NBER WORKING PAPER SERIES

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Kalina Manova
Zhiwei Zhang

Working Paper 15342
http://www.nber.org/papers/w15342

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2009

We thank Kyle Bagwell, Doireann Fitzgerald, Penny Goldberg, James Harrigan, Elhanan Helpman, Pete Klenow, Marc Melitz and Bob Staiger for insightful conversations, and four anonymous referees and seminar participants at Stanford, Harvard, Princeton, Yale, Penn State, UC Berkeley, UC Riverside, UBC, UVA, UC Boulder, Maryland, U Houston, Syracuse, World Bank, Dallas Fed, 2009 NBER ITI spring meeting, 2009 NBER China meeting, 2009 CESifo Venice Summer Institute, 2009 SNB-CEPR Zürich Conference and 2010 AEA annual meeting for their comments. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 15342
September 2009, Revised December 2010
JEL No. F10,F12,F14,L11,L16

ABSTRACT

This paper establishes six new stylized facts about firms' export prices using recently-released customs data on the universe of Chinese trade flows. First, firms that charge higher export prices earn greater revenues in each destination, have bigger worldwide sales, and export to more markets. Second, firms that export more, that sell to more destinations and that charge higher export prices use more expensive imported inputs. Third, firms set higher prices in larger, richer, bilaterally more distant and overall less remote destinations. Fourth, firms earn greater revenues in markets where they set higher prices. Fifth, firms that export to more destinations offer a wider range of export prices. Finally, firms that export more, that sell to more markets and that offer a wider range of export prices pay a wider range of imported-input prices and source inputs from more origin countries. We propose that trade models should incorporate two features to rationalize these patterns in the data: more successful exporters use higher-quality inputs to produce higher-quality goods (stylized facts 1 and 2), and firms vary the quality of their products across destinations by using inputs of different quality levels (stylized facts 3, 4, 5 and 6).

Kalina Manova
Department of Economics
Stanford University
579 Serra Mall
Stanford, CA 94305
and NBER
manova@stanford.edu

Zhiwei Zhang
International Monetary Fund
Research Department
700 19th Street NW
Washington, DC 20431 USA
zzhang@hkma.gov.hk

1 Introduction

A growing literature has documented substantial and systematic variation in export performance across firms. More productive firms are more likely to export, have higher export revenues, and enter more markets.[1] These patterns are consistent with early heterogeneous-firm models that emphasize firms' production efficiency as the main determinant of export success.[2] In these models, all producers use identical inputs to manufacture symmetric outputs, but more productive firms become more successful exporters because they have lower marginal costs and offer lower prices.[3] Recent evidence, however, suggests that larger exporters pay higher wages and are more skill and capital intensive. Moreover, exporters charge higher prices than non-exporters, and plant size is positively correlated with output and input prices.[4] To rationalize both sets of facts, recent models have re-interpreted the original heterogeneous-firm framework to incorporate quality differentiation across firms. In this context, more productive firms enjoy superior export performance because they choose to use more expensive, higher-quality inputs to sell higher-quality goods at higher prices.[5]

This paper establishes six new stylized facts about the variation in export prices and imported-input prices across firms, products and trade-partner countries using recently-released customs data on the universe of Chinese trade flows. We draw two main conclusions from these stylized facts. First, more successful exporters use higher-quality inputs to produce higher-quality goods which sell at higher prices. Second, firms vary the quality of their products across destinations with different market size, income, bilateral distance and overall remoteness by using inputs of different quality levels. While the first conclusion confirms recent evidence in the literature, the second is novel. Together, they suggest that international trade models should incorporate not only quality differentiation across firms, but also across trade partners within firms, in order to account for the patterns in the data. Our findings thus uncover a previously

[1] See Clerides, Lach and Tybout (1998), Aw, Chung and Roberts (2000), Eaton, Kortum and Kramarz (2004, 2008), Bernard, Jensen and Schott (2009), and Bernard, Jensen, Redding and Schott (2007) for a survey of the literature.
[2] We will refer to higher export sales and more destinations as superior export performance or export success.
[3] While this is the standard interpretation of the models in Melitz (2003), Bernard, Eaton, Jensen and Kortum (2003) and Melitz and Ottaviano (2008), they can also be re-interpreted in terms of quality-differentiated outputs (see below).
[4] See Bernard and Jensen (1995), Verhoogen (2008), Kugler and Verhoogen (2008), Hallak and Sivadasan (2008) and Iacovone and Javorcik (2008).
[5] See Johnson (2007), Baldwin and Harrigan (2007), Sutton (2007), Verhoogen (2008), Kugler and Verhoogen (2008), Hallak and Sivadasan (2008), Kneller and Yu (2008), and Gervais (2009).

unexplored dimension of firm heterogeneity and adjustments on the quality margin within firms across destinations that future theoretical and empirical work can pursue.

The first two systematic patterns we document constitute evidence consistent with quality differentiation across exporters. First, within narrowly defined product categories, firms that charge higher free-on-board (f.o.b.) export prices earn greater revenues in each destination, have bigger worldwide sales, and export to more markets. These patterns are more pronounced in richer destinations and in sectors with greater scope for quality differentiation, as proxied by the Rauch (1999) classification of non-homogeneous goods, R&D- or advertising intensity. These findings point to quality sorting across firms whereby higher prices are associated with better quality and superior export performance.

Second, firms that export more, that sell to more destinations and that charge higher export prices import more expensive inputs. We interpret this as indirect evidence that more successful exporters use higher-quality inputs to manufacture higher-quality goods. In the absence of detailed information on firms' domestic input purchases or direct measures of product quality, the prices of firms' imported inputs offer an imperfect signal of the quality of all of their inputs.[6] Since more productive firms may optimally use better-quality inputs, our results do not imply that firm efficiency is unimportant for export success. Instead, they suggest that marginal costs rise sufficiently quickly with product quality such that more productive firms charge higher prices.

These stylized facts corroborate the conclusion in the recent literature that quality differentiation across firms matters for export performance, although earlier work has relied on an entirely different set of empirical results. This literature has also typically examined country-level export prices or firm-level data on export status, plant size and input prices instead of detailed information on firms' export activity. Our paper is thus the first to document these patterns using comprehensive data on firms' matched exports and imports by product and trade partner. This level of detail is rare in trade datasets, and also allows us to establish new facts about the variation in export activity across destinations within firms, as we next describe.[7] Having access to information on firms' imported inputs is particularly helpful in establishing a quality interpretation.

The remaining stylized facts that we document together suggest that firms adjust the quality of their export products to characteristics of the destination market by varying the quality

[6] This is consistent with Kugler and Verhoogen (2009) who find a positive correlation between the prices Mexican plants pay for imported and domestic inputs.

[7] As far as we know, comparable data are available only for the United States, France and Denmark. Papers utilizing these data have examined other questions and rarely exploited the matched data on firms' export and import activity.

of their inputs. The third pattern we highlight is that, for a given product, a firm charges higher f.o.b. prices in larger, richer, bilaterally more distant and overall less remote destinations. Fourth, for a specific good, a firm earns more revenues in markets where it sets higher prices. Both of these results are magnified in richer destinations and for products with bigger potential for quality upgrading. Fifth, within each product, firms that export to more countries offer a wider range of export prices, especially for products with greater scope for quality differentiation. Lastly, firms that export more, that sell to more destinations and that offer a wider range of export prices pay a wider range of prices for their imported inputs and source inputs from more origin countries.

Stylized facts three and four are identified purely from the variation across export destinations within a firm-product pair, as they condition on firm-product fixed effects. Therefore, if firms export an identical good everywhere, the fixed effects would capture its cost and quality characteristics, and any residual variation in prices across markets would have to be due to variable mark-ups. However, current heterogeneous-firm models predict either a constant mark-up above marginal cost (CES demand) or a lower mark-up in big, distant and less remote markets where competition is tougher (linear demand). Thus, if firms sold an identical product to all destinations, export prices would counterfactually be either *un*correlated or *negatively* correlated with market size, income, distance and centrality.

Instead, we propose that firms respond to characteristics of the destination market not only by adjusting their mark-up, but also by varying the quality of their product. If firms do so by using inputs of different quality, then this explanation can also rationalize the last two systematic patterns that emerge in the data. In particular, while models with variable mark-ups can generate the positive correlation between the number of firms' destinations and the standard deviation of export prices across markets, they cannot explain the results for the dispersion in import prices and the number of source countries for firms' imported inputs. On the other hand, our findings are consistent with exporters varying product quality across markets and buying multiple quality versions of an input to produce multiple quality versions of an output.

While the stylized facts suggest that firms adjust product quality to destination characteristics, we cannot determine what drives firms' quality choice. We therefore discuss alternative rationalizations for the patterns we document, and leave it to future theoretical and empirical work to conclusively establish the underlying mechanism.

The finding that firms charge higher prices in richer destinations is consistent with non-homothetic preferences. With such preferences, firms have a stronger incentive to upgrade product quality when they face wealthier consumers with lower marginal utility of income and greater willingness to pay for quality.[8]

The results for market size, bilateral distance and centrality lend themselves to a number of interpretations. In the linear-demand models we consider, all three variables are positively correlated with market toughness. It is thus possible that firms respond to market competition both by reducing mark-ups and by increasing product quality. If quality upgrading requires more expensive, higher-quality inputs, it will raise marginal costs. When this effect is sufficiently strong, it can dominate the mark-up correction and generate higher export prices in big, distant and less remote destinations as we observe. Our results would then capture the net effect of quality and mark-up adjustment, and provide a lower bound for the response of product quality.

Alternatively, firms may export products of higher quality to more distant markets because they face per unit transportation costs. In particular, exporters may sell multiple quality versions of a product to each country but vary the quality mix with destinations' proximity. Firms would then optimally shift exports towards their better-quality goods in more distant markets because higher unit costs lower the relative price of and increase relative demand for such products.

As for market size, firms may offer products of higher quality in larger destinations if there are economies of scale in the production or delivery of higher-quality goods. On the production side, upgrading product quality may entail fixed investments in specialized equipment or hiring more skilled workers. On the delivery side, the fixed costs of marketing and distribution may be increasing in product quality. As long as firms expect to earn higher revenues in larger markets and the destination-specific fixed costs of exporting rise with product quality, firms will have an incentive to improve the quality of goods shipped to bigger countries.

Identifying the determinants of firms' export success is important for understanding the patterns of international trade across countries, the welfare and distributional consequences of globalization, and the design of export-promoting policies in developing economies.

Firm heterogeneity matters because of its implications for countries' trade and growth. Reallocations across sectors and across firms within a sector are both important in the adjustment to trade liberalization and its impact on aggregate productivity (Pavcnik 2002, Bernard, Jensen and

[8] See Verhoogen (2008), Fajgelbaum, Grossman and Helpman (2009), and Simonovska (2010).

Schott 2006, Chaney 2008). Most models in the literature, however, predict that these aggregate gains are the same whether firms sort on efficiency or quality. Arkolakis, Costinot and Rodriguez-Clare (2009) further suggest that, under certain conditions, models with and without firm heterogeneity may in fact have the same welfare implications. The distributional consequences of globalization, on the other hand, depend importantly on the nature of firm heterogeneity. In this context, our findings suggest that firms producing higher-quality goods will be more resilient to import competition and more likely to expand if given an export opportunity. If input quality and labor skill are complementary in the production of high-quality goods, trade liberalization will also affect employment and wages differentially across the skill distribution. This is consistent with the evidence that U.S. output and employment appear less vulnerable to import competition from low-wage countries in sectors characterized by longer quality ladders (Khandelwal 2008).[9]

Our results further raise the possibility that the quality differentiation we document may in fact affect aggregate gains from trade. While the stylized facts describe the cross-section of firms, they suggest that, in addition to adjusting trade volumes, product scope and export destinations, firms may also vary product quality within and across markets in response to trade liberalization. This may generate different welfare gains than a world in which firms export the same product quality to all markets. These gains may also exceed those in an environment with efficiency sorting only, since then increases in firm productivity following reforms would not affect products differentially across export destinations. This is a fruitful area for future research as the models we consider assume that firm productivity and product quality are fixed over time. The results in Arkolakis, Costinot and Rodriguez-Clare (2009) also apply only under this assumption.

Finally, a better understanding of the factors that drive firms' export success will facilitate the design of policies that promote trade, and ultimately growth and income in developing countries. The cross-sectional patterns we document say little about firms' capacity to improve efficiency or upgrade product quality. Nevertheless, an indirect implication of quality sorting is that the latter can boost export performance. This suggests that it may be beneficial for governments to encourage investment in R&D and technologies that allow firms to produce and export higher quality, and not only investment in cost reduction. In addition, firms in developing countries may find it difficult to source high-quality inputs domestically and instead rely on imported inputs from more developed countries. This may explain why more successful Chinese

[9] See also Fernandes and Paunov (2009) for related evidence from Chile.

exporters are able to offer higher-quality goods despite the widespread belief that product quality and quality control are weak in China. This argument provides one reason why developing countries may need to liberalize imports if they want to improve their export performance.[10]

The remainder of the paper is organized as follows. The next section discusses how our work builds on the previous literature. Section 3 describes the data, Section 4 documents the six stylized facts, and Section 5 discusses their robustness. Section 6 summarizes the implications of different heterogeneous-firm trade models for the behavior of export prices, which we use to interpret the empirical results in Section 7. The last section concludes.

2 Related Literature

Our work builds on recent papers that study aggregate export prices to determine whether production efficiency or product quality matter more for firms' export success. Baldwin and Harrigan (2007) and Johnson (2007), for instance, explore the variation in product-level export prices with destination size and distance, and find evidence in support of quality sorting. Since different models can deliver similar predictions for the behavior of aggregate prices, however, the latter may in principle be inconclusive. It may in fact be misleading if unit values at the product level exhibit patterns consistent with a given model, but the underlying firm prices do not. The detailed nature of our dataset allows us to address this challenge and directly analyze firms' export prices, while also providing evidence on firms' imported inputs.

Our results also contribute to recent firm-level evidence indicative of quality differentiation across firms. Verhoogen (2008), Kugler and Verhoogen (2008), Hallak and Sivadasan (2008) and Iacovone and Javorcik (2008) document that exporters charge higher prices than non-exporters, plant size is positively correlated with output and input prices, and more productive firms pay higher wages to produce better-quality goods. In concurrent work, Crozet, Head and Mayer (2009) show that highly-ranked French wine producers export more to more markets at a higher average price. Also in concurrent work, Bastos and Silva (2010) find that firms set higher prices in bigger, richer and more distant countries in a sample of Portuguese exporters. They do not, however, offer an explanation for these findings, explore the relationship between firms' export prices and revenues, or study firm inputs to make inferences about product quality.

[10] See Kugler and Verhoogen (2009) for evidence that Mexican firms import inputs of higher quality than local inputs.

Finally, Brambilla, Lederman and Porto (2009) show that Argentine firms that export to richer countries pay higher wages, and suggest that these firms sell products of higher quality.

This paper is the first to examine matched data on firm-level export and import prices by product and destination/source country, and to do so for the universe of trade flows. We uncover new stylized facts and offer a novel explanation based on firms varying product quality across countries in response to market characteristics. Our results suggest that international trade models should incorporate quality differentiation both across firms and across destinations within firms in order to explain the stylized facts in the data. Verhoogen (2008) constitutes a first step in this direction by modeling firms that produce two quality levels in the presence of non-homothetic preferences: one for home, and a higher one for a richer export market. In addition to rationalizing our results for GDP per capita, future theoretical work should also explain the patterns we document for market size, bilateral distance and remoteness.

Our findings are also related to the work of Schott (2004), Hummels and Klenow (2005), Hallak (2006) and Mandel (2008). They show that aggregate export prices systematically increase with both trade partners' GDP per capita and with the capital and skill intensity of the exporting country. They propose that cross-country quality differentiation in production capabilities and consumption preferences can explain these patterns.[11]

Finally, our results indirectly speak to the large literature on exchange-rate pass-through. This literature has found evidence of pricing to market, i.e. that firms vary mark-ups across markets segmented by variable exchange rates.[12] Combined with the new stylized facts we establish, this suggests that models with constant mark-ups or product quality across destinations are unlikely to explain either the trade or exchange-rate pass-through patterns in the data.

3 Data

We use recently released proprietary data on the universe of Chinese firms that participated in international trade over the 2003-2005 period.[13] These data have been collected by the Chinese Customs Office. They report the free-on-board value of firm exports and imports in U.S. dollars by product and trade partner for 243 destination/source countries and 7,526 different products in

[11] See also Hallak and Schott (2008) who decompose countries' export prices into quality and quality-adjusted prices.
[12] See Gopinath, Itskhoki and Rigobon (2008), Burstein and Jaimovich (2009), and Fitzgerald and Heller (2010).
[13] Manova and Zhang (2008) describe the data and stylized facts about firm heterogeneity in Chinese trade.

the 8-digit Harmonized System.[14] The dataset also provides information about the quantities traded in one of 12 different units of measurement (such as kilograms, square meters, etc.), which makes it possible to construct unit values. We have confirmed that each product is recorded in a single unit of measurement, and we include product fixed effects in all regressions to account for the different units used across goods.

In principle, unit values should precisely reflect producer prices. Since trade datasets at both the aggregate and firm level rarely contain direct information on producer prices, the prior literature has typically relied on unit values as we do. The level of detail in our data is an important advantage in the construction of unit prices as they are not polluted by aggregation across firms or across markets within firms. Nevertheless, we perform a number of specification checks in Section 5.1 to ensure that measurement error in unit values does not drive our results.

While the Chinese customs data are available at a monthly frequency, we focus on annual exports in the most recent year in the panel, 2005. This decision is motivated by a number of considerations. First, we aim to establish stylized facts that obtain in the cross-section of firms and are not interested in export dynamics. Second, there is a lot of seasonality and lumpiness in the monthly data, and most firms do not export a given product to a given market in every month. By focusing on the annual data, we can abstract from these issues and related concerns with sticky prices. Third, when we explore how firms' export prices vary with characteristics of the destination market, we use annual data on GDP, GDP per capita, distance and remoteness. If the outcome variable were at the monthly frequency, the standard errors could be misleadingly low because we would effectively multiply the number of observations without necessarily introducing new information. Finally, outliers are likely to be of greater concern in the monthly data. Section 5.1 confirms that all results hold at the monthly frequency and in fact become more significant.

Some state-owned enterprises in China are pure export-import companies that do not engage in manufacturing but serve exclusively as intermediaries between domestic producers (buyers) and foreign buyers (suppliers). Following standard practice in the literature, we identify such wholesalers using key words in firms' names and exclude them from our main results.[15] We do so in order to focus on the operations of firms that both make and trade goods since we are interested in how firms' production efficiency and product quality affect their export activities.

[14] Product classification is consistent across countries at the 6-digit HS level. The number of distinct product codes in the Chinese 8-digit HS classification is comparable to that in the 10-digit HS trade data for the U.S..

[15] We drop 23,073 wholesalers who mediate a quarter of China's trade. Using the same data, Anh, Khandelwal and Wei (2010) identify intermediaries in the same way in order to study wholesale activity.

Showing direct evidence on firms' imported-input prices is thus an important component of our analysis as they proxy for input quality. We cannot apply this approach to intermediaries because we do not observe their suppliers and cannot interpret their import transactions as input purchases. However, since wholesalers and producers compete in the same markets, their export prices should exhibit similar patterns. We confirm that this is indeed the case in Section 5.2.

Table 2 illustrates the substantial variation in prices across 96,522 Chinese exporters, 6,908 products, and 231 importing countries. After removing product fixed effects, the average log price in the data is 0.00, with a standard deviation of 1.24 across goods, firms, and trade partners. Prices vary significantly across Chinese producers selling in a given country and good. The standard deviation of firm prices in the average destination-product market is 0.90. This highlights the extent of firm heterogeneity in the data. There is also a lot of variation in unit values across trade partners within a given exporter. The standard deviation of log prices across destinations for the average firm-product pair is 0.46. This suggests that models, in which firms adjust mark-ups, product quality or both across markets may be more successful at matching the data.

We explore four destination-country characteristics in the analysis: market size, income, bilateral distance from China, and overall remoteness. We use data on GDP and GDP per capita from the World Bank's World Development Indicators, and obtain bilateral distances from CEPII.[16,17] As is standard in the literature, we construct a measure of remoteness as a weighted average of a country's bilateral distance to all other countries in the world, using countries' GDP as weights. A destination is remote in economic terms if it is isolated from most other nations or tends to be close to small countries but far away from big economies.[18] The correlation between distance to China and overall remoteness in our sample is 0.09, and is not significant at 10%.

Based on the availability of data for these country indicators, we work with 242,403 observations across 179 countries and 6,879 HS-8 codes at the destination-product level, and 2,098,634 observations across 94,664 firms at the firm-destination-product level. The firm-level regressions that do not require information on the importer's characteristics exploit the universe of trade flows for a total of 2,179,923 observations (96,522 firms, 6,908 products and 231 countries).

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[16] The data on bilateral and inner distance are available at http://www.cepii.fr/anglaisgraph/bdd/distances.htm.

[17] GDP and distance are imperfect, if commonly used proxies for market size and bilateral trade costs. We leave the study of alternative measures to future work.

[18] Specifically, we measure the remoteness of destination d as $remoteness_d = \sum_o GDP_o \cdot distance_{od}$, where GDP_o is the GDP of origin country o, $distance_{od}$ is the distance between o and d, and the summation is over all countries in the world o. See Baldwin and Harrigan (2007) for a discussion of alternative remoteness indices. Practically identical results obtain if we instead proxy remoteness with another common measure, $(\sum_o GDP_o / distance_{od})^{-1}$.

Our analysis makes use of three different proxies for products' scope for quality differentiation. These measures are relatively standard in the literature and meant to capture technological characteristics of a given product or sector that are exogenous from the perspective of an individual firm and innate to the nature of the manufacturing process. The first indicator is the Rauch (1999) dummy for differentiated goods, identified as products not traded on an organized exchange or listed in reference manuals. It is available for SITC-4 digit goods, which we concord to the Chinese HS-8 digit classification. We also employ continuous measures of R&D intensity or combined advertising and R&D intensity from Klingebiel, Kroszner and Laeven (2007) and Kugler and Verhoogen (2008), respectively. They are based on U.S. data for 3-digit ISIC sectors which we match to the HS-8 products in our sample. Exploiting the imperfect correlation among these three proxies for quality differentiation makes it less likely that our results are instead driven by some unobserved product characteristic.[19]

4 Stylized Facts

This section documents stylized facts about the variation in export and import prices across firms, products and trade-partner countries. We first explore the correlation between export prices and export revenues across firms within a given product- or destination-product market. We then examine the link between firms' export prices and number of export destinations. Next we study the relationship between export prices, revenues and country characteristics across trade partners within a firm-product pair. Finally, we examine how firms' imported-input prices, import price dispersion and number of source countries relate to their export performance.

4.1 Export prices at the product level

For consistency with the prior literature, we first briefly document how aggregate f.o.b. export prices at the product level vary with characteristics of the destination country. We construct these aggregate prices such that they equal the unit value that product-level data would report. In particular, we first sum the export value and quantity across all firms that sell a specific HS-8 good to a given market. We then obtain the average Chinese export price for each destination-product by dividing total revenues by total quantities.

[19] The correlation between R&D and combined advertising and R&D intensity across the 30 sectors is 0.21. At the HS-8 digit level, the correlation between the Rauch dummy and R&D (advertising and R&D) is 0.16 (0.20).

Table 3 reports results from a gravity-type regression of product-level unit values on destination size, income, bilateral distance to China, and overall remoteness, with all variables in logs. As columns 1 and 2 show, the average f.o.b. export price is higher in smaller, richer, more proximate and more central markets.[20] The coefficient on market size is imprecisely estimated when we do not control for remoteness, and turns positive and significant when we do not control for GDP per capita (results available upon request). The results for the other three country measures are very robust across alternative specifications.

In the rest of the table, we test whether these patterns differ between rich and poor markets. We repeat the analysis separately for destinations above and below the median income level in the sample. The average Chinese export price increases with income, distance and centrality for the 89 rich importers without varying systematically with market size. By contrast, it falls with GDP, distance and remoteness in the poorer half of the sample without responding to GDP per capita.

For reference, Baldwin and Harrigan (2007) find that average U.S. export prices rise with bilateral distance, fall with the importer's GDP and remoteness, and vary either positively or negatively with income depending on the specification. These patterns are similar to those we find for rich countries in our data. Since Baldwin and Harrigan (2007) focus on U.S.' top 100 export destinations which largely overlap with the countries in the richer half of our sample, our results are consistent with theirs at the product level. This suggests that our findings for firm-level prices are also likely not specific to China.

As we explain in Section 6, the behavior of aggregate prices may not conclusively distinguish between efficiency and quality heterogeneity across firms as both may exhibit the same patterns at the product level. More importantly, aggregate prices may be misleading if they are consistent with a given model, but the underlying firm prices are not. In the rest of the paper we therefore exploit the richness of our data and directly examine firm-level prices.

4.2 Export prices across firms

Consider first the correlation between free-on-board export prices and worldwide export revenues across firms selling a given HS-8 digit product. To explore this variation, we aggregate the data to the firm-product level by summing sales and quantities across markets. We then take their ratio

[20] We will describe countries that are closer to China as either less distant or more proximate. We will refer to countries that are globally more remote as more isolated or less central.

and construct firm f's average export price for product p across all destinations d it serves, $price_{fp} = \frac{\sum_d revenue_{fpd}}{\sum_d quantity_{fpd}}$. Using this measure, we estimate the following specification:

$$\log price_{fp} = \alpha + \beta \cdot \log revenue_{fp} + \delta_p + \varepsilon_{fp} \ , \quad (1)$$

where product fixed effects δ_p control for systematic differences across goods in consumer appeal, comparative advantage, transportation costs, units of measure, and other product characteristics that affect all manufacturers equally. At this level of aggregation, the sample comprises 898,247 observations spanning 96,522 firms and 6,908 products. We cluster errors ε_{fp} by firm.

We are primarily interested in the sign of β, which reflects the sign of the conditional correlation between export price and revenues across firms within a product.[21] The sign of this correlation will later allow us to evaluate the importance of production efficiency and product quality for firms' export performance. We emphasize that we cannot and do not want to give β a causal interpretation since firms' unit values and sales are both affected by unobserved firm characteristics and are the joint outcome of firms' profit maximization.

As column 1 in Table 4 shows, within a given product, firms that charge a higher average export price earn bigger worldwide revenues.[22] The point estimates suggest that a one-standard-deviation increase in log export sales is associated with a 27% higher export price, which represents 20% of the standard deviation in log average export prices.[23] The strength of this correlation, however, varies systematically across products with different scope for quality upgrading. In column 3, we regress unit values on firm sales and their interaction with the dummy for differentiated goods. The positive correlation between price and revenues across firms is two and a half times stronger among non-homogeneous products. Similar results obtain in columns 4 and 5 when we instead proxy the potential for quality differentiation with sectors' R&D intensity or combined advertising and R&D intensity.[24] All of these patterns are significant at 1%.[25]

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[21] More precisely, β is the ratio of the covariance of price and revenue to the variance of revenue. β thus has the same sign as the correlation between price and revenue.

[22] Column 2 in this table, as well as in Tables 5 and 7, documents the negative correlation between f.o.b. export prices and quantities. This is consistent with both efficiency and quality sorting and does not help differentiate between them. For this reason, we report these results only for completeness and do not discuss them further.

[23] These comparative statics use the standard deviation of export values and prices after demeaning them with their product-specific average. Very similar results obtain if we use the raw data without demeaning instead.

[24] The coefficient on the interaction with R&D intensity is negative, though only significant at 10%. R&D intensity is very unevenly distributed in the data, however, with many values between 0.00-0.03 and a few above 0.07. When we group sectors into high- and low-R&D intensity, the interaction with a dummy for high-R&D intensity is positive and significant at 1%.

In the last column of Table 4, we distinguish between firms' exports to rich and poor destinations. In particular, we compute average prices and total revenues at the firm-product level separately for countries above and below the median income in the sample, using the same cut-off as in Table 3. When we expand (1) to include a dummy for rich destinations and its interaction with revenues, we find that the correlation between export prices and sales is positive for both poor and rich markets, but a significant 50% higher for the latter.

This analysis abstracts away from the substantial variation across exporters in the number of countries they sell to. It also ignores potentially large differences in the market environment across destinations that may influence firms' export participation and pricing decisions. We therefore next exploit the full dimensionality in the data, and examine the variation in export prices across Chinese firms selling in a given market, where a market is defined as a destination-product pair. This could be, for example, all Chinese shoe manufacturers exporting to Germany.

We adopt the following estimating equation:[26]

$$\log price_{fpd} = \alpha + \beta \cdot \log revenue_{fpd} + \delta_{pd} + \varepsilon_{fpd} \tag{2}$$

Here $price_{fpd}$ and $revenue_{fpd}$ are the f.o.b. bilateral export price and revenue of firm f selling product p in destination d, and δ_{pd} are destination-product pair fixed effects. Once again, we interpret the sign of β as the sign of a conditional correlation that does not reflect causality. We conservatively cluster errors ε_{fpd} by destination-product, but note that all of our results are robust to alternative levels of clustering, such as by firm, product, destination, firm-destination or firm-product. Since the unit of observation is now at the firm-product-country level, the sample size in these regressions grows to 2,179,923 data points.

Similarly to (1), the extensive set of fixed effects in this specification implicitly control for product characteristics that are invariant across manufacturers and trade partners. However, they also condition on features of the importing country that affect all products and firms selling there, such as consumer income, regulatory restrictions, legal institutions, inflation and exchange rates. Finally and most importantly, the δ_{pd}'s take account of transportation costs, bilateral tariffs, demand conditions, market toughness, and other economic factors that influence exporters in any

[25] Using Danish firm-level data, Nguyen (2009) also finds that the sign and strength of the correlation between export price and revenues varies across products but he does not relate it to product characteristics.

[26] In all specifications, we use the same symbols for the intercept, coefficients, fixed effects and error terms as in equation (1). This is only for expositional convenience; these objects will of course differ across specifications.

given destination-product market. The coefficient on revenues is thus identified purely from the variation across firms within very fine segments of the world economy.

Table 5 presents robust evidence that firms setting a higher export price earn greater revenues even within such narrowly-defined destination-product markets. This relationship is highly statistically significant. It is also markedly stronger for goods with greater scope for quality variation, as proxied by product differentiation and sectors' R&D or advertising intensity. Finally, it is systematically more positive in richer destinations, as indicated by the interaction of revenues with the importer's GDP per capita.

In terms of economic magnitudes, these estimates have similar implications to those in Table 4. The elasticity of export prices with respect to revenues is 0.08. A doubling in firm sales in a given market is thus associated with 6% higher bilateral unit prices for the average product. This number is, however, 7 percentage points bigger for sectors at the upper end of the distribution in advertising and R&D intensity relative to sectors at the lower end of the distribution. Similarly, the magnitudes are 150% higher for differentiated goods relative to homogeneous products. Finally, the elasticity of price with respect to sales is twice as large in a rich destination (75^{th} percentile of the distribution of GDP per capita) compared to a poor export market (25^{th} percentile).[27]

When evaluating these results, it is important to note that constructing unit prices as the ratio of export revenues to export quantities does not restrict the sign of the correlation between price and revenue or between price and quantity. Appendix Table 1 illustrates this with six examples, in which five observations always have the same price profile but very different revenue and quantity patterns. Prices may be perfectly positively correlated with revenue and uncorrelated with quantity (Case 1), or negatively correlated with quantity and uncorrelated with revenue (Case 2). Prices may also be positively (negatively) correlated with both revenue and quantity (Cases 3 and 4), or positively correlated with revenue and negatively correlated with quantity (Case 5). Finally, prices may be only weekly correlated with revenue and/or quantity (Case 6). The only pattern ruled out by construction is the combination of a positive correlation between price and quantity and a negative correlation between price and revenue. A positive correlation between price and revenue in the data can thus be informative and does not arise mechanically by construction.

[27] All comparative statics in the paper are based on regressions which include product, firm-product or destination-product fixed effects. These fixed effects naturally absorb a lot of the variation in the data, but are necessary for the clean interpretation of the estimated coefficients.

4.3 Export prices and number of destinations

We next examine the relationship between firms' export prices and number of export destinations. Of interest are both firms' average unit value and the extent to which they vary prices across markets. The following regressions explore how these variables co-move with the number of trade partners at the firm-product level:

$$\log price_{fp} = \alpha + \beta \cdot \log \#destinations_{fp} + \delta_p + \varepsilon_{fp} \tag{3}$$

$$sd_{fp}(\log price_{fpd}) = \alpha + \beta \cdot \log \#destinations_{fp} + \delta_p + \varepsilon_{fp} \tag{4}$$

As before, $price_{fp}$ refers to firm f's average export price for product p, while $\#destinations_{fp}$ gives the number of countries which buy p from f. We measure price dispersion with $sd_{fp}(\log price_{fpd})$, the standard deviation of log f.o.b. export prices across destinations within each firm-product pair. The estimation controls for good-specific characteristics with product fixed effects δ_p, and clusters errors ε_{fp} by firm. In both equations, β is identified purely from the variation across firms within a given HS-8 code. It is thus not affected by any systematic differences across products in average price or in typical price variability across importers. Since firms' market entry decisions are made jointly with their pricing strategies, we will later interpret the results from these specifications in terms of correlations and not causality.

As reported in Table 6, exporters that supply more countries systematically charge a higher average price (Panel A). Firms selling to more destinations also exhibit greater price dispersion across importers (Panel B).[28] These results are both largely driven by products with substantial potential for quality differentiation. As columns 2-6 show, the patterns hold only for differentiated products (but not for homogeneous goods) and are more pronounced in R&D- and advertising-intensive sectors. Note also that the correlations in Panel B do not arise mechanically since firms can choose to offer the same price in every market or a narrower range of prices if they transact with more trade partners.

To gauge the economic significance of these correlations, consider a one-standard-deviation increase in a firm's trade-partner intensity, or 2.11 more destinations. Such an increase would be accompanied by a 1% rise in the firm's average export price and 0.5% more dispersion in export prices across markets. These calculations are for the average product. While these

[28] Price dispersion is only defined for firm-product pairs with at least two destinations, hence the smaller sample size.

magnitudes would be negligible for sectors at the low end of the distribution by R&D intensity, however, they would reach 3% and 2% respectively for a sector at the top of the distribution.

4.4 Export prices across destinations within firms

The analysis so far has focused on the variation in export prices across firms within narrowly-defined product categories or destination-product markets. This subsection instead documents systematic patterns in the variation of export prices across trade partners within firm-product pairs.

We first study the correlation between f.o.b. export prices and revenues across importing countries within an exporter with the following specification:

$$\log price_{fpd} = \alpha + \beta \cdot \log revenue_{fpd} + \delta_{fp} + \varepsilon_{fpd} \quad (5)$$

We now include firm-product pair fixed effects δ_{fp}. In addition to subsuming the role of product characteristics common to all firms, these fixed effects also control for firm attributes such as overall production efficiency, managerial talent, labor force composition, general input quality, etc. that affect the firm's export performance equally across products. Crucially, the δ_{fp}'s account for firm-product specific characteristics that are invariant across export markets.[29] The coefficient of interest, β, is thus identified purely from the variation in prices across destinations within a given manufacturer and product line. We cluster errors conservatively at the firm-product level, but our findings are robust to alternative clustering, such as by firm, product or destination.

In Table 7, we consistently find that firms earn bigger revenues from a given HS-8 product in markets where they set higher f.o.b. prices. This result cannot be explained by firms extracting higher mark-ups because of greater market power, as they are robust to controlling for firms' market share in each country and product (column 3).[30] The remainder of the table further shows that the positive correlation between export price and sales across destinations within a firm is stronger among richer destinations and for goods with greater scope for quality differentiation. This result is robust to the choice of proxy for quality upgradeability.

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[29] In all models we study in Section 6, all products enter the utility function symmetrically. This implicitly normalizes quantities by utils and not physical units. Technically, the models' predictions are for prices per utility-adjusted unit of output. Empirically, the concern is that consumers get different utils from the products of different firms. Firm-product pair fixed effects help address this problem.

[30] We measure firm *f*'s market share with the share of *f*'s exports of product *p* to destination *d* in total Chinese exports of *p* to *d*. *f*'s true market share is our measure, multiplied by the share of Chinese exports in total consumption of *p* in *d*, which is invariant across Chinese exporters. While imperfect, this is the best proxy for market power in these data.

So far we have largely treated destinations anonymously and symmetrically. Chinese trade partners, however, vary considerably along a number of dimensions. We focus on four country characteristics in particular: size (GDP_d), income ($GDPpc_d$, or GDP per capita), distance to China ($distance_d$), and overall economic remoteness ($remote_d$). To explore how these market features affect Chinese exporters' optimal f.o.b. bilateral prices, we estimate the following specification:

$$\log price_{fpd} = \alpha + \beta \cdot \log GDP_d + \gamma \cdot \log GDPpc_d + \\ + \lambda \cdot \log distance_d + \mu \cdot \log remote_d + \delta_{fp} + \varepsilon_{fpd} \quad (6)$$

As in (5), we include firm-product pair fixed effects δ_{fp} such that β, γ, λ and μ are identified purely from the variation in unit values across destinations for a given producer and good. To be conservative, we cluster errors by HS-8 product code; our findings are robust to other levels of clustering such as by firm or firm-product.

Table 8 establishes that firms methodically charge higher f.o.b. prices for the same HS-8 product in bigger, richer, more distant and less remote markets. These results cannot be attributed to firms exploiting market power, as they are robust to controlling for firms' country-product-specific market share (columns 3 and 4).[31] They are also highly statistically and economically significant. For example, raising market size from the first quartile to the third quartile of the distribution is associated with 2.3% higher bilateral export prices. The corresponding numbers for income, distance and remoteness are 4.3%, 0.9% and -1.1%, respectively.

Table 9 expands specification (6) to include the interactions of GDP, distance and remoteness with GDP per capita. This allows us to test whether the sensitivity of firms' prices to a market's size, proximity and centrality depends on the income level in that market. We will later interpret GDP per capita as an indicator of consumers' willingness to pay for quality.

We find that market size, distance and remoteness increase firm prices relatively more in richer countries. All three interaction terms enter positively and significantly at the 1%. Splitting the sample into homogenous and differentiated goods, we further observe that this result holds only for products with scope for quality upgrading (column 3). By contrast, there is no systematic variation in firms' export prices for the subsample of standardized items (column 2).

[31] Using market share as a proxy for market power may in fact be over-controlling in this context since firms likely have a higher market share when they offer a higher-quality product.

The coefficients on the main effects of GDP and distance change sign when we include their interactions with GDP per capita. The overall impact of size and proximity on firms' export prices is therefore positive whenever income is above a certain cut-off level, and negative otherwise. In the cross-section of 179 countries in the sample, the total effect of GDP (distance) is positive for the richest 107 (72) markets. However, in the full sample of firm-product-destination triplets, it is positive for fully 88% (82%) of all observations.[32] The sign of these estimated effects, though, says little about economic or statistical significance. We therefore re-ran the regression of export prices on GDP, income, distance and remoteness (without any interactions) for two subsamples: rich and poor destinations. We defined these groups either relative to the median GDP per capita in the data or relative to the income cut-off above which the overall effects of GDP and distance turn positive in Table 9. We found significant results for all four country characteristics in the rich subsample, but only for GDP per capita in the poor subsample. In none of the specifications did significant coefficients reverse sign relative to Table 8. We conclude that the effects of market characteristics on firms' export prices are concentrated in richer destinations.

4.5 Imported-input prices and export performance

The last set of stylized facts we uncover concern the relationship between firms' input purchases and export performance. In the absence of detailed figures on domestic input orders, we use data on producers' imported intermediates as an imperfect but informative signal of all their inputs. We examine three aspects of exporters' import activity: input prices, number of suppliers, and input price dispersion across source countries.

The detailed nature of our data allows us to distinguish between imported inputs used in the production of goods for the home and foreign markets. In particular, the Chinese customs records discriminate between "ordinary" trade and trade under the "processing-and-assembly" regime. We exploit information only on firms' imports in the latter category to ensure that we can correctly interpret them as inputs to the goods firms sell abroad.[33] Of the 96,522 exporting firms in our sample, 37,647 also import under processing and assembly. We observe all of their import values, quantities and hence unit prices by HS-8 product and country of origin. Below, we examine the correlation between import prices and export performance for this subset of firms.

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[32] This is because firms are substantially more likely to enter richer countries and there are many fewer observations for poorer destinations.

[33] All of our results hold if we instead use data on all imported inputs and not only those under the processing-and-assembly regime. We can then study 58,337 firms.

Many firms import and export multiple products, and we cannot match specific inputs to output categories. For this reason, we use four different firm-level measures of export performance that have been aggregated across export goods and destinations: total exports worldwide; number of countries to which the firm ships at least one product; the average export price across products and destinations; and the standard deviation of export prices across products and markets. For each firm, the average export price is the weighted average of all (log) firm-product-destination prices which have been demeaned by their HS-8 product-specific average, with export revenue shares as weights. The standard deviation of the (log) export price within a firm across goods and markets is also based on demeaned unit values.

We first study the relationship between imported-input prices and export activity with the following specification:

$$\log price_{fpo} = \alpha + \beta \cdot export\ performance_f + \delta_p + \varepsilon_{fpo}\ , \tag{7}$$

where $price_{fpo}$ is the price that firm f pays for import product p from origin country o, and $export\ performance_f$ is one of the four firm-level measures described above. At this level of disaggregation, the sample spans 724,790 observations. All regressions in this subsection cluster errors by firm, and are robust to alternative levels of clustering.

The product fixed effects δ_p in this estimation control for characteristics of each imported good that are common across firms, such as average value and quality, import restrictions, domestic distribution costs, the measurement unit for quantities, or the need for specialized labor or equipment to process the input. β is thus identified from the variation across exporting firms that import a given intermediate product. We are only interested in the sign of β as the sign of a conditional correlation, since we expect that unobserved firm characteristics determine both input choices and export performance.

We find that firms paying more for their imported inputs have consistently higher export prices, larger worldwide export revenues, and a bigger number of export destinations (Panel A of Table 10). Exporters that vary prices more across markets also tend to buy more expensive inputs on average. All of these results are highly statistically and economically significant. For example, a firm that exports twice as much typically uses inputs that are 10% more expensive, while a firm whose exports are twice as expensive pays 38% higher prices for its imported inputs.

We next examine the spread (standard deviation) of prices that firms are willing to incur for a given imported input:

$$sd_{fp}(\log price_{fpo}) = \alpha + \beta \cdot export\ performance_f + \delta_p + \varepsilon_{fp} \quad (8)$$

The unit of observation is now a firm-product pair, for 129,059 data points. The left-hand-side variable is the standard deviation of (log) import unit values across origin countries *o* within a firm *f* and import product *p*.

We systematically observe that firms paying a broader range of import prices for a given good export more to more markets at a higher average price (Panel B of Table 10). They also offer a broader menu of export prices across destinations. These results obtain even after controlling for product fixed effects which capture, among other things, the average amount of price dispersion and scope for quality differentiation in each imported input. Similar patterns emerge in Panel D, where we collapse the data to the firm level and study the total variation in import prices across all products and source countries within a firm.[34]

Since $sd_{fp}(\log price_{fpo})$ is only defined for firms which purchase a given input *p* from multiple countries of origin, in Panel C we also look directly at the (log) number of source countries from which producers import *p*. Consistently with the results above, firms that employ more suppliers offer a wider menu of export prices and ship more to more destinations at a higher average price.

4.6 Summary of stylized facts

We summarize the systematic patterns we have established with six stylized facts.

Stylized Fact 1: *Within each product, firms that charge higher export prices earn greater revenues in each destination, have bigger worldwide sales, and export to more markets. These patterns are more pronounced for products with greater scope for quality differentiation and for richer destinations.*

Stylized Fact 2: *Firms that export more, that sell to more destinations and that charge higher export prices use more expensive imported inputs.*

[34] In particular, we estimate $sd_f(\log price_{fpo}) = \alpha + \beta \cdot export\ performance_f + \varepsilon_f$ in the cross-section of firms. The left-hand-side variable is now the standard deviation of (log) import unit values across origin countries *o* and products *p* within a firm *f*, after these prices have been demeaned with their product-specific average.

Stylized Fact 3: *For a given product, a firm sets higher prices in larger, richer, more distant and less remote destinations. The effects of market size and proximity are stronger in richer markets and for products with greater scope for quality differentiation.*

Stylized Fact 4: *For a given product, a firm earns more revenues in markets where it sets higher prices. This pattern is more pronounced for products with greater scope for quality differentiation and for richer destinations.*

Stylized Fact 5: *Within each product, firms that export to more destinations offer a wider range of export prices. This pattern is more pronounced for products with greater scope for quality differentiation.*

Stylized Fact 6: *Firms that export more, that sell to more destinations and that offer a wider range of export prices pay a wider range of imported-input prices and source inputs from more origin countries.*

5 Robustness

5.1 Measurement error

A potential concern with the analysis is that export revenues or quantities may be measured with error. If there is classical measurement error (ME) in revenues, it would generate attenuation bias in the regressions of export prices on export sales (Tables 4, 5 and 7). Because unit values are the ratio of revenues to quantities, however, measurement error may also be non-classical and appear on both sides of these regressions. By contrast, such ME cannot affect any of the other specifications. In particular, it does not pose a challenge for the correlations between export prices and country characteristics (Tables 3, 8 and 9), between export prices and the number of destinations (Table 6), or between import and export activity (Table 10).

Non-classical measurement error in export prices may introduce either positive or negative bias in Tables 4, 5 and 7. To understand why the direction of the bias is ex-ante ambiguous, consider first ME in export quantities. If this error is uncorrelated with revenues, it would not affect the coefficient point estimates but potentially reduce precision. Downward bias would arise, though, if this ME is positively correlated with revenues, i.e. if quantities are systematically inflated in high-revenue transactions. Conversely, β would be overestimated if the opposite were true. Measurement error in revenues could similarly generate either positive or negative bias, depending on how it correlates with the true values of price and revenues.

The extensive set of fixed effects in the regressions help alleviate concerns with ME to a certain degree. The product fixed effects in all specifications ensure that the results are not driven by some goods being easier to monitor by customs officers. Firm-product fixed effects further control for the fact that some exporters may systematically misreport in certain goods. Similarly, destination-product fixed effects account for the possibility that all firms have more incentives to be truthful about exports of some products to certain markets, or that customs officials are more conscientious about given goods in some countries. ME would thus have to vary in very particular ways across firms, products and markets in order to explain our findings.

Exploiting the variation across products with varying scope for quality differentiation and across destinations with dissimilar income levels is also useful in dealing with potential measurement error. For example, the ME in quantity would not only have to be negatively correlated with revenue in general, but this correlation would have to be systematically stronger in richer markets and in differentiated, R&D- and advertising intensive goods, in order to explain the findings in Tables 4, 5 and 7. In other words, ME is more likely to affect the coefficients on the main effects rather than on the interaction terms in the regressions.

To address concerns with ME, we nevertheless perform a number of robustness checks and find that our results continue to hold at comparable levels of economic and statistical significance. Unless reported in the appendix, the results from these specifications are available upon request.

First, all results in Tables 3-10 obtain when outliers are removed from the sample. Following common practice in the literature, we identified outliers as firm-product-destination triplets with export value, quantity and/or unit price below the 1st percentile or above the 99th percentile of the respective distribution.[35] This is a conservative classification since observations are labeled as outliers even if only one of these three variables lies in the bottom or top percentile, while the other two do not. Such outliers likely reflect severe measurement error, and it is reassuring that they do not drive the results. Our findings also hold when we instead winsorize the data and set outliers equal to the value at the 1st (99th) percentile of the distribution if they were below (above) this cut-off point.

[35] Qualitatively and quantitatively the same patterns emerge whether we choose cut-off points in the full distribution in the sample or in product-specific distributions. When the analysis called for aggregation to the firm, firm-product, or product-destination level, we first excluded outliers at the firm-product-destination level before aggregating up.

Second, our results are based on annual data that have been aggregated from raw data at the monthly level. The stylized facts remain unchanged, however, when we instead estimate all specifications in Tables 3-10 at the monthly frequency, including month fixed effects. In fact, all coefficients are of comparable magnitudes but often become statistically more significant. It is ex ante unclear whether monthly data are more or less subject to measurement error than annual data, but it is encouraging that the same systematic patterns emerge at both frequencies.

Third, turning specifically to the potential for ME in Tables 4, 5 and 7, our results are robust to using the *ranking* of firms' export price and revenues instead of price and revenue *levels*. This approach allows us to rely much less directly on the construction of unit prices. For space considerations, Panel A of Appendix Table 2 reports the rank results only for Table 5; as Section 7 explains, this is the most important of the three tables in question. There is a strong positive correlation between firms' rank by price and rank by revenue across firms within a product-destination. It is moreover higher in goods with greater scope for quality differentiation and in richer markets. This sensitivity analysis suggests that our findings are not driven by ME bias, since such bias would have to be quite severe to distort firm rankings in a systematic way.

Fourth, the positive correlation between price and revenue across firms in a destination-product market (Table 5) holds when we change the outcome variable from firms' bilateral price by product and destination to firms' average export price by product (Panel B of Appendix Table 2). The latter is constructed as the ratio of firms' worldwide export sales and quantity, by product. Since this average price is not directly related to firms' bilateral revenues on the right-hand-side of the regression, this specification is less likely to be affected by non-classical measurement error bias. On the other hand, classical ME may still introduce attenuation bias. The fact that we continue to observe a significant positive coefficient and that it is higher in richer countries and in goods with greater scope for quality upgrading is thus further indication that our results are not driven by ME. This robustness check cannot be applied to Table 4 where the unit of observation is at the firm-product level already, or to Table 7 where we include firm-product pair fixed effects.

Finally, the patterns in Tables 4, 5 and 7 are equally well pronounced in a subsample of sectors which are less likely to suffer from measurement error: textiles and apparel. In these industries, China faced restrictive export quotas under the Multi-Fiber Agreement. While these quotas were relaxed on January 1, 2005, textile and apparel exports remained under scrutiny throughout 2005 (the year of our sample) as many importing countries were concerned about

China's rapid export growth. For this reason, firms and customs authorities arguably recorded trade flows in these industries with considerable precision. The robustness of our results in these sectors gives us further confidence in our conclusions.

5.2 Wholesalers vs. retailers

Our analysis has focused on the operations of firms that both make and trade goods since we are ultimately interested in how firms' production efficiency and product quality affect their export activities. However, since wholesalers and producers compete in the same destination-product markets, their export success should be governed by the same market conditions and underlying mechanisms (efficiency vs. quality sorting). In particular, their export prices should exhibit the same patterns across firms in a destination and across destinations within a firm.

In unreported regressions, we have confirmed that all of our results in Tables 3-9 indeed hold in the full sample of Chinese exporting firms that includes both manufacturers and wholesalers. The point estimates in these specifications are almost always qualitatively and quantitatively the same. The only notable exception is Panel A of Table 6, where many of the coefficients turn insignificant. As will become clearer, however, this table examines the theoretically ambiguous relationship between firms' average export price and number of export destinations, by product. Since we cannot interpret wholesalers' import transactions as input purchases, we are also not interested in the correlations in Table 10 for these firms.

5.3 Functional form for distance

Prior researchers have suggested that trade costs as proxied by bilateral distance may have a non-linear effect on trade flows and unit values (c.f. Baldwin and Harrigan 2007). In robustness checks, we have allowed the elasticity of export prices with respect to distance to vary non-linearly in Tables 3, 8 and 9. In particular, we grouped the 179 countries in our sample into 3 tertiles by distance from China. We then regressed (log) prices on (log) distance and the interactions of (log) distance with dummies for countries that are in the second and third (top) tertile in the distribution. In these specifications, the coefficient on distance captures the baseline elasticity of price to distance in the first tertile of the distribution, while the two interaction terms show whether this elasticity is significantly different for countries at higher tertiles.

The point estimates on the main effect of distance double when we allow for non-linearity in Table 8, but are less affected in Tables 3 and 9 (results available upon request). The interaction terms typically enter with the opposite sign, but are an order of magnitude smaller. This implies that, while the elasticity of export prices with respect to distance remains of the same sign at all distance levels, it is generally lower at higher distances.

6 Heterogeneous Firm Models in the Literature

This section briefly reviews different models in the literature that feature firm heterogeneity in production efficiency and product quality. The models we consider share the assumption that firms can be ranked according to a single exogenous attribute, productivity, which uniquely determines their export status, pricing, revenues and profits. All firms with productivity above a certain threshold level become exporters, and more productive firms perform better, though the underlying mechanism behind this pattern depends on the specifics of the model.

In the absence of quality differentiation across firms, all producers are assumed to use identical inputs to manufacture symmetric outputs, but more productive firms have lower marginal costs and charge lower prices. Models with quality heterogeneity re-interpret this framework and allow firms to choose the quality of their product by choosing the quality of their inputs. Since more productive firms optimally employ better-quality inputs which are more expensive, their marginal costs and prices may be higher. For expositional convenience, we will refer to these two interpretations of firm heterogeneity as efficiency and quality sorting, with the understanding that efficiency matters for export success with or without quality differentiation across firms.

To highlight the distinctions between efficiency and quality sorting, we focus on their implications for firms' export pricing behavior. We emphasize three sets of relationships: (1) the correlation between f.o.b. export prices and revenues across Chinese exporters in a given market; (2) the correlation between f.o.b. export prices and revenues across markets within a firm; and (3) the correlation between f.o.b. export prices and market characteristics across destinations within a firm. These relationships depend on the nature of firm heterogeneity and firm competition. Table 1 summarizes the predictions of alternative models, where each comparative static is *ceteris paribus*. For example, the results for distance apply holding GDP, GDP per capita and remoteness fixed.

We focus on four country characteristics in the models we consider: total expenditure, consumer income, bilateral iceberg trade costs and aggregate price index. Like other researchers, we think of GDP, GDP per capita, bilateral distance and overall economic remoteness as the empirical counterparts to these variables. GDP is an imperfect proxy for total spending in an economy, which in the models is equivalent to total output. Intuitively, bilateral shipping costs are increasing in bilateral distance. As for remoteness, a country which is relatively far from most other economies has high shipping costs, high c.i.f. (cost, insurance and freight inclusive) import prices, and thus a high aggregate price index.

While the models below characterize one-sector economies, their implications for export prices readily carry over to a multi-sector world.[36] We will thus be interested in the extent to which these models can explain the stylized facts we have documented for narrowly defined product categories. The models we discuss also focus on single-product firms. However, existing multi-product-firm models examine firms' optimal product scope and do not find that it affects pricing behavior at the firm-product level.[37] We can therefore relate the predictions of the models to our results for the variation in prices across countries within firm-product pairs and across firms within destination-product markets.

6.1 Efficiency sorting with CES demand

In the standard framework of efficiency sorting (Melitz 2003), firms draw a productivity level upon entering an industry, which fixes their marginal production cost. With CES demand and product differentiation, all firms optimally charge a constant mark-up above variable cost in every market. Thus, a firm's f.o.b. export price does not depend on the identity of its trade partner, and does not vary systematically with revenues, market size, income, distance or remoteness across the firm's destinations. Since more productive firms have lower marginal costs, however, they offer lower prices, sell higher quantities and earn larger revenues. The model thus predicts a negative correlation between f.o.b. export prices and export revenues across Chinese firms exporting a particular good in a given destination. This is the main characteristic of efficiency sorting models.

While firm-level f.o.b. prices do not differ across markets, the set of exporting firms does, and this has implications for the average export price at the product level. In the presence of fixed trade costs, only the most productive firms become exporters. The threshold productivity level for each export destination is pinned down by the marginal firm which makes zero profits there. Since export revenues increase with aggregate spending and the aggregate price index in an economy, the cut-off is lower for bigger and more remote markets. On the other hand, the productivity threshold rises with bilateral distance because selling to more distant countries entails higher

[36] For a multi-sector version of Melitz (2003), for example, see Bernard, Redding and Schott (2007).
[37] See, for example, Bernard, Redding and Schott (2009) and Mayer, Melitz and Ottaviano (2009).

transportation costs and lower profits.[38] Because less productive firms charge higher prices, the average export price across all Chinese firms selling in a given country-product market should therefore rise with destination size and remoteness, and fall with bilateral distance. Since CES preferences are homothetic, GDP per capita has no effect on firm selection into exporting nor on the average price across exporters, holding GDP, proximity and centrality constant.

6.2 Efficiency sorting with linear demand

Melitz and Ottaviano (2008) provide an alternative model of efficiency sorting which maintains product differentiation and monopolistic competition but assumes that firms face linear demand as in Ottaviano, Tabuchi and Thisse (2002). As in Melitz (2003), a productivity draw determines firms' marginal production cost. However, the price elasticity of residual demand is no longer exogenously fixed but depends on the toughness of competition in a market. A firm from a given export country (e.g. China) optimally charges lower mark-ups and hence lower f.o.b. prices for the same product in bigger and more distant destinations. This is because larger markets attract a greater number of competitors, while countries further away from China are serviced by relatively more productive Chinese firms that set lower prices. Both forces put downward pressure on the aggregate price index and incentivize Chinese exporters to reduce their mark-ups. On the other hand, the aggregate price index is higher in remote countries. Holding bilateral distance from China fixed, a Chinese exporter is thus predicted to price higher in remote markets.

Since more productive firms have lower production costs, they offer lower prices, sell higher quantities and earn larger revenues, even though they charge higher mark-ups. This efficiency-sorting model thus also delivers a negative correlation between f.o.b. export prices and sales across Chinese exporters in a given market. On the other hand, the correlation between export prices and revenues within a firm across destinations is theoretically ambiguous. This occurs because lower trade costs (distance) and larger market size both increase export sales but have opposite effects on mark-ups, and hence on f.o.b. prices.

With linear demand, demand for any product is zero above a given price and only firms above a certain productivity cut-off become exporters. This threshold is higher for bigger, more

[38] The comparative statics for market size hold even with free entry in general equilibrium. See Helpman, Melitz and Yeaple (2004), Helpman, Melitz and Rubinstein (2008), and Chaney (2008) for the case of exogenous wages, and Baldwin and Harrigan (2010) for the case of endogenous wages. The intuition is that larger countries attract more entry, but this bids up wages due to increased demand for labor. This dampens entry and results in higher firm-level revenues and a lower export threshold in bigger markets.

distant and less remote destinations where competition is tougher. Thus, tougher markets both attract relatively more productive firms that have lower marginal costs and force each exporter to set a lower mark-up. For these reasons, the average f.o.b. price among all Chinese firms selling to a given country falls with its GDP and bilateral distance, and rises with remoteness.

Since linear demand preferences are not homothetic, this model does not deliver clear predictions for the variation in export prices within a firm across countries at different income levels. The effect of GDP per capita on the average price across Chinese exporters is also theoretically ambiguous.

6.3 Quality sorting with CES demand

In order to explain new empirical facts, a number of recent papers have incorporated quality differentiation across firms in the Melitz (2003) framework, including Baldwin and Harrigan (2007), Johnson (2007), and Kugler and Verhoogen (2008). In these models, product quality enters the utility function through a quantity-augmenting term and all implications for quality-adjusted prices are as in Melitz (2003).

While the micro-foundations of firms' quality choice differ across papers, more successful firms always sell higher-quality goods. For example, Johnson (2007) suggests that quality upgrading entails a big fixed cost which only more productive firms can afford, while Verhoogen (2008) and Kugler and Verhoogen (2008) allow firms to choose the quality of their inputs. In view of our results, we consider the latter framework in greater detail.

Although more productive firms can process any given input more efficiently, they optimally choose to use more expensive, better-quality inputs to produce higher-quality goods. If quality increases in productivity sufficiently quickly, so will marginal costs and f.o.b. prices. In sharp contrast to efficiency sorting, quality sorting would then predict a positive correlation between f.o.b. export prices and revenues across firms selling in a given market. On the other hand, when the elasticity of marginal costs with respect to quality is not sufficiently high, all predictions of the quality-augmented model will be identical to those of Melitz (2003). In Table 1 and below, we summarize the former case, because only then can the models be distinguished.

With CES demand, firms optimally sell at a constant mark-up above marginal cost in all markets. Thus, each firm's f.o.b. prices are uncorrelated with export revenues and market characteristics across destinations. Aggregate, product-level prices do, however, vary systematically with country variables that influence firm selection into exporting. With fixed trade costs, only firms above a certain productivity (quality) cut-off become exporters. Since this cut-off is lower for bigger, more proximate and more isolated countries, the average f.o.b. export price across Chinese exporters falls with market size and remoteness and rises with bilateral distance. This prediction is the exact opposite of that for efficiency sorting and CES demand. On the other hand, in this framework, too, GDP per capita has no effect on firm selection into exporting nor on the average price across exporters because CES preferences are homothetic.

6.4 Quality sorting with linear demand

Most recently, Kneller and Yu (2008) propose a heterogeneous-firm model that embeds quality differentiation in the Melitz-Ottaviano (2008) framework with linear demand. In this model, too, product quality enters the utility function through a quantity-augmenting term.

Kneller and Yu (2008) do not explicitly model quality choice, but instead directly assume that firms with higher marginal costs produce higher quality.[39] Better-quality firms set higher prices not only because of their larger variable costs, but also because they can charge a bigger mark-up. If quality rises sufficiently quickly with marginal costs, higher-quality firms will capture a larger market share. This will generate the classic quality-sorting prediction of a positive correlation between f.o.b. prices and revenues across firms in a given destination. Otherwise, the results of this quality-augmented model will be identical to those in Melitz and Ottaviano (2008).

With linear demand, the price elasticity of residual demand depends on the toughness of competition in a market. A firm therefore optimally charges lower mark-ups and lower f.o.b. prices for the same product in bigger, more distant and less remote countries. Because export revenues increase with market size but fall with distance, however, unit values may be either positively or negatively correlated with sales within a firm across destinations.

The predictions of this model for the average price across Chinese exporters to a given market are also ambiguous. On the one hand, tougher markets attract firms above a relatively higher quality cut-off that charge higher prices. On the other hand, tougher markets incentivize firms to reduce their mark-up. The overall effect of country size, distance and remoteness on product-level f.o.b. export prices can thus be either positive or negative. Because linear demand preferences are not homothetic, the predicted impact of destinations' income on export prices at the firm level, as well as on the average price across Chinese exporters, is also ambiguous.

[39] Antoniades (2008) explicitly models firms' quality choice under linear demand. The current draft, however, does not solve for export prices in a multi-country equilibrium. See also Auer and Sauré (2009).

7 Interpreting the stylized facts

We next interpret the stylized facts we have established in the context of the heterogeneous-firm models described above. We carefully examine in what ways the models are consistent or inconsistent with our findings, and conclude that none of the existing theoretical frameworks can match all empirical results. We suggest that a successful model should incorporate quality differentiation across firms, as well as across destinations within firms, in order to rationalize the systematic patterns in the data.

7.1 Efficiency vs. quality sorting: variation across firms

The evidence we find for the variation in export and import activity across firms lends strong support to models that feature quality sorting. In particular, stylized fact 1 states that firms charging higher export prices earn greater revenues in any given destination, have bigger worldwide sales, and export to more markets. These relationships hold within narrowly-defined product categories. Stylized fact 2 further establishes that firms that export more, that sell to more destinations and that charge higher export prices import more expensive inputs.

These patterns are consistent with the idea that firms that use higher-quality inputs, as proxied by higher input prices, are able to produce more expensive, higher-quality products and thereby enjoy superior export performance.[40,41] Quality sorting can thus account for the positive correlation between export prices and revenues across firms within destination-product markets. Conversely, were this correlation negative, it would have indicated that efficiency sorting better characterized the nature of firm heterogeneity.

While not tabulated in Table 1, the results for firms' worldwide sales and number of export destinations provide further support for quality sorting. Heterogeneous-firm models predict that more productive firms not only have bigger revenues in any given country, but also enter more markets because they are above the exporting cut-off for more destinations. As a result, more productive firms also earn larger revenues from their exports worldwide. Quality sorting thus

[40] Exporters that use imported inputs have bigger sales, more export destinations, and higher f.o.b. prices than exporters who do not. This suggests that imported inputs may be of higher quality than local inputs, and that more productive firms are able to incur the costs of sourcing inputs from abroad. See also Kugler and Vehoogen (2009).

[41] We have also explored the possibility that firms improve output quality by buying bigger input quantities per unit of output. The evidence is mixed. While this quantity ratio is positively correlated with firms' average export price, it is negatively correlated with firms' export revenues and number of destinations. Input quantity is more positively correlated with sales and number of trade partners when the input is a raw material instead of a manufactured input, but the opposite is true for the correlation with firms' average export price.

implies that, across firms selling a given product, firms' export price should be positively correlated with firms' worldwide sales and number of trade partners. This is indeed what we find in the data. On the other hand, these correlations would have been negative with efficiency sorting.

The evidence based on firms' imported inputs and number of export destinations is crucial for establishing the quality story. This is because we have considered a prominent, yet specific class of models, and frameworks with other market structures may deliver a positive correlation between prices and sales across firms in a market even in the absence of quality differentiation. Alternatively, in some environments the correlation may be negative even when firms do in fact differ in product quality. This may be the case, for example, in the market for luxury goods or over some range of the quality spectrum.[42] Finally, our robustness checks notwithstanding, concerns with measurement error in export unit values may affect the estimated sign of this correlation. Different market structures, however, cannot rationalize the relationships of export performance with input prices and with trade partner intensity. These relationships are also not subject to the same ME bias, because the data on input values are unrelated to that on export activity, and the number of export markets is unrelated to export values.

Our results do not imply that efficiency is unimportant for firms' export success. If more productive firms choose to use higher-quality inputs, export prices may be either increasing or decreasing in firms' efficiency draw, depending on the elasticity of the marginal production cost with respect to quality. When this elasticity is sufficiently low, export prices may be negatively correlated with export revenues and number of destinations even in the presence of quality differentiation across firms. Thus, finding $\beta > 0$ is consistent with quality variation across firms, whereas $\beta < 0$ could mean either that all firms produce symmetric outputs, or that firms offer products of different quality levels but efficiency sorting prevails.

In light of this, the systematic variation we document across products with varying scope for quality differentiation and across countries with different income levels further corroborates the quality interpretation. While stylized fact 1 holds for all products, it applies to a greater degree to differentiated goods and sectors intensive in R&D and advertising − precisely the cases where

[42] Price and revenue may be more positively correlated across firms at the lower end of the quality spectrum and less positively or even negatively correlated at the high end. If so, the patterns we document may hold because Chinese producers differ in product quality but nevertheless remain at the bottom of the worldwide quality distribution.

we expect the elasticity of quality with respect to marginal cost to be high.[43,44] We also expect firms to have a bigger incentive to invest in quality when serving richer consumers with a higher willingness to pay for quality. We discuss this point in more detail below.

7.2 Variable mark-ups vs. variable quality: variation across destinations

While the variation across firms in the data is consistent with existing models of quality sorting, the variation across destinations within a firm cannot be reconciled with any of the heterogeneous-firm models we have examined.

Recall that when firms face CES demand, they charge a constant mark-up above marginal cost and offer all trade partners the same free-on-board price. With linear demand, on the other hand, firms optimally adjust their mark-up to the destination market. In particular, exporters set lower mark-ups and hence lower f.o.b. prices in countries that are bigger, more distant and less remote where market competition is tougher.

These theoretical predictions are, however, in sharp contrast with stylized fact 3: that a firm charges systematically higher prices for the same product in larger, richer, more distant and less isolated economies. Moreover, the effects of market size and proximity are stronger in richer markets and for products with greater scope for quality differentiation.

How can these empirical patterns be rationalized? The models we have discussed assume that each firm exports an identical product to all of its trade partners. If so, the firm-product pair fixed effects in our regressions would capture the marginal cost and quality characteristics of the firm's good. Any residual variation in f.o.b. prices across destinations would then have to be due to variable mark-ups. Extant models, however, predict either no systematic variation in f.o.b. prices across markets (CES demand) or a pattern exactly opposite to that in the data (linear demand).

What can explain our results is that firms adjust not only mark-ups, but also the quality of their products to the destination market. We further propose that firms do so by varying the quality of their inputs. In particular, firms may respond to market competition in two ways that are not mutually exclusive: by lowering mark-ups (for a given quality level) and by increasing product quality (for a given mark-up). Both of these modifications would reduce the quality-adjusted price

[43] The positive correlation between export prices and revenues holds for all products, but is more positive for goods with greater scope for quality differentiation. The positive correlation between firms' average export price and number of destinations is, on the other hand, driven entirely by products with potential for quality upgrading.

[44] While the Rauch classification does not distinguish between horizontal and vertical differentiation, R&D and advertising intensity proxy the latter. The robustness of our results across these three measures, as well as the findings for firms' imported inputs, suggest that the variation identified by the Rauch dummy in our data is of a quality nature.

for their product, thereby making them more competitive and their good more appealing to consumers. Importantly, if quality upgrading requires more expensive, higher-quality inputs, it would raise marginal costs. When this effect is sufficiently strong, it can dominate the mark-up adjustment. We would then observe firms charging higher export prices in bigger, more distant and less remote destinations where market competition is tougher.

If this explanation is correct, our results capture the net effect of quality and mark-up adjustments on firm prices. Our estimates thus provide a lower bound for the response of product quality to characteristics of the destination market. On the other hand, our analysis offers no direct evidence of variable mark-ups as we cannot separately identify firms' modifications to mark-ups and product quality across importing countries.

The positive correlation between f.o.b. prices and destinations' GDP per capita can also be attributed to quality differentiation across markets within a firm. Exporters may offer higher-quality versions of their product and/or charge a higher mark-up for it in richer countries because wealthier consumers have a lower marginal utility of income and a greater willingness to pay for quality.[45] This is consistent with the theoretical predictions Verhoogen (2008), Fajgelbaum, Grossman and Helpman (2009) and Simonovska (2010) derive using non-homothetic preferences. It can also explain why the effects of market size and proximity are magnified in richer countries, especially for differentiated products: In response to market toughness, firms have a greater incentive to upgrade quality when prospective consumers are willing to pay more for it.

To illustrate these mechanisms, consider a Chinese shoe maker. This manufacturer may choose cheap man-made upper and low-quality soles to produce a cheap pair of shoes for export to Malaysia. He could then use high-quality leather upper and expensive waterproof soles to make shoes for the German or American market. This may be optimal because Malaysia is a poor country where consumers have little taste for quality and the market is not very tough because it is relatively small and close to China but otherwise quite remote. By contrast, American and German consumers are richer and have lower marginal utilities of income. The shoe maker also faces more competition in those big, distant and more central markets, but can increase profits by improving

[45] Firms may offer more quality versions of a product in countries with greater income inequality in order to cater to different consumer segments of the market. We can measure this imperfectly with (i) the standard deviation of export prices across months within a firm, product and destination triplet; and with (ii) the standard deviation of export prices across months and firms within a product-destination pair. While both are negatively correlated with countries' Gini coefficient on average, the correlation is indeed more positive for products with greater scope for quality upgrading.

quality and charging a higher price. Moreover, he need not incur fixed costs for each quality line, but could simply use different inputs and the same assembly technology.

This quality interpretation is consistent with the other empirical patterns we document. According to stylized fact 5, firms entering more markets offer a broader menu of export prices. While this pattern is evidence against constant mark-ups, it could emerge either if firms vary quality across destinations or if firms offer identical quality, at the same marginal cost worldwide, but adjust mark-ups across importers. However, the relationship is more pronounced for products with greater potential for quality upgrading. This speaks to quality discrimination across countries.

Stylized fact 6 can in turn be viewed as indirect evidence that firms use inputs of varying quality to manufacture multiple quality versions of their output product. In particular, firms that export more, that sell to more destinations, and that offer a broader menu of export prices pay a wider range of imported-input prices and buy inputs from more origin countries. In the absence of detailed information on firms' domestic input purchases, this evidence is an imperfect signal of the quality range of all their inputs.

Finally, the positive correlation between f.o.b. prices and revenue across markets within a firm-product pair is also consistent with firms varying quality across importing countries (stylized fact 4). Two factors can generate this pattern. First, firms offer higher quality versions of a product in bigger markets, where revenues are higher. On the other hand, firms also sell higher quality versions of a product in more distant markets, where f.o.b. sales are lower. If the sensitivity of product quality with respect to market size is sufficiently high, the former effect would dominate. Second, if firms both increase quality and lower mark-ups in tougher markets, their quality-adjusted price may fall. Since consumers respond both to a product's quality and to its quality-adjusted price, this may increase firm revenues precisely in markets where export prices are high.

While market size, bilateral distance and centrality are positively correlated with the toughness of competition in the linear-demand models we have considered, they need not be more generally. We therefore emphasize that the stylized facts are consistent with firms varying product quality in response to these destination characteristics without arguing that market toughness is necessarily the driving force behind these adjustments. Instead, we view it as one possible explanation for the systematic patterns we find, and leave it to future theoretical and empirical work to conclusively establish the underlying mechanism.

One alternative rationalization for why firms offer higher-quality versions of their products in bigger markets is that there are economies of scale in the production or delivery of higher-quality goods. On the production side, upgrading product quality may entail fixed investments in specialized equipment or hiring more skilled workers. On the delivery side, the fixed costs of marketing and distribution may be increasing in product quality. For example, goods of superior quality may require more sophisticated packaging, costlier transportation, or better-trained local sales managers. As long as firms expect to earn higher revenues in larger markets and the destination-specific fixed costs of exporting increase with product quality, firms will have an incentive to improve the quality of goods shipped to bigger countries.

Firms may also export products of higher quality to more distant countries for reasons other than market toughness. For example, exporters may face per-unit transportation costs instead of the iceberg shipping costs assumed in the models we have discussed. Per-unit costs lower the relative price of and rise relative demand for higher-quality goods.[46] If firms produce and export multiple quality versions of an HS-8 product to each market, per unit export costs would lead them to vary the quality mix across destinations. In particular, firms would have an incentive to sell relatively more of their expensive, better-quality varieties to more distant countries. This argument builds on the Alchian and Allen (1964) model, which assumes that each firm sells an identical product to all markets. That framework predicts that high-quality firms will export relatively more to distant countries. This will in turn result in higher aggregate f.o.b. prices at the product level (i.e. averaged across firms) in distant markets, as confirmed by Hummels and Skiba (2004). In our data (Table 3), this is also born out for rich countries, but we actually find the opposite pattern in the full sample and in the sample of countries below the median GDP per capita.

Finally, we briefly discuss two peripheral results which we do not emphasize among the main six stylized facts that are nevertheless informative. Table 10 shows that exporters that vary prices more across markets also tend to import more expensive inputs on average (Column 4 of Panel A). In addition, firms charging a higher average export price pay a wider range of import prices and source inputs from more markets (Column 3 in Panels B, C and D). This suggests that successful exporters both offer higher quality products on average and are better at varying product quality across markets.

[46] This phenomenon has been termed "shipping the good apples out" to suggest that demand for better apples is higher in export markets than domestically because of the associated higher transportation cost.

To summarize, we conclude that theory will have to incorporate two sources of heterogeneity in order to be consistent with the stylized facts in the data: quality differentiation across firms and across destinations within a firm. Moreover, exporters vary product quality across markets by using inputs of different quality levels. A successful framework will likely inherit some of the properties of existing heterogeneous-firm models with quality sorting, but be able to rationalize why firms export products of higher quality to bigger, richer, more distant and less remote markets. We surmise that more productive firms will be found to more efficiently upgrade quality and thereby successfully enter more competitive markets and cater to richer consumers. More efficient firms will thus have higher bilateral and worldwide export revenues, more trade partners, and greater quality dispersion across destinations. In addition, they will on average import more expensive, higher-quality inputs and export products of higher quality at higher prices.

We are aware of only one paper in the literature that allows firms to vary product quality across markets by varying the quality of their inputs. Verhoogen (2008) studies non-homothetic (logit) preferences and heterogeneous firms that choose two quality levels, one for domestic production and one for exports abroad. The assumption behind this result is that foreign consumers exhibit a greater taste for quality because they are richer and have a lower marginal utility of income. This approach cannot, however, explain why firms adjust product quality in response to markets' size, bilateral distance and overall remoteness. These are the dimensions that future theoretical work should pursue.

7.3 Alternative explanations

Since we do not observe product quality directly, we cannot definitively establish our quality interpretation. We can, however, consider other potential explanations and examine how well they can account for the stylized facts in the data. This section discusses three such alternatives. While each of them can match some of the results, they are inconsistent with other patterns in the data.

7.3.1 Efficiency sorting with per unit transportation costs

With CES preferences and per-unit transportation costs, it is optimal for firms to charge higher mark-ups in more distant countries, even in the absence of quality differentiation across firms (Martin 2009). This is consistent with firms setting lower f.o.b. export prices for the same product in closer destinations, and suggests that quality sorting is not necessary to explain this result.

This model of spatial price discrimination, however, is contradicted by our other findings which require quality differentiation across firms. In particular, it cannot generate a positive correlation between export prices and revenues across firms in a given market or rationalize the systematic patterns we find for firms' imported input prices.

7.3.2 Firm-specific demand shocks

We interpret the positive correlation between price and revenues across firms in a market as indicative of quality differentiation across firms, and the positive correlation between price and revenues across destinations within a firm as consistent with firms varying product quality across markets. Both patterns, however, could be induced by firm-product-destination specific demand shocks under certain demand conditions.

Such shocks cannot, however, explain why firms regularly charge higher prices in bigger, richer, more distant and less remote markets, unless these shocks also vary systematically across countries. This demand-based explanation can also not account for the relationships we find between import price levels, import price dispersion, export prices and export performance. Finally, it is not obvious why the positive correlation between price and revenue should be more pronounced for goods with greater scope for quality differentiation.

7.3.3 Firm-specific demand shocks and market power in input markets

The last alternative we consider combines firm-product-destination specific demand shocks with market power in input markets. As above, the former can generate a positive correlation between price and revenues across firms within a market, as well as across destinations within a firm. The latter, on the other hand, can produce some but not all of our results for import prices.

If exporters have monopsony power in input markets, a positive demand shock can increase their demand for inputs and induce a positive correlation between import and export prices and between import prices and export revenues. Similar patterns can emerge if input suppliers have market power, since then a positive demand shock could reduce exporters' elasticity of input demand, and input suppliers would be able to extract a higher price.

This explanation cannot, however, account for a number of other stylized facts. It remains silent about firms charging higher prices in larger, richer, more distant and less remote markets. It also does not explain why the correlation between price and revenues increases with goods' scope for quality differentiation and with destination income. Finally, it cannot rationalize the relationship between firms' range of import prices, range of export prices and export performance.

8 Conclusion

This paper examines the variation in export and import prices across firms, products and trade partners to shed light on the determinants of firms' export success. We establish six new stylized facts using rich data on the universe of Chinese trading firms. These stylized facts have two main implications. First, more successful exporters use higher-quality inputs to produce higher-quality goods. Second, firms vary the quality of their products across destinations with different market size, income, bilateral distance and overall remoteness by using inputs of different quality levels. We conclude that international trade models should incorporate both of these features in order to rationalize the systematic patterns in the data. While we discuss alternative explanations for the effects of country characteristics on firms' quality choice, we remain agnostic about the underlying mechanism driving this decision. Our findings thus point to previously unexplored dimensions of firm heterogeneity and adjustments on the quality margin within firms across destinations that future theoretical and empirical work should pursue.

Understanding the nature of firm heterogeneity is important because of its implications for aggregate trade patterns and growth. Our results raise the possibility that, in addition to modifying trade volumes, product scope and export destinations, firms might also vary product quality within and across markets in response to trade liberalization. A fruitful area for future research is the implications of this new margin of adjustment for the effects of globalization on aggregate welfare and inequality.

References

Alchian, A. and W. Allen (1964). *University Economics*. Wadsworth Publishing Company.

Anh, J., Khandelwal, A. and S.-J. Wei (2010). " The Role of Intermediaries in Facilitating Trade." NBER Working Paper 15706.

Antoniades, A. (2008). "Heterogeneous Firms, Quality, and Trade." *Columbia University mimeo.*

Arkolakis, K., Costinot, A. and A. Rodriguez-Clare (2009). "New Trade Models, Same Old Gains?" NBER Working Paper 15628.

Auer, R. and P. Sauré (2009). "Spatial Competition in Quality." *Swiss National Bank mimeo*.

Aw, B., Chung, S., and M. Roberts (2000). "Productivity and Turnover in the Export Market: Micro-level Evidence from the Republic of Korea and Taiwan (China)." *World Bank Economic Review* 14 (1), p.65-90.

Baldwin, R. & J. Harrigan (2007). "Zeros, Quality and Space: Trade Theory and Trade Evidence," *American Economic Journal: Microeconomics* (forthcoming).

Bastos, P. and J. Silva (2010). "The Quality of a Firm's Exports: Where You Export to Matters." *Journal of International Economics* 82 (2), p.99-111.

Bernard, A., Eaton, J., Jensen, J. and S. Kortum (2003). "Plants and Productivity in International Trade." *American Economic Review* 93 (4), p. 1268-1290.

Bernard, A. and J. Jensen (1995). "Exporters, Jobs, and Wages in U.S. Manufacturing, 1976-1987." Brookings Papers on Economic Activity, Microeconomics.

Bernard, A., Jensen, J., Redding, S. and P. Schott (2007). "Firms in International Trade." *Journal of Economic Perspectives* 21(3), p. 105-130.

Bernard, A., Jensen, J. and P. Schott (2006). "Trade Costs, Firms and Productivity." *Journal of Monetary Economics* 53(5), p.917-37.

Bernard, A., Jensen, J. and P. Schott (2009). "Importers, Exporters, and Multinationals: A Portrait of Firms in the U.S. that Trade Goods," in T. Dunne, J.B. Jensen, and M.J. Roberts, eds., *Producer Dynamics: New Evidence from Micro Data*, University of Chicago Press.

Bernard, A., Redding, S. and P. Schott (2007). "Comparative Advantage and Heterogeneous Firms." *Review of Economic Studies* 74, p.31-66.

Bernard, A., Redding, S. and P. Schott (2009). "Multi-Product Firms and Trade Liberalization." NBER Working Paper 12782.

Brambilla, I., Lederman, D. And G. Porto (2009). "The Quality of Trade: Exports, Export Destinations, and Wages." *Yale University mimeo*.

Burstein, A. and N. Jaimovich (2009). "Understanding Movements in Aggregate and Product-Level Real-Exchange Rates." *Duke University mimeo.*

Chaney, T. (2008). "Distorted Gravity: The Intensive and Extensive Margins of International Trade." *American Economic Review* 98 (4), p.1707-21.

Clerides, S., Lach, S. and J. Tybout (1998). "Is Learning by Exporting Important? Micro-dynamic Evidence from Colombia, Mexico, and Morocco." *Quarterly Journal of Economics* 113 (3), p.903-47.

Crozet, M., Head, K. and T. Mayer (2009). "Quality Sorting and Trade: Firm-level Evidence for French Wine." *University of British Columbia mimeo*.

Eaton, J., Kortum, S. and F. Kramarz (2004). "Dissecting Trade: Firms, Industries, and Export Destinations." *American Economic Review Papers and Proceedings* 94(2), p.150-54.

Eaton, J., Kortum, S. and F. Kramarz (2008). "An Anatomy of International Trade: Evidence from French Firms." NBER Working Paper 14610.

Fajgelbaum, P., Grossman, G. and E. Helpman (2009). "Income Distribution, Product Quality and International Trade." NBER Working Paper 15329.

Fernandes, A. and C. Paunov (2009). "Does Tougher Import Competition Foster Product Quality Upgrading?" World Bank Policy Research Working Paper 4894.

Fitzgerald, D. and S. Heller (2010). "Pricing-to-Market: Evidence from Producer Prices." *Stanford University mimeo.*

Gervais, A. (2009). "Product Quality and Firm Heterogeneity in International Trade." *University of Maryland mimeo.*

Gopinath, G., Itskhoki, O. and R. Rigobon (2008). *American Economic Review (forthcoming).*

Hallak, J.-C. (2006). "Product Quality and the Direction of Trade." *Journal of International Economics* 68(1), p.238-65.

Hallak, J.-C. and P. Schott (2008). "Estimating Cross-Country Differences in Product Quality." NBER Working Paper 13807.

Hallak, J.-C. and J. Sivadasan (2008). "Productivity, Quality and Exporting Behavior under Minimum Quality Requirements." *University of San Andres mimeo*.

Hummels, D. and P. Klenow (2005). "The Variety and Quality of a Nation's Exports." *American Economic Review* 95(3), p. 704-723.

Hummels, D. and A. Skiba (2004). "Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conujecture." *Journal of Political Economy* 112, p.1384-1402.

Johnson, R. (2007). "Trade and Prices with Heterogeneous Firms." *Dartmouth mimeo*.

Khandelwal, A. (2008). "The Long and Short (of) Quality Ladders." *Review of Economic Studies (forthcoming)*.

Kneller and Yu (2008). "Quality Selection, Chinese Exports and Theories of Heterogeneous Firm Trade." *University of Nottingham mimeo.*

Kugler, M. and E. Verhoogen (2008). "Prices, Plant Size, and Product Quality." *Review of Economic Studies (forthcoming)*.

Kugler, M. and E. Verhoogen (2009). "Plants and Imported Inputs: New Facts and an Interpretation." *American Economic Review Papers and Proceedings* 99(2), p. 501-507.

Mandel, B. (2008). "Heterogeneous Firms and Import Quality: Evidence from Transaction-Level Prices." *University of California at Davis mimeo*.

Manova, K. and Z. Zhang (2008). "China's Exporters and Importers: Firms, Products, and Trade Partners." NBER Working Paper 15249.

Martin, J. (2009). "Spatial Price Discrimination in International Markets." *CREST-INSEE mimeo.*

Mayer, T., Melitz, M. and G. Ottaviano (2009). "Market size, Competition, and the Product Mix of Exporters." *Harvard University mimeo*.

Melitz, M. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71(6), p.1695-725.

Melitz, M. and G. Ottaviano (2008). "Market Size, Trade, and Productivity." *Review of Economic Studies* 75 (1), p. 295-316.

Nguyen, D. (2009). "Does Quality or Cost Matter More for Exporting?" *University of Copenhagen mimeo.*

Ottaviano, G., Tabuchi, T. and J. Thisse (2002). "Agglomeration and Trade Revisited." *International Economic Review* 43(2), p. 409-436.

Pavcnik, N. (2002). "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants." *The Review of Economic Studies* 69, p.245-76.

Rauch, J. (1999). "Networks Versus Markets in International Trade." *Journal of International Economics* 48, p.7-35.

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

Simonovska, I. (2010). "Income Differences and Prices of Tradables." NBER Working Paper 16233.

Sutton, J. (2007). "Quality, Trade and the Moving Window: The Globalization Process." *Economic Journal* 117, p. 469-498.

Verhoogen, E. (2008). "Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector." *Quarterly Journal of Economics* 123 (2), p. 489-530.

Table 1. Firm Heterogeneity in Efficiency and Quality

This table summarizes the predicted behavior of export prices when export success is driven by efficiency or quality heterogeneity across firms. Each cell reports the predicted sign of the correlation between firm or average (product-level) free on board prices with export revenues, export quantities, market size, income, distance or remoteness *ceteris paribus* . The column headings indicate whether this correlation is across firms in a destination or across destinations within a firm. The bottom row shows the patterns that obtain in the data.

	Firm Price								Avg Price			
	Across firms in a destination		Across destinations within a firm						Across destinations			
Nature of Firm Heterogeneity	Export Revenue	Export Quantity	Export Revenue	Export Quantity	GDP	GDP per Capita	Distance	Remoteness	GDP	GDP per Capita	Distance	Remoteness
Efficiency sorting, CES demand	-	-	0	0	0	0	0	0	+	0	-	+
Efficiency sorting, linear demand	-	-	+/-	-	-	+/-	-	+	-	+/-	-	+
Quality sorting, CES demand	+	-	0	0	0	0	0	0	-	0	+	-
Quality sorting, linear demand	+	-	+/-	-	-	+/-	-	+	+/-	+/-	+/-	+/-
Data	+	-	+	-	+	+	+	-	-	+	+/-	-

Table 2. The Variation in Export Prices across Firms, Products and Destinations

This table summarizes the variation in free-on-board export prices across 96,522 Chinese firms, 6,908 products, and 231 importing countries in 2005. Line 1: summary statistics for firm-product-destination log prices, after taking out HS-8 product fixed effects. Line 2: for each HS-8 product, we take the standard deviation of log prices across firms and destinations. Line 2 shows how this standard deviation varies across the 6,591 HS-8 products traded by at least two firm-destination pairs. Line 3: for each firm that exports a given product to multiple countries, we record the standard deviation of log prices across destinations, by product. Line 3 shows how this standard deviation varies across firm-product pairs. Line 4: for each destination-product market with multiple Chinese exporters, we record the standard deviation of log prices across firms. Line 4 shows how this standard deviation varies across destination-product pairs.

	# Obs	Average	St Dev	Min	5th Percentile	95th Percentile	Max
Variation in (log) prices across firms and destinations within HS-8 products							
1. firm-product-destination prices (product F.E.)	2,179,923	0.00	1.24	-12.12	-1.93	2.02	13.65
2. st dev of prices across firms and destinations within products (product F.E.)	6,591	1.11	0.65	0.00	0.26	2.33	5.92
Variation in (log) prices across destinations within firm-HS-8 product pairs							
3. st dev of prices across destinations within firm-product pairs (firm-product pair F.E.)	303,935	0.46	0.49	0.00	0.01	1.39	9.14
Variation in (log) prices across firms within destination-HS-8 product pairs							
4. st dev of prices across firms within destination-product pairs (destination-product pair F.E.)	159,778	0.90	0.74	0.00	0.08	2.30	8.36

Table 3. Product-Level Average Export Prices and Destination Characteristics

This table examines the effect of destination market size, income, distance and remoteness on average export prices. The outcome variable is the (log) average free-on-board export price across all successful Chinese exporters in a given destination and HS-8 product. Columns 1-2 present results for the full sample of 179 countries, while Columns 3-4 (Columns 5-6) show estimates from separate regressions for countries with GDP per capita above (below) the sample median. All regressions include a constant term and HS-8 product fixed effects, and cluster errors by HS-8 product. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Dependent variable: (log) average f.o.b. export price, by HS-8 product and destination

	All Destinations		Rich Destinations		Poor Destinations	
	(1)	(2)	(3)	(4)	(5)	(6)
(log) GDP	-0.002	-0.005	0.000	-0.003	-0.025	-0.025
	(-0.94)	(-2.02)**	(0.16)	(-1.10)	(-6.45)***	(-6.40)***
(log) GDP per capita	0.027	0.019	0.065	0.053	-0.002	-0.006
	(9.22)***	(6.60)***	(14.59)***	(12.07)***	(-0.25)	(-0.76)
(log) Distance	-0.024	-0.027	0.026	0.021	-0.106	-0.108
	(-4.82)***	(-5.62)***	(4.78)***	(3.91)***	(-11.60)***	(-11.79)***
(log) Remoteness		-0.148		-0.134		-0.106
		(-15.48)***		(-13.60)***		(-4.39)***
Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.853	0.854	0.855	0.855	0.876	0.876
# observations	242,403	242,403	161,835	161,835	80,568	80,568
# product clusters	6,879	6,879	6,773	6,773	5,860	5,860
# destinations	179	179	89	89	90	90

Table 4. Firms' Export Prices and Worldwide Export Revenues

This table examines the relationship between firms' export prices and worldwide export revenues, and how it varies across products with different scope for quality differentiation. It exploits the variation across firms within products, by including HS-8 product fixed effects. The outcome variable is the (log) average free on board export price by firm and HS-8 product, constructed as the ratio of worldwide revenues and quantities exported by firm and product. The scope for quality differentiation is proxied by (1) a dummy variable equal to 1 for differentiated products as classified by Rauch (1999), Column 3; (2) R&D intensity by 3-digit ISIC sector from Klingebiel, Kroszner and Laeven (2007), Column 4; a dummy variable equal to 1 for R&D intensity above the median, Column 5; or (3) the combined advertising and R&D intensity by 3-digit ISIC sector from Kugler and Verhoogen (2008), Column 6. In Column 7, the average price and worldwide revenues are computed separately for countries above and below the median income in the sample, and the regression includes a dummy for rich destinations and its interaction with revenues. All regressions include a constant term and cluster errors by firm. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Dependent variable: (log) average f.o.b. export price, by firm and HS-8 product

	Variation Across Firms Within Products						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(log) Revenue	0.094 (49.25)***		0.040 (14.15)***	0.097 (48.26)***	0.091 (47.14)***	0.085 (41.31)***	0.067 (24.07)***
(log) Quantity		-0.165 (-103.75)***					
(log) Revenue x Different. Good			0.065 (22.83)***				
(log) Revenue x R&D Intensity				-0.079 (-1.73)*			
(log) Revenue x High R&D Intensity					0.008 (4.67)***		
(log) Revenue x Adv.+R&D Intensity						0.362 (8.23)***	
(log) Revenue x Rich destinations							0.031 (11.37)***
Product FE	Y	Y	Y	Y	Y	Y	Y
R-squared	0.644	0.671	0.642	0.637	0.637	0.637	0.649
# observations	898,247	898,247	619,357	871,596	871,596	875,097	974,033
# products	6,908	6,908	4,276	6,182	6,182	6,252	6,879
# firm clusters	96,522	96,522	84,464	93,514	93,514	94,005	94,664

Table 5. Variation in Export Prices Across Firms in A Destination

This table examines the relationship between firms' export prices and revenues, and how it varies across products with different scope for quality differentiation. It exploits the variation across firms within a destination-product market by including country-HS-8 product pair fixed effects. The outcome variable is the (log) free-on-board export price by firm, destination and HS-8 product. The scope for quality differentiation is proxied by (1) a dummy variable equal to 1 for differentiated products as classified by Rauch (1999), Column 3; (2) R&D intensity by 3-digit ISIC sector from Klingebiel, Kroszner and Laeven (2007), Column 4; or (3) the combined advertising and R&D intensity by 3-digit ISIC sector from Kugler and Verhoogen (2008), Column 5. Column 6 includes the interaction of revenues with the destination's GDP per capita. All regressions include a constant term and cluster errors by destination-product. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Dependent variable: (log) f.o.b. export price, by firm, HS-8 product and destination

	Variation Across Firms Within Destination - Product Pairs					
	(1)	(2)	(3)	(4)	(5)	(6)
(log) Revenue	0.081 (70.07)***		0.036 (9.36)***	0.077 (54.61)***	0.065 (35.32)***	0.061 (9.72)***
(log) Quantity		-0.183 (-144.72)***				
(log) Revenue x Different. Good			0.054 (12.97)***			
(log) Revenue x R&D Intensity				0.200 (3.17)***		
(log) Revenue x Adv.+R&D Intensity					0.616 (10.63)***	
(log) Revenue x (log) GDP per capita						0.002 (3.17)***
Destination-Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.744	0.773	0.729	0.741	0.741	0.743
# observations	2,179,923	2,179,923	1,494,839	2,130,413	2,139,735	2,098,634
# dest-product pairs	258,056	258,056	163,873	247,867	249,874	242,403

Table 6. Firms' Export Prices and Number of Export Destinations

This table examines the relationship between firms' export prices and number of destinations, by firm and HS-8 product. The outcome variable in Panel A is the (log) average fre- on-board export price, constructed as the ratio of worldwide revenues and quantities exported by firm and product. The outcome variable in Panel B is the standard deviation of the (log) export price across destinations within firm-product pairs with more than one destination. The table explores how the correlation between the outcome variable and the number of destinations by firm-product varies across products with different scope for quality differentiation. The latter is proxied by (1) a dummy variable equal to 1 for differentiated products as classified by Rauch (1999), Columns 2-4; (2) R&D intensity by 3-digit ISIC sector from Klingebiel, Kroszner and Laeven (2007), Column 5; or (3) the combined advertising and R&D intensity by 3-digit ISIC sector from Kugler and Verhoogen (2008), Column 6. All regressions include a constant term and cluster errors by firm. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Panel A. Dep. variable: (log) average f.o.b. export price, by firm and HS-8 product

			Hom. Goods	Diff. Goods		
	(1)	(2)	(3)	(4)	(5)	(6)
(log) # Destinations	0.014 (2.79)***	0.010 (1.41)	0.010 (1.40)	0.022 (4.12)***	0.004 (0.70)	-0.003 (-0.46)
(log) # Dest x Different. Good		0.012 (1.50)				
(log) # Dest x R&D Intensity					0.428 (2.43)**	
(log) # Dest x Adv.+R&D Intensity						0.577 (3.77)***
Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.632	0.628	0.647	0.622	0.624	0.624
# observations	898,247	619,357	61,843	557,514	871,596	875,097
# products	6,908	4,276	1,321	2,955	6,182	6,252
# firm clusters	96,522	84,464	23,390	76,793	93,514	94,005

Panel B. Dep. variable: st. dev. of (log) f.o.b. export prices across destinations within a firm-HS-8 product pair

			Hom. Goods	Diff. Goods		
	(1)	(2)	(3)	(4)	(5)	(6)
(log) # Destinations	0.004 (2.12)**	0.004 (0.90)	0.004 (0.88)	0.006 (2.65)***	-0.002 (-0.77)	0.007 (2.33)**
(log) # Dest x Different. Good		0.002 (0.53)				
(log) # Dest x R&D Intensity					0.248 (3.21)***	
(log) # Dest x Adv.+R&D Intensity						-0.112 (-1.36)
Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.139	0.137	0.200	0.126	0.135	0.136
# observations	303,935	210,419	18,741	191,678	296,777	298,032
# products	5,852	3,666	1,026	2,640	5,365	5,426
# firm clusters	66,360	54,545	10,560	48,845	64,223	64,616

Table 7. Variation in Export Prices Across Destinations Within A Firm

This table examines the relationship between firms' export prices and revenues, and how it varies across products with different scope for quality differentiation. It exploits the variation across destinations within a firm by including firm-HS-8 product pair fixed effects. The outcome variable is the (log) free-on-board export price by firm, destination and HS-8 product. Column 3 controls for the share of each firm's exports in total Chinese exports, by destination and product. The scope for quality differentiation is proxied by (1) a dummy variable equal to 1 for differentiated products as classified by Rauch (1999), Column 4; (2) R&D intensity by 3-digit ISIC sector from Klingebiel, Kroszner and Laeven (2007), Column 5; or (3) the combined advertising and R&D intensity by 3-digit ISIC sector from Kugler and Verhoogen (2008), Column 6. Column 7 includes the interaction of revenues with the destination's GDP per capita. All regressions include a constant term and cluster errors by firm-product pair. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level

Dependent variable: (log) f.o.b. export price, by firm, HS-8 product and destination

	Variation Across Destinations Within Firm - Product Pairs						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(log) Revenue	0.021 (34.52)***		0.020 (34.37)***	0.015 (7.01)***	0.018 (24.09)***	0.017 (14.76)***	0.004 (3.62)***
(log) Quantity		-0.080 (-114.53)***					
Market Share			0.015 (3.95)***				
(log) Revenue x Different. Good				0.008 (3.50)***			
(log) Revenue x R&D Intensity					0.093 (3.09)***		
(log) Revenue x Adv.+R&D Intensity						0.145 (3.81)***	
(log) Revenue x (log) GDP per capita							0.002 (21.04)***
Firm-Product FE	Y	Y	Y	Y	Y	Y	Y
R-squared	0.954	0.957	0.954	0.950	0.953	0.953	0.954
# observations	2,179,923	2,179,923	2,179,923	1,494,839	2,130,413	2,139,735	2,098,634
# firm-product pairs	898,247	898,247	898,247	619,357	871,596	875,097	869,203

Table 8. Firms' Export Prices and Destination Characteristics

This table examines the effect of destination market size, income, distance and remoteness on firms' export prices. It exploits the variation in prices across destinations within a firm, by including firm-HS-8 product pair fixed effects. The outcome variable is the (log) free-on-board export price by firm, destination and HS-8 product. Columns 3 and 4 control for the share of each firm's exports in total Chinese exports, by destination and product. All regressions include a constant term and cluster errors by HS-8 product. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Dependent variable: (log) f.o.b. export price, by firm, HS-8 product and destination

	Variation Across Destinations Within Firm - Product Pairs			
	(1)	(2)	(3)	(4)
(log) GDP	0.006 (7.03)***	0.005 (6.04)***	0.009 (9.64)***	0.008 (8.71)***
(log) GDP per capita	0.016 (11.19)***	0.015 (10.37)***	0.016 (11.48)***	0.015 (10.80)***
(log) Distance	0.014 (5.91)***	0.012 (5.17)***	0.010 (4.39)***	0.009 (3.86)***
(log) Remoteness		-0.027 (-7.12)***		-0.021 (-5.67)***
Market Share			0.070 (13.55)***	0.067 (12.89)***
Firm-Product FE	Y	Y	Y	Y
R-squared	0.954	0.954	0.954	0.954
# observations	2,098,634	2,098,634	2,098,634	2,098,634
# product clusters	6,879	6,879	6,879	6,879
# firm-product pairs	869,203	869,203	869,203	869,203
# destinations	179	179	179	179

Table 9. Firms' Export Prices Across Destinations and Willingness to Pay for Quality

This table examines the differential effect of market size, distance and remoteness on firms' export prices across destinations at different income levels. It exploits the variation in prices across destinations within a firm, by including firm-HS-8 product pair fixed effects. The outcome variable is the (log) free-on-board export price by firm, destination and HS-8 product. Column 1 examines the full sample, while Column 2 (Column 3) restricts the sample to homogeneous (differentiated) goods only, according to the Rauch (1999) classification. All regressions include a constant term and cluster errors by HS-8 product. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Dependent variable: (log) f.o.b. export price, by firm, HS-8 product and destination

	Variation Across Destinations Within Firm - Product Pairs		
	All Goods	Hom. Goods	Diff. Goods
	(1)	(2)	(3)
(log) GDP	-0.015	0.007	-0.013
	(-3.38)***	(0.55)	(-2.25)***
(log) GDP x (log) GDP per capita	0.002	0.000	0.002
	(4.41)***	(0.17)	(3.03)***
(log) Distance	-0.097	-0.024	-0.117
	(-6.57)***	(-0.40)	(-5.76)***
(log) Distance x (log) GDP per capita	0.011	0.003	0.014
	(7.04)***	(0.57)	(6.12)***
(log) Remoteness	-0.107	-0.008	-0.134
	(-3.36)***	(-0.06)	(-3.13)***
(log) Remoteness x (log) GDP per capita	0.009	-0.001	0.012
	(2.86)***	(-0.11)	(2.76)***
(log) GDP per capita	-0.505	0.038	-0.626
	(-3.81)***	(0.07)	(-3.54)***
Firm-Product FE	Y	Y	Y
R-squared	0.954	0.958	0.949
# observations	2,098,634	125,495	1,315,615
# product clusters	6,879	1,311	2,951
# firm-product pairs	869,203	58,732	541,348
# destinations	179	175	179

Table 10. Firms' Imported-Input Prices and Export Performance

This table examines the relationship between firms' imported-input prices, export performance and export prices for the subset of Chinese exporters that import inputs under the processing and assembly regime. The dependent variable in Panel A is the (log) import price by firm, source country and HS-8 product. In Panel B, it is the standard deviation of (log) import prices across source countries within a firm and HS-8 product pair. In Panel C, it is the (log) number of source countries within a firm and HS-8 product pair. All regressions in Panels A, B and C include HS-8 product fixed effects and cluster errors by firm. The dependent variable in Panel D is the standard deviation of (log) import prices within a firm across source coutries and HS-8 products, after these prices have been demeaned by their HS-8 product average. The right-hand side variables include (log) worldwide firm exports and the (log) number of export destinations. For each firm, the average (log) export price is the weighted average of (log) (firm, export destination, HS-8 product) prices which have been demeaned by their HS-8 product average, with export shares as weights. The standard deviation of (log) export prices within a firm across destinations and HS-8 products is also based on product-demeaned (log) export prices. All regressions include a constant term. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Panel A. Dep. variable: (log) import price, by firm, source country and HS-8 product

	(1)	(2)	(3)	(4)
(log) Total Firm Exports	0.139 (25.45)***			
(log) # Export Destinations		0.047 (4.58)***		
Average (log) Export Price			0.459 (44.30)***	
St. Dev. of (log) Export Price				0.669 (33.05)***
Product FE	Y	Y	Y	Y
R-squared	0.603	0.589	0.630	0.599
# observations	724,790	724,790	724,790	587,110
# products	5,351	5,351	5,351	5,142
# firm clusters	37,647	37,647	37,647	27,291

Panel B. Dep. variable: st. dev. of (log) import prices across source countries within a firm and HS-8 product

	(1)	(2)	(3)	(4)
(log) Total Firm Exports	0.042 (24.07)***			
(log) # Export Destinations		0.051 (17.04)***		
Average (log) Export Price			0.076 (21.39)***	
St. Dev. of (log) Export Price				0.147 (19.48)***
Product FE	Y	Y	Y	Y
R-squared	0.193	0.182	0.191	0.185
# observations	129,059	129,059	129,059	125,828
# products	3,760	3,760	3,760	3,738
# firm clusters	21,248	21,248	21,248	20,027

Table 10. Firms' Imported-Input Prices and Export Performance

This table examines the relationship between firms' imported-input prices, export performance and export prices for the subset of Chinese exporters that import inputs under the processing and assembly regime. The dependent variable in Panel A is the (log) import price by firm, source country and HS-8 product. In Panel B, it is the standard deviation of (log) import prices across source countries within a firm and HS-8 product pair. In Panel C, it is the (log) number of source countries within a firm and HS-8 product pair. All regressions in Panels A, B and C include HS-8 product fixed effects and cluster errors by firm. The dependent variable in Panel D is the standard deviation of (log) import prices within a firm across source coutries and HS-8 products, after these prices have been demeaned by their HS-8 product average. The right-hand side variables include (log) worldwide firm exports and the (log) number of export destinations. For each firm, the average (log) export price is the weighted average of (log) (firm, export destination, HS-8 product) prices which have been demeaned by their HS-8 product average, with export shares as weights. The standard deviation of (log) export prices within a firm across destinations and HS-8 products is also based on product-demeaned (log) export prices. All regressions include a constant term. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Panel C. Dep. variable: (log) number of source countries within a firm and HS-8 product

	(1)	(2)	(3)	(4)
(log) Total Firm Exports	0.059 (41.37)***			
(log) # Export Destinations		0.065 (26.77)***		
Average (log) Export Price			0.013 (4.68)***	
St. Dev. of (log) Export Price				0.026 (4.86)***
Product FE	Y	Y	Y	Y
R-squared	0.189	0.159	0.138	0.141
# observations	460,213	460,213	460,213	443,702
# products	5,362	5,362	5,362	5,326
# firm clusters	37,671	37,671	37,671	34,584

Panel D. Dep. variable: st. dev. of (log) import prices within a firm across source countries and HS-8 products

	(1)	(2)	(3)	(4)
(log) Total Firm Exports	0.045 (29.70)***			
(log) # Export Destinations		0.022 (8.04)***		
Average (log) Export Price			0.074 (25.53)***	
St. Dev. of (log) Export Price				0.349 (64.73)***
R-squared	0.027	0.002	0.074	0.123
# observations (# firms)	32,187	32,187	32,187	29,803

Appendix Table 1. The Correlation Between Price, Revenue and Quantity: An Illustration

This table illustrates that constructing unit prices as the ratio of export revenues to export quantities does not restrict the sign of the correlation between price and revenue or between price and quantity. The table shows 6 hypothetical scenarios in which 5 observations display the same price profile but exhibit very different revenue and quantity profiles. Prices may be perfectly positively correlated with revenue and uncorrelated with quantity (Case 1) or negatively correlated with quantity and uncorrelated with revenue (Case 2). Prices may also be positively (negatively) correlated with both revenue and quantity (Cases 3 and 4), or positively correlated with revenue and negatively correlated with quantity (Case 5). Finally, prices may be only weekly correlated with revenues and/or quantities (Case 6). The only pattern ruled out by construction is the combination of a positive correlation between price and quantity and a negative correlation between price and revenue.

	Case 1			Case 2		
Observation	Revenue	Quantity	Price=R/Q	Revenue	Quantity	Price=R/Q
1.	10	10	1	60	60	1
2.	20	10	2	60	30	2
3.	30	10	3	60	20	3
4.	40	10	4	60	15	4
5.	50	10	5	60	12	5
Corr (Price,Revenue)		1.000			0.000	
Corr (Price,Quantity)		0.000			-0.902	

	Case 3			Case 4		
Observation	Revenue	Quantity	Price=R/Q	Revenue	Quantity	Price=R/Q
1.	10	10	1	18	18	1
2.	30	15	2	30	15	2
3.	36	12	3	30	10	3
4.	76	19	4	24	6	4
5.	70	14	5	15	3	5
Corr (Price,Revenue)		0.941			-0.277	
Corr (Price,Quantity)		0.560			-0.996	

	Case 5			Case 6		
Observation	Revenue	Quantity	Price=R/Q	Revenue	Quantity	Price=R/Q
1.	15	15	1	1	1	1
2.	18	9	2	6	3	2
3.	18	6	3	15	5	3
4.	28	7	4	8	2	4
5.	20	4	5	5	1	5
Corr (Price,Revenue)		0.643			0.307	
Corr (Price,Quantity)		-0.902			-0.094	

Appendix Table 2. Alternative Specifications for Table 5

This table examines the relationship between firms' export prices and revenues, and how it varies across products with different scope for quality differentiation. It exploits the variation across firms within a destination-product market by including country-HS-8 product pair fixed effects. The outcome variable in Panel A is the (log) rank of the free-on-board export price of a firm in a destination and HS-8 product; the (log) revenue rank on the right-hand side is similarly defined. The outcome variable in Panel B is the (log) average free-on-board export price by firm and HS-8 product, constructed as the ratio of worldwide revenues and quantities exported by firm and product; the right-hand-side variable is the firm's (log) revenue by HS-8 product and destination. The scope for quality differentiation is proxied by (1) a dummy variable equal to 1 for differentiated products as classified by Rauch (1999); (2) R&D intensity by 3-digit ISIC sector from Klingebiel, Kroszner and Laeven (2007); or (3) the combined advertising and R&D intensity by 3-digit ISIC sector from Kugler and Verhoogen (2008). All regressions include a constant term and cluster errors by destination-product. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Panel A. Dep. variable: (log) rank of a firm's f.o.b. export price, by HS-8 product and destination

	Variation Across Firms Within Destination - Product Pairs					
	(1)	(2)	(3)	(4)	(5)	(6)
(log) Revenue Rank	0.077 (41.63)***		0.026 (3.05)***	0.073 (30.06)***	0.051 (13.60)***	0.057 (5.53)***
(log) Quantity Rank		-0.254 (-189.44)***				
(log) Revenue Rank x Different. Good			0.059 (6.69)***			
(log) Revenue Rank x R&D Intensity				0.192 (2.65)***		
(log) Revenue Rank x Adv.+R&D Intensity					0.973 (8.49)***	
(log) Revenue Rank x (log) GDP per capita						0.002 (1.85)*
Destination-Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.796	0.808	0.795	0.796	0.796	0.796
# observations	2,179,923	2,179,923	1,494,839	2,130,413	2,139,735	2,098,634
# dest-product pairs	258,056	258,056	163,873	247,867	249,874	242,403

Appendix Table 2. Alternative Specifications for Table 5

This table examines the relationship between firms' export prices and revenues, and how it varies across products with different scope for quality differentiation. It exploits the variation across firms within a destination-product market by including country-HS-8 product pair fixed effects. The outcome variable in Panel A is the (log) rank of the free-on-board export price of a firm in a destination and HS-8 product; the (log) revenue rank on the right-hand side is similarly defined. The outcome variable in Panel B is the (log) average free-on-board export price by firm and HS-8 product, constructed as the ratio of worldwide revenues and quantities exported by firm and product; the right-hand-side variable is the firm's (log) revenue by HS-8 product and destination. The scope for quality differentiation is proxied by (1) a dummy variable equal to 1 for differentiated products as classified by Rauch (1999); (2) R&D intensity by 3-digit ISIC sector from Klingebiel, Kroszner and Laeven (2007); or (3) the combined advertising and R&D intensity by 3-digit ISIC sector from Kugler and Verhoogen (2008). All regressions include a constant term and cluster errors by destination-product. T-statistics in parenthesis. ***, **, and * indicate significance at the1%, 5%, and 10% level.

Panel B. Dep. variable: (log) f.o.b. export price, by firm and HS-8 product

	Variation Across Firms Within Destination - Product Pairs						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(log) Revenue	0.065 (58.85)***		0.023 (6.38)***	0.065 (48.40)***	0.061 (53.05)***	0.054 (30.22)***	0.061 (3.61)***
(log) Quantity		-0.154 (-126.72)***					
(log) Revenue x Different. Good			0.050 (13.02)***				
(log) Revenue x R&D Intensity				0.007 (0.11)			
(log) Revenue x High R&D Intensity					0.009 (4.00)***		
(log) Revenue x Adv.+R&D Intensity						0.417 (7.41)***	
(log) Revenue x (log) GDP per capita							0.005 (7.23)***
Destination-Product FE	Y	Y	Y	Y	Y	Y	Y
R-squared	0.762	0.784	0.748	0.758	0.758	0.758	0.760
# observations	2,185,553	2,185,553	1,499,163	2,136,030	2,136,030	2,145,355	2,103,953
# dest-product pairs	258,382	258,382	164,083	248,190	248,190	250,199	242,710