlikely to be a major problem. Nonetheless, in our regression results the coefficient estimate of δ should be interpreted as reflecting the partial correlations between the unit values of exported products and the characteristics of exporting countries.

The results related to Equations (1) and (2) are presented in Table 1 for the US, Brazilian, Indian, and Japanese imports. Focusing first on the results with imports into the USA, we find that the findings are consistent with factor-endowments and the Ricardian hypotheses. That is, countries with a higher GDP per capita and higher capital stock per worker export products with higher unit values. Estimated coefficients are economically meaningful. For example, for the full sample of all types of products, the coefficient estimates of GDP per capita and capital per worker imply that 10% increases in these

Table 1. The relationship between exporter characteristics and unit values.

	Ind. variables							
	log(GDPC)	log(*K*/*L*)	log(GDPC)	log(*K*/*L*)	log(GDPC)	log(*K*/*L*)	log(GDPC)	log(*K*/*L*)
	USA		*Brazil*		*India*		*Japan*	
All types of products								
δ	0.26[c]	0.37[c]	0.42[c]	0.51[c]	0.28[c]	0.44[c]	0.37[c]	0.47[c]
t-statistic	(8.07)	(7.10)	(7.49)	(6.56)	(3.18)	(6.85)	(7.78)	(8.92)
No. of obs.	4257665	2675091	272663	272603	273338	273253	470600	470381
Multiple-sourced								
δ	0.25[c]	0.37[c]	0.34[c]	0.43[c]	0.29[c]	0.46[c]	0.34[c]	0.44[c]
t-statistic	(8.38)	(7.03)	(5.88)	(5.35)	(3.11)	(6.32)	(7.89)	(7.85)
No. of obs.	2989006	2070335	35286	35270	89524	89486	128273	128154
Double-sourced								
δ	0.30[c]	0.42[c]	0.43[c]	0.55[c]	0.26[c]	0.40[c]	0.37[c]	0.50[c]
t-statistic	(6.58)	(7.58)	(9.90)	(9.39)	(2.89)	(6.23)	(8.21)	(10.05)
No. of obs.	668949	306089	111314	111276	97953	97927	243901	243816
Single-sourced								
δ	0.35[c]	0.51[c]	0.58[c]	0.56[c]	0.36[c]	0.47[c]	0.59[c]	0.52[c]
t-statistic	(4.40)	(4.16)	(5.75)	(2.93)	(4.86)	(7.63)	(4.12)	(2.39)
No. of obs.	366233	177133	121101	121100	41831	41811	65910	65901

Notes: (1) All regressions include product-year dummies. (2) a, b, and c indicate significance at the 10%, 5%, and 1% levels, respectively. (3) *t*-statistics in the parentheses are computed based on the robust standard errors adjusted for clustering on trading partners.

factors are associated with 2.5% and 3.7% increases, respectively, in the unit values of multiple-sourced imports into the USA. Note that the US 1972–2004 sample consists of more than four million observations, of which multiple-, double-, and single-sourced products account for 70%, 16%, and 9%, respectively. Note also that our results are very similar in magnitude to the results obtained by Schott (2004) who used the import data of the USA from 1972 to 1994. Specifically, the results on Table V of Schott (2004) show that the coefficients on GDP per capita and capital stock per worker are 0.134 and 0.435, respectively.

Table 1 shows that the estimates are also positive and statistically significant for double- and single-sourced products. Overall, these results indicate evidence of endowment- and technology-based specialization along the quality dimension in exports to the USA. It is also clear that this product specialization is not limited to multiple-sourced products. Since the USA belongs to the North, the evidence above parallels the macro phenomenon that countries of the North trade more with each other, while countries of the South export disproportionately less to developed markets of the North.

The results using the import data of Brazil, India, and Japan also confirm the findings above. Importantly, patterns of specialization in accordance with the differences in technology and relative factor endowments are found for all of the multiple-, double-, and single-sourced products. Not surprisingly, this finding is very strong in the case of the Japanese imports data. Consistent with the evidence related to the USA above, it refers to endowment- and technology-based product specialization even among high-wage exporters that belong to the same cone of diversification (given that Japan itself is a high-wage country). It must be noted that in line with our theoretical framework, high-wage economies can export products to other high-wage economies within the same cone of diversification with quality differences concomitant with their relative capital abundance. In addition, these economies can differ in their economic size such that larger countries can command greater comparative advantage in exports. For example, Japan imports high-quality products from high-wage exporters because its size does not allow it to produce all of the products, including those with high unit values.[25] Conversely, the significant and positive associations of GDP per capita and capital stock per worker with the unit values of exports in the cases of Brazil and India are also consistent with the fact that the North (having higher GDP per capita and capital stock per worker) export disproportionately more to the South.

Taken together, to the extent that capital abundant and technologically advanced exporters export products of higher unit value to not only developed markets like the USA and Japan but also to emerging and developing markets like Brazil and India, the above evidence is consistent with the macro trade regularity that countries of the North trade more with each other and are the major exporters to countries of the South.

Table 1 raises an additional important result that requires attention. The effect of GDP per capita and capital per worker on the unit values of exports is generally higher for single-sourced products than multiple-sourced products. For example, for Japan, which exhibits this differential in the strongest sense among the four economies considered, a 10% increase in GDP per capita and capital stock per worker is associated with increases of 3.4% and 4.4% in the unit values of multiple-sourced products, respectively, but increases of 5.9% and 5.2% in the unit values of single-sourced products. This result seems to be surprising at first glance, since differences in technology and relative factor endowments are clearly narrower among high wage exporters (which export single-sourced products) than among exporters belonging to three cones of diversification (which export the multiple-sourced products).

The explanation is likely to lie in the scope of quality differentiation, or what Khandelwal (2010) refers to as quality ladder. It is plausible to argue that quality ladder is different for single-, double-, and multiple-sourced products. As a slight digression, we therefore compute the quality ladders of all products in four samples to shed light on this important issue. Following Khandelwal (2010), we define the quality ladder as the difference between the maximum and minimum unit value within a product p:

$$\text{Quality\_Ladder}_p = \log\left[\frac{\max(\text{unit\_value}_p) - \min(\text{unit\_value}_p)}{\text{number of countries exporting product } p}\right].$$

Appendix 2 presents the mean of this measure normalized by the number of exporting countries of product p by group of products. For all the importing markets but India, the means of this normalized measure of quality differentiation are larger for the group of single-sourced products than for the group of multiple-sourced products. That is, the products that are exported by only high-wage countries have, on average, a longer quality ladder than the multiple-sourced products that are sourced simultaneously from low-, middle-, and high-wage economies. Consequently, GDP per capita and capital stock per worker of exporters have a larger positive association with the unit values of single-sourced products than the unit values of multiple- and double-sourced products.

The evidence that technology-based and relative endowment-based specialization occurs for multiple-sourced products, double-sourced and especially single-sourced products may also suggest that there has been some realignment by both the North and the South. In other words, the increasing competition by low-wage exporters of the

South, especially China, in multiple-sourced products has posed a threat to the performance of high-wage exporters of the North in these products and has arguably forced the latter to strengthen and consolidate their specialization and comparative advantages in single-sourced products.[26]

4.2. Robustness checks

In this section, we perform a number of robustness checks to investigate the sensitivity of our main results. First, we use different cutoffs to identify the three cones of diversification. Specifically, we define exporters of high-, middle-, and low-wage cohorts depending on whether their GDP per capita lies in the 0th–40th, 40th–85th, or 85th–100th percentiles of the global distribution of GDP per capita, respectively. These cutoffs result in an increased number of multiple- and double-sourced products and a reduced number of single-sourced products. Re-estimating Equations (1) and (2) using this classification essentially mimics the results in Table 1.[27]

Second, we estimate Equations (1) and (2) using the subsample of differentiated products only. As mentioned above, the concept of product specialization within and across different cones of diversification is central to understanding the volumes of trade across the North and the South, and specialization along the quality dimension is closely associated with this phenomenon. The idea here is that such specialization is likely to be most noticeable for differentiated products because they exhibit quality differentiation the most.[28] We define differentiated products as those where no reference price is quoted on organized exchanges or in trade publications (Rauch 1999).[29] The results, which are presented on Online Appendix Table 4, show that exporters' GDP per capita and capital stock per worker are still significantly associated statistically with the unit values of exported differentiated products. This finding applies to all multiple-, double-, and single-sourced products. It is found that, in most cases, the coefficient estimates of GDP per capita and capital stock per worker are larger and the standard errors are lower than the estimates obtained in Table 1 using the full sample that includes also the homogenous products. Note that the sample sizes of all four countries in this analysis decrease by more than 20%.

Third, there may be some concern that the results presented in Table 1 are obtained without controlling for the 'Washington Apples' effect, which was suggested by Hummels and Skiba (2004). Specifically, Hummels and Skiba find that exporting countries chose to export higher quality goods to more distant destinations, in order to cover the higher transportation costs. This effect may confound, if not drive, the relationship between exporters' endowment characteristics and the unit values because of the geographic clustering among most economies of the North and the South and the distance between the two groups. In order to address this concern, we follow Schott (2008) and apply the following augmented versions of Equations (1) and (2):

$$\log(\mathrm{UV}_{\mathrm{pct}}) = \alpha_{\mathrm{pt}} + \delta \log(\mathrm{GDPC}_{\mathrm{ct}}) + \log(\mathrm{Dist}_{\mathrm{ck}}) + [\log(\mathrm{Dist}_{\mathrm{ck}})]^2 + \mathrm{Landlock}_{\mathrm{c}} + \mathrm{China}_d + \varepsilon_{\mathrm{pct}}, \tag{1*}$$

$$\log(\mathrm{UV}_{\mathrm{pct}}) = \alpha_{\mathrm{pt}} + \delta \log(\mathrm{Endowment}_{\mathrm{ct}}) + \log(\mathrm{Dist}_{\mathrm{ck}}) + [\log(\mathrm{Dist}_{\mathrm{ck}})]^2 + \mathrm{Landlock}_{\mathrm{c}} + \mathrm{China}_d + \varepsilon_{\mathrm{pct}}, \tag{2*}$$

where $Dist_{ck}$ denotes the bilateral distance between the exporter c and the importer k, and $Landlock_c$ is a dummy variable indicating whether or not exporter c is a landlocked country. Note that we include $\log(\text{Dist}_{ck})$ in quadratic form to control for the non-monotonic effect of distance on unit values. This effect was found by Harrigan (2010). The regressions also include a China dummy to make sure that the exceptional performance of China in contemporary world trade, which has been demonstrated by a number of recent studies (e.g., Pham 2008; Schott 2008), does not drive our results.[30] Finally, since the import data at the product level may be noisy, we also limit our regressions to large exporters and transactions with a value of more than US$10,000.

The upper panel of Table 2, presenting the results using only the sample of Rauch's (1999) differentiated products, shows that the GDP per capita and capital stock per worker of exporters remain economically and statistically significant correlates of the quality of products imported into the USA, Brazilian, Indian, and Japanese markets. Consistent with the 'Washington Apples' effect, both landlocked countries and those that are farther from the four markets export products of higher unit values within a given product category. According to Hummels and Skiba (2004), the 'Washington Apples' effect occurs when trade cost consists of two components: a tariff component per unit transport cost, and when the elasticity of freight costs with respect to prices is low. If transport costs rise more slowly than the good price, an increase in the per unit transport cost (i.e., distance and/or landlocked status) reduces the price of high-quality goods relative to low-quality ones. In the case of the USA, coefficient estimates of $\log(\text{distance}_{pck})$ and $\log(\text{distance}_{pck})^2$ are 7.28 and –0.42, respectively, meaning that the positive effect of distance on unit values is at a maximum when the distance between the exporter and the US market is around 6000 km. This result is consistent with that of Harrigan (2010) in that the effect of distance on unit values peaks in the distance range of 4000–7000 km. In sum, controlling for the 'Washington Apples' effect does not change our main findings.

The regression results using the subsample of homogeneous products presented in the lower panel of Table 2 confirm the point that while product specialization along the quality dimension exists for homogenous products, it is much less noticeable than for differentiated products. The effects of GDP per capita and capital stock per worker of exporters have substantially smaller effects for homogeneous products than for differentiated products. In the majority of cases, we also find the t-statistics of GDP per capital and capital stock per worker to be significantly larger for the sample of differentiated products. It is important to note that Schott (2004) also found a similar result. Specifically, he found that the effect of capital stock per worker on the unit value was largest for Machinery SITC7 industry and smallest for Chemicals SITC 5 industry.[31] Machinery industry is believed to contain more differentiated products than Chemicals industry.

4.3. Factor endowments, economic size, technology, and the quantity and range of exported products

We next turn to the investigation of quantity and range of exports as two other major components of the volume of trade, and the characteristic differences in the North–North, North–South, and South–South trades. The theoretical framework laid down in Section 1 shows that economic size matters to the extent that it imposes limits on the range of products a country can produce and export. Specifically, the model predicts that exports from larger countries will be associated with a larger range of products and that, other things being equal, such countries will be able to produce and export larger

Table 2. The relationship between exporter characteristics and unit values.

Robustness checks – differentiated products vs. homogeneous products								
	Dependent variable: $\ln(UV_{pct})$							
Ind. variables	USA		Brazil		India		Japan	
	Rauch's differentiated products – large exporters – large trade value							
ln(GDPC)	0.26[c]		0.39[c]		0.19[a]		0.31[c]	
	(9.31)		(6.42)		(1.64)		(10.64)	
ln(K/L)		0.31[c]		0.42[c]		0.34[c]		0.40[c]
		(8.66)		(4.53)		(3.34)		(13.02)
ln(distance)	7.28[c]	7.61[c]	2.69	4.95[a]	3.41[b]	3.91[b]	2.46[c]	3.09[c]
	(3.40)	(3.03)	(1.34)	(1.53)	(1.89)	(2.02)	(2.50)	(2.58)
$[\ln(\text{distance})]^2$	−0.42[c]	−0.44[c]	−0.16	−0.30[a]	−0.21[b]	−0.24[b]	−0.16[c]	−0.19[a]
	(−3.41)	(−3.07)	(−1.39)	(−1.59)	(−1.91)	(−2.08)	(−2.67)	(−2.77)
Landlocked	0.24[c]	0.24[c]	0.44[c]	0.53[b]	0.40[a]	0.44	0.44[b]	0.49[b]
	(3.99)	(2.86)	(3.61)	(2.08)	(1.61)	(1.50)	(2.29)	(1.92)
Product-year dummies	128152	128141	30141	30141	32813	32813	39243	39243
No. of obs.	2080674	2228598	193389	193389	185380	185380	338348	338348
Adjusted R^2	0.74	0.74	0.57	0.56	0.67	0.71	0.59	0.59
	Rauch's homogeneous products – large exporters – large trade value							
ln(GDPC)	0.13[b]		0.29[c]		0.18[c]		0.21[c]	
	(2.27)		(6.83)		(2.63)		(7.98)	
ln(K/L)		0.15[b]		0.38[c]		0.28[c]		0.29[c]
		(1.83)		(7.29)		(3.13)		(8.30)
ln(distance)	6.26[c]	5.68[c]	4.49	7.93[b]	5.90[c]	6.43[c]	3.02	3.66[b]
	(4.93)	(2.68)	(1.15)	(1.81)	(3.41)	(3.52)	(1.48)	(1.89)
$[\ln(\text{distance})]^2$	−0.35[c]	−0.32[c]	−0.27	−0.47[b]	−0.36[c]	−0.39[c]	−0.20[b]	−0.24[c]
	(−4.70)	(−2.53)	(−1.18)	(−1.84)	(−3.61)	(−3.67)	(−1.72)	(−2.13)
Landlocked	0.20[b]	0.28[c]	1.51[c]	1.62[b]	1.57[c]	1.64[c]	0.29[a]	0.37[b]
	(3.21)	(5.14)	(3.04)	(1.70)	(3.64)	(3.63)	(1.56)	(1.75)
Product-year dummies	6565	6565	960	960	1078	1078	1495	1495
No. of obs.	23848	23848	2853	2853	4040	4040	8408	8408
Adjusted R^2	0.86	0.83	0.65	0.66	0.39	0.39	0.52	0.60

Notes: (1) a, b, and c indicate significance at the 10%, 5%, and 1% levels, respectively. (2) *t*-statistics in the parentheses are computed based on the robust standard errors adjusted for clustering on trading partners. (3) All the regressions include a China dummy that is equal to 1 if the exporter is China and equal to zero otherwise.

quantities, and consequently, greater volumes of each product. Also, all else equal, technologically more advanced countries are likely to export a greater range of exports, as they will be capable of producing more of those products, and more differentiated products are more likely to be technology intensive.

We use the following regression to investigate the economic size and product quantity relationship using product-level trade data:

$$\log(\text{quantity}_{\text{pct}}) = \alpha_{\text{pt}} + \delta \log(X_{ct}) + \varepsilon_{\text{pct}}, \qquad (3)$$

Table 3. Relationship between exporter characteristics, quantity of products and range of products.

Ind. variables	USA	Brazil	India	Japan
	(A) Dependent variable: ln(quantity$_{pct}$)			
	Regressions include product-year dummies and China dummy			
ln(GDP)	0.34[c]	0.39[c]	0.41[c]	0.58[c]
	(5.48)	(4.24)	(5.67)	(6.01)
ln(pop)	0.45[c]	0.54[c]	0.41[c]	0.64[c]
	(7.11)	(5.49)	(4.54)	(6.25)
ln(labor)	0.45[c]	0.53[c]	0.39[c]	0.66[c]
	(7.38)	(5.27)	(4.45)	(6.68)
	(B) Dependent variable: ln(number of products $_{ct}$) *Regressions include year dummies and China dummy*			
ln(GDP)	0.67[c]	0.95[c]	0.87[c]	0.88[c]
	(6.04)	(12.21)	(9.96)	(10.67)
ln(GDPC)	0.77[c]	0.89[c]	0.88[c]	0.87[c]
	(8.80)	(6.29)	(8.44)	(8.13)
ln(K/L)	0.88[c]	1.013[c]	1.090[c]	1.023[c]
	(8.56)	(5.82)	(8.03)	(7.75)
ln(pop)	0.52[c]	0.71[c]	0.66[c]	0.63[c]
	(8.00)	(8.46)	(8.59)	(9.65)
ln(labor)	0.60[c]	0.77[c]	0.72[c]	0.71[c]
	(7.97)	(8.54)	(9.04)	(9.36)

Notes: (1) a, b, and c indicate significance at the 10%, 5%, and 1% levels, respectively. (2) *t*-statistics in the parentheses are computed based on the robust standard errors adjusted for clustering on trading partners. (3) Regressions in panel A are at the product level and include product-year dummies and China dummy while regressions in panel B are aggregated from product-level data to cross-country panel and include year dummy and China dummy.

where X_{ct} stands for the GDP, population, or labor force of exporter *c* at time *t* employed in alternate regressions, and is used as a proxy for its size. As before, α_{pt} are the product-time dummies, and control for factors that determine differences in the quantities of exported products and are specific to both time *and* product (e.g., the difference between 1000 tons of rice exported by Vietnam to the USA and 1 million liters of wine exported by Australia to the USA).

The results of the regression in Equation (3), which are presented in panel A of Table 3, show that, within the same product category, countries with a larger GDP, population, or labor force export larger quantities to a given destination. The size of an exporter is statistically and economically related to its exported quantities. Specifically, a 10% increase in an exporter's GDP is associated with an increase of 3%–5.8% in the quantities of a product that it exports to the USA, Brazil, India, and Japan. This finding is very important because it demonstrates convincingly that the sizes of exporters shape the volume of trade, even at the product level. Thus, to the extent that the North consists of larger economies than the South and that larger exported quantities of a product contributes to larger volume of exports of a country, the evidence above provides an explanation for the macro phenomenon that economies of the North trade with each other more and export much more than economies of the South.

Next, we investigate the roles of economic size, technology, and endowments in the range of exported products (using product-level data that are aggregated to a cross-country panel). We estimate the following regression:

$$\log(\text{Number\_Product}_{ct}) = \alpha_t + \delta \log(W_{ct}) + \varepsilon_{ct} \tag{4}$$

where $Number\_Product_{ct}$ is a measure of the range of products, and is equal to the total number of products country c exports at time t, and W is the economic size, endowment, and technology indicators, including GDP, population, labor force, GDP per capita, and capital per worker, adopted in alternate regressions.

The results in panel B of Table 3 clearly show that the economic size, technology, and capital stock per worker of exporters are significantly associated with the range of exported products. The coefficient estimates of these covariates are economically and statistically significant at the 1% level in the samples of all four countries. Specifically, Table 3 shows that, in the case of the USA, a 10% increase in the size of an exporter is on average associated with an increase of about 5%–7% in the range of products it exports to the US market. Similarly, an increase of 10% in GDP per capita or capital stock per worker of an exporter results in an increase of about 6.7%–7.7% in the range of exported products. Our result is comparable to that of Hummels and Klenow (2005), who find that the extensive margin accounts for 60% of the greater exports of larger economies.

Table 3 also shows analogous results using the data for Brazil, India, and Japan. The role of covariates included in W in the range of products is the strongest in the case of Brazilian import data, while ranges of the coefficients for India and Japan are similar, and generally lie in between those of the USA and Brazil.

In sum, the finding above of a significant positive association between economic size, endowments, and the level of technology of exporters on the range of products imported by developed, emerging, and developing markets provides further strong supporting evidence that countries of the North trade disproportionately more with each other than those of the South and that they are also major exporters to the developing markets.

4.4. Factor endowments, technology, economic size, and new products

So far, our investigation has focused on *existing* products. *New* products are also critical for volume of global trade, more so, for future trade flows. The separate treatment of trade in new products is motivated by several reasons. First, there is a growing interest in the literature on new products (see Klinger and Lederman 2004; Xiang 2005, 2007). Second, determinants of specialization in new products could be different than the determinants of specialization in existing products. These differences are important to understand because new products become increasingly a larger component of world trade. Finally, empirical evidence on specialization in new products can constitute a building block for macro patterns in the North–North, North–South, and South–South trades.

Our theoretical framework predicts that developed countries will be the major exporters of new products because most of these products would be capital-, technology-, and skill-intensive. Nevertheless, further qualifications can also be made to our theoretical prediction. First, developed and technologically more advanced exporters are likely to export new products of *higher unit values*, even when those new products belong to the same product category in the data. Second, such exporters can export a *larger range* of new products. Third, economic size also matters to the extent that *larger economies* produce a larger range of products, including new products.

To explore the extent to which predictions of the theoretical model with respect to new products are consistent with the patterns in the data, we use the data of new products in US imports data compiled by Xiang (2005).[32] Specifically, in order to identify new goods Xiang compares the product listings of the 1987 SIC manual and the 1972 SIC manual.

Table 4. The relationship between exporter characteristics and the unit values of new products.

1989–2004 US imports					
Ind. variables	Full sample (1)	Full sample (2)	Ind. variables	Rauch's differentiated products (3)	Rauch's differentiated products (4)
Multiple-sourced			*Full sample*		
ln(GDPC)	0.29[c]		ln(GDPC)	0.25[c]	
	(6.90)			(7.94)	
ln(K/L)		0.38[c]	ln(K/L)		0.31[c]
		(6.61)			(7.63)
No. of obs.	2034175	201621	ln(distance)	8.83[c]	9.34[c]
				(3.28)	(3.20)
Double-sourced			$[\ln(\text{distance})]^2$	−0.51[c]	−0.55[c]
ln(GDPC)	0.35[c]			(−3.32)	(−3.26)
	(9.05)		Landlocked	0.13[b]	0.13[b]
Ln (K/L)		0.48[c]		(1.87)	(1.98)
		(9.71)	No. of obs.	225880	224135
No. of obs.	29929	29897			
Single-sourced					
ln(GDPC)	0.46[c]				
	(7.93)				
ln(K/L)		0.63[c]			
		(4.87)			
No. of obs.	16699	16695			

Notes: (1) All regressions are based on product-level trade data and include product-year dummies and China dummy. (2) a, b, and c indicate significance at the 10%, 5%, and 1% levels, respectively. (3) *t*-statistics in parentheses are computed based on the robust standard errors adjusted for clustering on trading partners.

The two SIC manuals contain a few lines of description and a list of the products the four-digit industry produces. The new entries that appeared in the list of the revised manual of 1987 were candidates for identification as new products.[33]

Focusing on three types of new products, multiple-sourced, double-sourced, and single-sourced,[34] we apply the unit value regressions in Equations (1) and (2) to the data. The regression results, presented in columns 1 and 2 of Table 4, clearly show that within the same product category, as classified in the data, more developed and more capital-abundant countries export new products of higher unit values to the US market. Importantly, this pattern of specialization applies not only to multiple-sourced but also to double- and single-sourced new products. The last two columns of Table 4 show that within a product category the association of GDP per capita and capital stock per worker of exporters with the unit values remains economically and statistically significant when we control for the bilateral distance and include the China dummy in the regression.

We now investigate the relationship between the economic size of exporters and the quantity of exported new products, using Equation (3). Columns 1, 2, and 3 of panel A of Table 5 document that even at the product level, the exporter size is significantly associated with the volume of exports of new products. Within a given product category, larger exporters on average export larger quantities of a new product.

We next explore the number of new products by estimating the following equation:

$$\log\left(\text{Number\_NewProduct}_{\text{ct}}\right) = \alpha_t + \delta \log\left(W_{\text{ct}}\right) + \varepsilon_{\text{ct}}, \tag{4}$$

Table 5. The relationship between exporter characteristics and the quantity and range of new products.

1989–2004 US imports						
	Independent variables					
Dependent variable	ln(GDP)	ln(pop)	ln(labor)	ln(GDPC)	ln(K/L)	ln(patent)
(A) ln(quantity$_{pct}$)	0.43[c]	0.46[c]	0.47[c]			
	(4.16)	(4.59)	(4.70)			
No. of obs.	236892	258335	243758			
(B) ln(number of products $_{ct}$)	0.67[c]	0.45[c]	0.51[c]	0.83[c]	0.89[c]	0.44[c]
	(5.65)	(7.24)	(7.27)	(10.92)	(8.52)	(15.32)
No. of obs.	1371	1753	1600	1709	1615	777

Notes: (1) In panel A, all regressions are based on product-level data and include product-year dummies and China dummy while in panel B, all regressions are at the country level and include year dummies and China dummy. (2) a, b, and c indicate significance at the 10%, 5%, and 1% levels, respectively. (3) *t*-statistics in parentheses are computed based on the robust standard errors adjusted for clustering on trading partners.

where W_{ct} is any one of the following variables, utilized in alternate regressions: GDP, GDP per capita, capital stock per worker, labor force, and also the log number of patents granted by the USA to the exporter at time t; and α_t is the time fixed effects.

While the patent data do not make any distinction between the product and the process of innovation, the number of patents that the USA granted to its trading partners can be considered as a direct measure of the level of technology owned by its trading partners.[35] Note that a patent granted by the USA gives the owner the right to exclude others from using the invention for a period of time (usually 20 years), and that new products are usually produced using new technologies. Consequently, exporters have an incentive to obtain patents covering the technologies used in the production of new products, and to protect the exports of these products to the US market.[36]

Table 5 documents that larger, more technologically advanced, more capital-abundant, and more patent-abundant economies export more new products. All of the estimated coefficients are both statistically and economically significant. A 10% increase in the GDP, GDP per capita, capital stock per worker, or numbers of patents granted of exporting countries is associated with a 4.4%–8.9% increase in the number of new products that they export. This finding is consistent with our prediction that the production of new products will be relatively more capital- and technology-intensive than that of existing products; consequently, capital-abundant and technologically advanced countries are likely to have a comparative advantage in new products.

In sum, we find strong evidence that developed countries, due to their advantages in technology, capital abundance, and the size of their economies, have a comparative advantage in the production of new products. This comparative advantage is reflected in the higher quality, larger quantities and larger range of new products that these countries can export to developed, emerging, and developing markets. To the extent that new products represent an increasing component of world trade over time, the evidence documented above provides an important explanation to the robust macro regularity that the majority of the world's trade takes place among the North while the exporters of the North are also the most important exporters to the South.

5. Conclusions

Extending the seminal paper of Schott (2004) into four different directions, the paper investigates the role of economic size, factor endowments, and technology in the range, quantity, and unit value of both *existing* and *new* products, exported from more than 150 countries to the USA, Brazil, India, and Japan, which are major economies in the world characterized by different development levels. Our key objective is to shed light on the manner in which aggregate trade flows are formed at the world scale and, therefore, to explain the macro phenomenon that a large proportion of the world's trade takes place among developed economies (the North), which are also major exporters to developing markets (the South).

We find robust and clear evidence that exporters specialize in accordance with their relative factor endowments, technology, and economic size. More capital-abundant and technologically advanced countries export significantly more of both existing and new products, and products with higher unit values. Importantly, the positive effect of endowments and the technological capacity of exporters on the unit values are statistically and economically significant with respect to products sourced from all cones of diversification, including the one that involves only developed countries. Economic size is also a key determinant of specialization patterns. Larger economies export a larger range of products, but also larger quantities of a given product category, suggesting that, as a country grows in size, it also increases its exports via both the extensive and intensive margins.

In this context, investigating the role of economic size and the phenomenon of new products for different cones of diversification, features as important contributions of this paper to the related strands of literature. More generally, our study contributes to the growing body of empirical literature on new products, and expands the understanding of the central role that economic size plays in the specialization patterns of existing and new export commodities.

To the extent that the USA and Japan represent developed markets, our findings support the established evidence of North–North trade in the aggregate trade data, namely, that most of the world's trade takes place among developed countries. Furthermore, since Brazil and India represent emerging and developing economies, the findings show that disadvantages in technology, endowments, and size together lead developing exporters to trade disproportionately less both among themselves and with developed countries. Finally, advantages in these same factors lie behind the evidence of developed economies being the major exporters to developing markets.

With respect to the policy implications of our paper, our findings suggest that governments may want to promote the production and export of high-quality products as well as a diversified trade pattern in order to increase the volume of exports. This increase in exports is likely to result in faster economic growth as firmly documented by studies such as Frankel and Romer (1999), Irwin and Tervio (2002) and Noguer and Siscart (2005). In this context, our findings and their policy implications parallel Hausmann, Hwang, and Rodrik (2007), who argue that specializing in some products brings higher growth than specializing in others, and consequently in addition to a country's fundamentals (i.e., its endowments of capital, labor and natural resources), its specialization policy can, too, play potentially a positive role in economic growth. [37] Finally, it is important to emphasize that while the findings of our study advocate the specialization in technology- and skill-intensive products, our analysis assumes away foreign ownership in the production process, which may matter for the success of export activities. In this respect, it is worthwhile mentioning Jarreau and Poncet (2012), who find that China's regions specializing in and exporting more sophisticated goods subsequently grow faster but that this growth is mainly driven by domestic firms but not by foreign firms. Therefore, it is unlikely that our results would be driven by foreign ownership of firms as opposed to domestic endowments.

Notes

1. While Evenett and Venables (2002) and Kehoe and Ruhl (2013) overlap with some of our analysis, there are also major differences. For example, Evenett and Venables (2002) decompose trade growth by product line and destination using bilateral trade data of a sample of 23 developing economies. Yet, they use data at the three-digit level, which are much more aggregate than the data at 6-, 10-, or 12-digit levels used in this study. They also do not look into the extent to which the endowment and technology of exporters are related to the components of the intensive and extensive margins of trade. Kehoe and Ruhl (2013) use detailed trade data to investigate the determinants of the extensive margin of international trade, but their focus is on the effects of trade costs.
2. Schott (2004) focuses on multiple-sourced products, Hummels and Klenow (2005) make no distinction between products sourced from one or different cones of diversification.
3. While our static analysis of new products cannot provide a direct answer to the dynamic question of whether there exist product cycles in the US imports over time, our findings at the disaggregate level can provide certain insights into this phenomenon. For example, the evidence that low-wage exporters of the South and high-wage exporters of the North both export the 'same' new products to the US market seems to contradict the product cycles theory. Yet, we show that that while these new products may belong to the same product category in the data, they are of very different quality.
4. The gravity equation is also found to be robust and successful in explaining the volume of world trade both within and between the North and the South, but this model does not reveal what factors of standard trade theories (i.e., technology or factor endowments or both) explain the volume of bilateral trade. Deardorff (1998) showed that the gravity equation is not specific to any trade theory.
5. Costinot (2009) sets up another important model in which technology and factor endowments jointly determine the patterns of trade. See also Morrow (2010) for a related empirical study.
6. The reason for setting up a three-country Heckscher–Ohlin model is that it is straightforward to relate the three-country theoretical setting to the empirical analysis with three cones of diversification.
7. Letters (A, B, C...) can be considered as industry classifications (e.g., TV industry B) in the data, and numbers (z^1,z^2, z^3...) can be considered to denote the products (e.g., black-and-white TVs, colored TVs and LCD TVs).
8. Another example is the difference in quality of cars made by local Chinese and Indian producers versus cars made by Japanese and German producers.
9. It is reasonable empirically to assume that products of a higher capital intensity and more advanced technology are of a better quality, and, consequently, have higher unit values.
10. Schott (2004) referred to the specialization in products D and C as 'across-product' specialization and the specialization in product B as 'within-product' specialization.
11. Schott (2003) show that empirical trade economists face a serious problem when using industry-level data to test the Heckscher–Ohlin model in that the three-digit ISIC manufacturing industries exhibit significant variation in terms of both input intensity and price across countries.
12. The prediction about the size effect is not limited to the DFS theoretical framework but it also applies to other trade models as well.
13. Specifically, Zhu and Trefler incorporate international technology differences in their model of trade between the North and the South, by assuming that, for each *common* set of factor prices the North has relatively lower marginal costs for relatively more skill-intensive goods.
14. In Figure 1 country *Developing* that is the least productive also has its unit cost lower than countries *Emerging* and *Advanced* on the range of products with the lower capital intensity. As it falls

further behind other countries its unit cost will shift upward, which results in the country's having comparative advantage in a lower range of products.

15. It is worth noting that in order to meet the condition of full employment of the factors in the Heckscher–Ohlin model, the two arrows representing the vectors of capital-labor ratio of developing countries 5 and 6 must lie inside the vectors of the capital-labor ratio requirements of products D and A. In order to keep the diagram simple, only the two dotted rays connecting the origin to the tangencies between the isoquants and isocost lines of products 1 and 2 are drawn, to define the diversification cone of developing countries 5 and 6.
16. Large economies of the European Union such as France, Germany and United Kingdom are also good candidates to be included in our analysis. We decided not to include these countries for two reasons. First, like China these three largest economies of the EU have their data at six-digit HS classifications for the period starting 1992 only. Second, our sample already includes the U.S. and Japan, the two developed economies which are, we believe, very similar to France, Germany and the UK.
17. See Online Appendix 1 for the list of exporting countries used in our analysis.
18. An alternative way of identifying new products is to look for new product *codes* after taking into account changes in product codes over time and the fact that obsolete codes may be mapped to the new codes. We applied this method using the concordances constructed by Pierce and Schott (2012). This approach yielded essentially the same results as reported in the working version of this paper (link suppressed for reviewing purposes).
19. Penn World Table, Version 8, is available from the following link: http://www.rug.nl/research/ggdc/data/penn-world-table.
20. Hallak and Schott (2011), for example, can only estimate the cross-country differences in product quality for a sample of 50 countries.
21. Only 5% of the total number of observations correspond to products that are sourced exclusively from low-wage and/or middle-wage exporting countries. See Online Appendix 2 for the number of different types of products in the US import data from 1972 to 2004. Similar patterns are also observed in the import data of Brazil, India, and Japan.
22. The main disadvantage of GDP per capita to classify exporters into different cones is that it is not *strictly* based on the theoretical foundation of the Heckscher–Ohlin with multiple cones of diversification.
23. Specifically, Schott (2003) first constructs more theoretically appropriate industry aggregates by grouping together products that are manufactured with identical techniques and then identifies the cones by looking at how the output of those aggregates varies with endowment. The idea behind this method of identifying cones is that within the same diversification cone the Rybczynski relationship is expected to be linear.
24. While sample selection may be a problem in the regression Equations (5) and (6), it is impracticable to address this problem: for the USA there are 12,000 products over 20 years from 130 exporting countries, hence the sample size would make up more than 30 million observations. Note also that we do not include α_c, the exporter fixed effects, in Equations (1) and (2). Since GDP per capita and capital stock per worker of exporters vary insignificantly from one year to another, if we include α_c (in addition to) there is not much within-exporter *variation* left in GDP per capita or relative factor endowment that can affect the unit value $\log(UV_{pct})$. The regression results with α_c included showed that it was actually the case
25. Thus, the explanation for the trade among high-wage/developed economies based on differences in countries from the supply side differs from the explanation provided by Hallak (2006) on the demand side.
26. Note that this finding is in line with the recent study by Pierce and Schott (2014) who find that when the USA opened up its markets to Chinese exports, the US manufacturing employment declined by some 18%. The finding may have been the result of somewhat 'sticky' USA wages in the face of the downward pressure on the wages of low-skilled workers across all sectors which resulted from the increase in USA/China trade (Petit 2010).
27. These results are available in Online Appendix Table 3.
28. Khandelwal (2010) finds that unit values were more correlated with estimated qualities for products for which there is scope for quality differentiation, and that prices were appropriate proxies of quality for these products.

29. We used Rauch's (1999) conservative definition of differentiated products. The results remain essentially the same when Rauch's liberal definition of differentiated products is applied.
30. We control for a China dummy in all regressions in the rest of the paper.
31. For more details see the results on Table VI of Schott (2004).
32. Xiang (2013) identifies new products as those product classifications for which the assigned fraction of trade value is equal to or greater than 25%. That is, if a product category consists of, say, two products, with both of them identified as new, then the assigned fraction of trade value of new products in that product category is 100%. If one of them is identified as new and the other is not, then the fraction is equal to the value of the new product divided by the total value of trade of that category. When we restrict our analysis to product classifications only to those with assigned fraction of trade value being 100%, the sample size is reduced by around 20%, but the regression results remain essentially the same.
33. Note that if a new product was identified in a given year it remains new in subsequent years of our sample.
34. We also found that the numbers of single-sourced new products that are exported exclusively by low- or middle-wage exporters, and the numbers of double-sourced new products that are exported simultaneously by low- and middle-wage exporters, are insignificant.
35. According to Hall, Trajtenberg and Jaffe (2001), the patents included in their dataset are utility patents representing more than 90% of the total number of patents. An innovation is patentable only if it provides some identifiable benefit and is capable of use.
36. Note that the number of patents granted by the USA to its trading partners, as pointed out by Keller (2004), is not a perfect measure of technology of the latter. Yet, this is the measure that is available for a large number of countries for the period spanning the data of this study.
37. It is important to note a nuance between this paper and the study by Hausmann et al. (2007). While our study makes the case for specializing in and exporting products in accordance with a country's fundamentals, Hausmann et al. (2007) advocate a more flexible specialization policy that is based not only on a country's fundamentals but also on the number of entrepreneurs eager to engage in the process of discovering the underlying cost structure of the economy. More cost discovery will generate knowledge spillovers and will result in a better growth-enhancing mix of goods that a country produces with higher productivity and exports. Hausmann et al. (2007) call this mix of goods 'rich-country products' to distinguish them from the mix of 'poor country products' associated with low productivity. We thank an anonymous referee to bring this difference between our study and the study by Hausmann et al. (2007) to our attention.

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No potential conflict of interest was reported by the authors.

References

Costinot, A. 2009. "An Elementary Theory of Comparative Advantage." *Econometrica* 77 (4): 1165–1192.

Deardorff, A. 1998. "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World." In *Regionalization of the World Economy*, edited by J. Frankel, 7–41. Chicago: Chicago University Press.

Eaton, J., S. Kortum, and S. Sotelo. 2012. "International Trade: Linking Micro and Macro." *National Bureau of Economic Research Working Paper No. 17864*. Cambridge, Massachusetts: NBER Publisher.

Evenett, S., and A. Venables. 2002. "Export Growth in Developing Countries: Market Entry and Bilateral Trade Flows". Mimeo.

Feenstra, R.C. 1996. "U.S. Imports, 1972-1994: Data and Concordances.". *National Bureau of Economic Research Working Paper No*. 5515. Cambridge, MA, USA: NBER Publisher.
Feenstra, R.C., and A. Rose. 2000. "Putting Things in Order: Trade Dynamics and Product Cycles." *Review of Economics and Statistics* 82 (2): 369–382.
Feenstra, R.C., and J. Romalis. 2002. "U.S. Imports, Exports and Tariff Data 1989-2001." *National Bureau of Economic Research Working Paper No*. 9387. Cambridge, MA, USA: NBER Publisher.
Feenstra, R.C., and J. Romalis. 2014. "International Prices and Endogeneous Quality." *Quarterly Journal of Economics* 129 (2): 477–527.
Frankel, J.A., and D. Romer. 1999. "Does Trade Cause Growth?" *American Economic Review* 89 (3): 379–399.
Hall, B., M. Trajtenberg, and A.B. Jaffe. 2001. "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools." *NBER Working Paper* No. 8498. Cambridge, MA, USA: NBER Publisher.
Hallak, J.C. 2006. "Product Quality and the Direction of Trade." *Journal of International Economics* 68: 238–265.
Hallak, J.C. 2010. "A Product-Quality View of the Linder Hypothesis." *Review of Economics and Statistics* 92 (3): 453–466.
Hallak, J.C., and P. Schott. 2011. "Estimating Cross-Country Differences in Product Quality." *Quarterly Journal of Economics* 126 (1): 417–474.
Harrigan, J. 2010. "Airplanes and Comparative Advantages." *Journal of International Economics* 82: 181–194.
Hausmann, R., J. Hwang, and D. Rodrik. 2007. "What You Export Matters." *Journal of Economic Growth* 12 (1): 1–25.
Hummels, D., and A. Skiba. 2004. "Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture." *Journal of Political Economy* 112: 1384–1402.
Hummels, D., and P.J. Klenow. 2005. "The Variety and Quality of a Nation's Exports." *American Economic Review* 95(3): 704–723.
Irwin, D.A., and M. Terviö. 2002. "Does Trade Raise Income? Evidence From the Twentieth Century." *Journal of International Economics* 58 (1): 1–18.
Jarreau, J., and S. Poncet. 2012. "Export Sophistication and Economic Growth: Evidence from China." *Journal of Development Economics* 97 (2): 281–292.
Kehoe, T.J., and J.R. Kim. 2013. "How Important Is the New Goods Margins in International Trade?" *Journal of Political Economy* 121: 358–92.
Keller, W. 2004. "International Technology Diffusion." *Journal of Economic Literature* XLII: 752–782.
Khandelwal, A. 2010. "The Long and Short (of) Quality Ladders." *Review of Economic Studies* 77: 1450–1476.
Klinger, B., and D. Lederman. 2004. "Discovery and Development: An Empirical Exploration of 'New' Products." *World Bank Policy Research Working Paper No. 3450*. Washington D.C.: The World Bank.
Koen, P., G. Ajamian, R. Burkart, A. Clamen, J. Davidson, R. D'Amore, C. Elkins, et al. 2007. "Providing Clarity and Common Language to the 'Fuzzy Front End'." *Research Technology Management* 44 (2): 46–55.
Morrow, P. 2010. "Ricardian-Heckscher-Ohlin Comparative Advantage: Theory and Evidence." *Journal of International Economics* 82: 137–151.
Noguer, M., and M. Siscart. 2005. "Trade Raises Income: a Precise and Robust Result." *Journal of International Economics* 65: 447–460.
Petit, P. 2010. "The Systematic Nature of the Rise in Inequality in Developed Economies." *International Review of Applied Economics* 24 (3): 251–267.
Pham, C.S. 2008. "Product Specialization in International Trade: A Further Investigation." *Journal of International Economics* 75: 214–218.
Pierce, J.R., and P.K. Schott. 2014. "The Surprising Swift Decline of U.S. Manufacturing Employment." *CESifo Working Paper* No. 4563. Stockholm, Sweden: Statistics Sweden.
Pierce, J.R., and P. Schott. 2012. "Concording U.S. Harmonized System Codes Over Time." *Journal of Official Statistics* 28 (1): 53–68.
Rauch, J. 1999. "Networks versus Markets in International Trade." *Journal of International Economics* 48: 7–35.
Schott, P.K. 2003. "One Size Fits All? Heckscher-Ohlin Specialization in Global Production." *American Economics Review* 93 (2): 686–708.

Schott, P.K. 2004. "Across-Product versus Within-Product Specialization in International Trade." *Quarterly Journal of Economics* 119 (2): 647–678.

Schott, P.K. 2008. "The Relative Sophistication of Chinese Exports." *Economic Policy* 53: 5–49.

Xiang, C. 2005. "New Goods and the Relative Demand for Skilled Labor." *Review of Economics and Statistics* 87 (2): 285–298.

Xiang, C. 2007. "New Goods and Skill Premium." *Journal of International Economics* 71 (1): 133–147.

Xiang, C. 2014. "Product Cycles in U.S. Imports Data." *Review of Economics and Statistics*. 96 (5): 999–1004

Zhu, S.C. 2005. "Can Product Cycles Explain Skill Upgrading?" *Journal of International Economics* 66: 131–155.

Zhu, S.C., and D. Trefler. 2005. "Trade and Inequality in Developing Countries: A General Equilibrium Analysis." *Journal of International Economics* 65: 21–48.

Appendix 1

Table A1. Summary statistics of the main variables

Variable	Obs.	Mean	Std. dev.	Min.	Max.
			USA		
log(unit value)	5220233	3.295	7.934	−13.091	123
log(GDPC)	4653679	8.915	1.354	4.034	11.053
log(distance)	4920950	8.923	0.548	7.64	9.709
Land locked	4872878	0.074	0.262	0	1
log(capital/worker)	2982929	12.895	2.827	20.638	26.849
log(population)	3524737	17.253	1.575	10.919	20.983
log(labor)	2577401	16.498	1.574	11.049	20.439
			Brazil		
log(unit value)	280207	2.679	1.84	−12.963	17.353
log(GDPC)	281443	9.51	1.009	5.321	10.795
log(distance)	281433	8.473	0.637	5.363	9.796
Land locked	280780	0.094	0.292	0	1
log(capital/worker)	230333	15.580	21.231	26.747	18.724
log(population)	281146	17.502	1.352	10.689	20.970
log(labor)	259076	16.792	1.338	11.096	20.421
			India		
log(unit value)	282627	2.564	2.037	−13.285	18.309
log(GDPC)	282077	9.527	1.077	4.751	10.795
log(distance)	282066	8.379	0.601	5.363	9.796
Land locked	281320	0.105	0.306	0	1
log(capital/worker)	214851	15.640	21.231	26.747	18.724
log(population)	281458	17.421	1.419	10.678	20.970
log(labor)	252893	16.745	1.412	11.394	20.421
			Japan		
log(unit value)	484984	2.833	1.903	−13.624	18.433
log(GDPC)	491043	9.248	1.24	4.751	10.795
log(distance)	489785	8.428	0.614	5.363	9.796
Land locked	488005	0.105	0.306	0	1
log(capital/worker)	400984	15.825	21.231	26.747	18.724
log(population)	490072	17.396	1.526	10.654	20.970
log(labor)	433281	16.725	1.506	10.703	20.421

Notes: This table reports the summary statistics of the sample of trade flows of value greater than $1000.

Appendix 2

Table A2. Summary statistics of quality ladder measure

	USA	Brazil	India	Japan
Multiple-sourced mean	2.44	2.16	2.43	3.96
Double-sourced mean	2.41	2.20	2.23	3.97
Single-sourced mean	2.93	2.62	2.29	4.78

Notes: The quality ladder is defined as follows: $\text{Quality\_Ladder}_p = \log[\max(\text{unit–value}_p) - \min(\text{unit–value}_p)]/\text{number of countries exporting product } p$.