Export Prices and Heterogeneous Firm Models

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September 2009
First draft: December 2008

Abstract. This paper examines the variation in export prices across firms, products and destinations to distinguish between alternative heterogeneous firm models of international trade. We establish five stylized facts using new data on the universe of Chinese trading firms. First, firms charging higher export prices earn larger revenues within each destination, have greater worldwide sales, and export to more markets. Second, firms that pay higher import prices set higher export prices, have greater worldwide sales, and export to more markets. Third, firms offer higher prices in larger, richer and more distant markets. Fourth, there is a positive correlation between export price and revenue across destinations within a firm. Finally, firms that export more to more countries pay a wider range of import prices and offer a broader menu of export prices. None of the heterogeneous firm models in the literature can match all of these patterns. Our results are instead consistent with quality differentiation across firms (stylized facts 1 and 2) and firms adjusting both quality and mark-ups across destinations in response to market toughness (stylized facts 3, 4 and 5).

JEL Classification codes: F12, F14, L11, L16
Keywords: export prices, firm heterogeneity, productivity, quality.

We thank Kyle Bagwell, Doireann Fitzgerald, James Harrigan, Amit Khandelwal, Pete Klenow, Marc Melitz, Bob Staiger and Eric Verhoogen for insightful conversations, and seminar participants at Stanford, Penn State, UBC, UVA, Maryland, UT Houston, UC Berkeley, UC Riverside, the spring 2009 NBER ITI meeting, the 2009 CESifo Venice Summer Institute and the 2009 SNB-CEPR conference on Product and Quality Heterogeneity in International Trade for their comments. Kalina Manova (corresponding author): Department of Economics, Stanford University, 579 Serra Mall, Stanford, CA 94305, *manova@stanford.edu*. Zhiwei Zhang: Hong Kong Monetary Authority, *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 *efficiency* sorting across firms: more productive firms become more successful exporters because they have lower marginal costs and charge lower prices.[2] 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.[3] To rationalize these facts while retaining the advantages of the efficiency sorting framework, recent models have introduced *quality* differentiation across firms: more productive firms have superior export performance because they sell higher quality goods at higher prices.[4]

This paper examines the variation in free on board (f.o.b.) export prices across firms, products and destinations using detailed proprietary data on the universe of Chinese trading firms. We establish five stylized facts which allow us to distinguish between alternative heterogeneous firm models. Our results are consistent with quality sorting across firms and firms adjusting both quality and mark-ups across destinations in response to market toughness. Since existing models assume either no quality differentiation across firms or no quality differentiation within a firm across trade partners, however, they are unable to explain the patterns in the data. Our findings thus point to previously unexplored dimensions of firm heterogeneity and adjustments on the quality margin within firms across destinations.

First, we establish that, *among exporters selling in a given destination-product market, firms charging higher f.o.b. prices earn bigger revenues*. When we look at the variation in worldwide exports across firms trading a given product, we also find a *positive correlation between firms' average export price, worldwide sales and number of export destinations*. Moreover, these patterns are more pronounced in sectors with greater scope for quality

[1] See for example Clerides, Lach and Tybout (1998), Aw, Chung and Roberts (2000), Eaton, Kortum and Kramarz (2004, 2008) and Bernard, Jensen and Schott (2009), and Bernard, Jensen, Redding and Schott (2007) for a survey of the literature.
[2] See Melitz (2003), Bernard, Eaton, Jensen and Kortum (2003) and Melitz and Ottaviano (2008).
[3] See Bernard and Jensen (1995), Verhoogen (2008), Kugler and Verhoogen (2008), Hallak and Sivadasan (2008) and Iacovone and Javorcik (2008).
[4] See Johnson (2007), Baldwin and Harrigan (2007), Verhoogen (2008), Kugler and Verhoogen (2008), Hallak and Sivadasan (2008) and Kneller and Yu (2008).

differentiation, as proxied by the Rauch (1999) classification of differentiated goods, R&D or advertising intensity. These findings are at odds with the predictions of efficiency sorting models. They are, on the other hand, consistent with quality sorting whereby higher prices are associated with better quality and superior export performance.

Second, we provide indirect evidence that the variation in output quality across firms is driven by variation in input quality. While we do not observe firms' domestic input purchases, we use information on their imports as an imperfect signal of the quality of all their inputs. We find that *firms paying higher import prices have higher export prices, larger worldwide export revenues, and a bigger number of export destinations*. These results are consistent with more successful exporters using higher quality inputs to manufacture higher quality products.

Third, we show that *firms set higher f.o.b. prices for the same product category in larger, richer and more distant markets. Fourth, firms earn greater revenues in countries where they charge higher f.o.b. prices*. Both of these results are partial correlations controlling for firm-product fixed effects and are thus identified purely from the variation across export destinations within a firm-product pair. If firms export an identical product everywhere, the fixed effects would thus capture its cost and quality characteristics, and any residual variation in price across markets would have to be due to variable mark-ups.

Existing heterogeneous firm models, however, predict either no systematic variation in f.o.b. prices across markets (CES demand and constant mark-ups above marginal cost) or a *negative* correlation between f.o.b. prices and revenue, size and distance (linear demand with variable mark-ups). In the latter case, firms optimally reduce mark-ups in response to tougher competition in big markets, where more firms enter, and distant markets, where competitors' average productivity is relatively higher. These predictions hold irrespectively of whether firms sort on efficiency or quality. Thus, if firms sold an identical product to all destinations, export prices would not behave in the manner that we observe.

Instead, we believe that firms respond to market competition not only by lowering their mark-up, but also by increasing product quality. If quality upgrading requires more expensive, higher quality inputs, it would raise marginal costs. When this effect is sufficiently strong, it could dominate the mark-up adjustment and generate higher export prices in big and remote destinations.[5] Our results would then capture the net effect of quality and mark-up adjustment, and

[5] Note that this need not imply higher quality-adjusted prices.

provide a lower bound for the response of product quality. Firms may also set higher prices in richer countries because wealthier consumers have higher willingness to pay for quality.[6]

In line with this interpretation, we find that the positive correlation between export prices and revenues across destinations within a firm is stronger for goods with greater scope for quality differentiation. Moreover, market size and distance have a bigger effect on firm prices in richer countries. This is consistent with the idea that firms would be particularly likely to upgrade quality in tougher markets when consumers there are willing to pay more for quality.

Finally, our explanation rests on the premise that firms optimally use inputs of varying quality to modify the quality of their exports across markets. Indeed, *firms that export more to more countries pay a wider range of import prices and offer a broader menu of export prices*. While models with variable mark-ups can generate a positive correlation between the number of export destinations and the standard deviation of export prices across markets, they cannot explain the result for the dispersion in import prices. On the other hand, our findings are consistent with firms varying product quality across destinations and buying multiple quality versions of an input to produce multiple quality versions of an output.

Understanding the nature of firm heterogeneity is important because of its implications for aggregate trade patterns and growth. Reallocations across sectors and across firms within a sector are both essential in the adjustment to trade liberalization and its impact on aggregate productivity (Pavcnik 2002, Bernard, Jensen and Schott 2006, Chaney 2008). The welfare effects of these reallocations, however, do not depend on whether firms sort on efficiency or quality. Where that distinction becomes crucial is in determining *which* firms and workers benefit or suffer from trade reforms. This is particularly relevant in view of the rise of low-cost giants such as China and India. Indeed, U.S. output and employment appear less vulnerable to import competition from low-wage countries in sectors characterized by longer quality ladders (Khandelwal 2009).

In this context, our results shed new light on the nature of firm heterogeneity and raise the possibility 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 would have implications for the effects of globalization on both aggregate welfare and inequality.

[6] See Fajgelbaum, Grossman and Helpman (2009) and Simonovska (2009).

Our work builds on recent papers that study aggregate export prices to distinguish between efficiency and quality sorting models. 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 suggestive of quality sorting. When we replicate their analysis with our data, however, we find patterns that can obtain under either efficiency or quality sorting. Examining aggregate prices alone may thus be inconclusive. It may in fact be misleading if aggregate prices behave in a manner consistent with a given model, but firm prices do not. The detailed nature of our dataset allows us to address this challenge and directly analyze firm export prices.

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. To our knowledge, our paper is the first to explore firm-level export prices by product and destination. We uncover new stylized facts that present challenges to all existing heterogeneous firm models, and offer a novel explanation based on firms varying product quality across countries in response to market toughness.

Finally, our results are 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 can explain these patterns.[7]

The remainder of the paper is organized as follows. The next section summarizes the implications of different efficiency and quality sorting models for export prices. Section 3 describes the data, while Sections 4 and 5 present our analyses of export and import prices, respectively. Section 6 argues against alternative explanations. The last section concludes.

2 Heterogeneous Firm Models in the Literature

This section briefly reviews alternative efficiency and quality sorting models in the literature. We focus on their implications for firms' export pricing behavior which allow us to distinguish

[7] See also Hallak and Schott (2008) who decompose countries' export prices into quality and quality-adjusted prices.

between different frameworks. We highlight 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 destination size and distance. While the first two relationships depend on the nature of firm heterogeneity, the latter depends on the nature of firm competition. Table 1 summarizes the predictions of alternative models.

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.

While the models below characterize one-sector economies, their implications for export prices readily carry over to a multi-sector world.[8] In our empirical implementation, we explore the variation in prices across firms and destinations within narrowly defined product categories.

The models we present 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.[9] Our empirical analysis correspondingly studies how prices vary across countries within firm-product pairs or across firms within destination-product markets.

2.1 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. Since more productive firms have lower marginal costs, 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 selling a particular good in a given destination. This is the main characteristic of the efficiency sorting model. On the other hand, a firm's f.o.b. export price does not depend on the identity of its trade partner, and should not vary systematically with revenues, market size or distance across the firm's destinations.

[8] For multi-sector versions of Melitz (2003) see for example Bernard, Redding and Schott (2007) and Manova (2007).
[9] See Bernard, Redding and Schott (2009a,b,c) and Melitz and Ottaviano (2009).

While firm-level f.o.b. prices do not differ across markets in this model, the set of exporting firms does, and this has implications for the average export price observed 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 in an economy, the cut-off is lower for bigger markets. On the other hand, the productivity threshold rises with distance because selling to more remote countries entails higher transportation costs and lower profits. 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 fall with distance.

2.2 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. Firms thus optimally charge lower mark-ups and 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 remote countries are serviced by relatively more productive firms which set lower prices. Both forces put downward pressure on the aggregate price index and incentivize firms to reduce their mark-ups.

Since more productive firms have lower production costs, they offer lower prices, sell higher quantities and earn larger revenues, although 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. However, because firms set lower prices in bigger markets where exports are higher, the model also implies a negative correlation between f.o.b. price and revenues across destinations within a firm.

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

2.3 Quality sorting with CES demand

In order to explain new empirical facts, a number of recent papers have incorporated quality differentiation across firms into the Melitz (2003) framework, including Baldwin and Harrigan (2007), Johnson (2007), Verhoogen (2008) 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) generates differentiation in output quality by allowing firms to choose the quality of their inputs.[10] In view of our results below, 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 models, quality sorting would then predict a *positive* correlation between f.o.b. export prices and export revenues across firms selling in a given destination. On the other hand, when the elasticity of marginal costs with respect to quality is not sufficiently high, all implications of the quality-augmented model will be identical to those of Melitz (2003). In Table 1 and below, we summarize the former case only, because only then can the models be distinguished in the data.

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, market size and distance across destinations. Aggregate, product-level prices do, however, vary systematically with market characteristics 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 more proximate countries with bigger aggregate spending, the average f.o.b. export price

[10] Baldwin and Harrigan (2007) directly assume that firms with higher marginal production costs produce higher quality products without modeling input choice. Their predictions for export prices are the same.

across all Chinese exporters falls with market size and rises with distance. This prediction is the exact converse of that for efficiency sorting and CES demand.

2.4 Quality sorting with linear demand

Most recently, Kneller and Yu (2008) propose a heterogeneous-firm model that imbeds 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 products.[11] Better quality firms set higher prices not only because of their bigger variable costs, but also because they can charge a larger 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 of Melitz and Ottaviano (2008).

With linear demand, the price elasticity of residual demand depends on the toughness of competition in a market. As in Melitz and Ottaviano (2008), firms therefore optimally charge lower mark-ups and lower f.o.b. prices for the same product in bigger and more distant countries. F.o.b. prices are also negatively correlated with export revenues within a firm across destinations.

The predictions of this model for the average price across Chinese exporters in a given market are, however, ambiguous. On the one hand, tougher markets attract firms above a relatively higher quality cut-off who charge higher prices. On the other hand, tougher markets incentivize firms to reduce their mark-up. The overall effect of country size and distance on product-level f.o.b. export prices can thus be either positive or negative.

3 Data

We use a recently released proprietary database on the universe of Chinese firms that participated in international trade over the 2003-2005 period.[12] These data have been collected by the Chinese Customs Office. They report the free on board value of firm exports and imports (in US dollars) by product and trade partner for 243 destination/source countries and 7,526 different products in

[11] Antoniades (2008, in progress) also studies quality sorting with linear demand and explicitly models firms' quality choice. The current draft, however, does not fully develop the pricing implications of a multi-country equilibrium.
[12] Manova and Zhang (2008) describe the data and establish stylized facts about firm heterogeneity in Chinese trade.

the 8-digit Harmonized System.[13] The dataset also provides information on the quantities traded in one of 12 different units of measure (such as pieces, 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 measure, and we include product fixed effects in all of our regressions to account for the different units used across goods. While the data are available at a monthly frequency, we focus on annual exports in the most recent year in the panel, 2005.

Some state-owned enterprises in China are pure export-import companies which do not engage in manufacturing and serve exclusively as intermediaries between domestic producers (buyers) and foreign buyers (suppliers). In this paper, we examine the operations of firms that both make and trade goods, and leave the study of wholesalers for future work. Since the data does not indicate these intermediaries, we use key words in firms' names to identify them.[14]

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 exporters selling a given good in a given country. The standard deviation of firm prices in the average destination-product market is 0.90. This emphasizes 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. Focusing on firms that sell the same good to multiple countries, 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 use data on GDP and GDP per capita for 175 countries from the World Bank's World Development Indicators. Our bilateral distance measure comes from Glick and Rose (2002).

Based on the availability of data on market size and distance, we work with 242,311 observations across 175 countries and 6,879 HS-8 codes at the destination-product level, and 2,098,551 observations across 94,663 firms at the firm-destination-product level. The firm-level regressions that do not require data 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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[13] 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..

[14] We drop 23,073 wholesalers which mediate a quarter of China's trade by value.

3.1 The value of firm-level data

As Table 1 illustrates, alternative heterogeneous firm models deliver very different predictions for the behavior of firm and aggregate export prices. To distinguish between these models, others have examined product-level unit values and their correlation with destination size and distance. For example, Baldwin and Harrigan (2007) find that average U.S. export prices rise with bilateral distance and fall with the importer's GDP. These results are clearly inconsistent with models of efficiency sorting and point to quality sorting instead. Because of the ambiguous predictions of quality sorting with linear demand, however, this approach may be inconclusive because certain patterns in the data can obtain under both efficiency and quality sorting.

This is indeed the case in our sample. We construct the average Chinese export price across importing countries such that it equals the unit price that product-level data would report. In particular, we first sum across the f.o.b. value and quantity of exports across all firms that sell a specific HS-8 good to a given market. We then obtain the average export price for each destination-product by dividing total revenues by total quantities.

Table 3 reports results from a gravity-type regression of product-level unit values on destination GDP and distance, with all variables in logs. The average f.o.b. export price is higher in bigger and more proximate markets. Since more developed countries may have a taste or greater willingness to pay for quality, we control for GDP per capita in the second column, and find that average export prices are indeed higher in richer destinations. The correlation with market size is now imprecisely estimated, but that with distance remains unchanged. These results are consistent with the efficiency sorting Melitz (2003) model, but also with quality sorting and linear demand.

In the rest of the table, we repeat the analysis separately for destinations above and below the median GDP per capita.[15] While the average Chinese export price increases with size and distance for the 88 rich importers, the opposite holds in the poorer half of the sample. Once again, these results do not conclusively point to one heterogeneous firm model or another. They may be jointly accounted for by quality sorting with linear demand. Alternatively, quality sorting with linear demand may describe exporting to richer countries who value quality more, while efficiency sorting with linear demand may be more relevant for trade with lower-income trade partners.

To understand the nature of firm heterogeneity, we therefore need to directly examine firm-level data.

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[15] We obtain similar results when we instead split the sample by market size (GDP).

4 Export Prices across Firms and Destinations

We begin the analysis by exploring the variation in export prices across firms within a given destination-product market. We find evidence consistent with quality sorting that efficiency sorting models cannot explain. We then study the relationship between export prices, revenues and destination characteristics across trade partners within a firm-product pair. We document systematic patterns that pose a challenge to extant trade theory, and suggest that they may instead be attributed to firms varying both mark-ups and product quality across markets.

4.1 Variation across firms

Consider first the variation in f.o.b. 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 estimate the following specification:

$$\log price_{fpd} = \alpha + \beta \cdot \log revenue_{fpd} + \delta_{pd} + \varepsilon_{fpd} \quad (1)$$

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, δ_{pd} are destination-product pair fixed effects, and ε_{fpd} is an error term. We interpret the estimate of β as a conditional correlation that does not reflect causality.[16] Indeed, in the context of the heterogeneous firm models described above, both export price and revenue are uniquely pinned down by firm productivity, which is unobserved. We conservatively cluster errors 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.

As column 1 in Table 4 shows, firms charging a higher export price earn greater revenues in a given destination-product market. This relationship is highly statistically and economically significant. It lends strong support to models of quality differentiation across firms, in which higher prices are associated with better quality and superior export performance.[17]

We find more corroborative evidence when we compare products of varying scope for quality differentiation. In column 3, we regress export price on firm sales and their interaction with the Rauch (1999) dummy for differentiated goods. The positive correlation between price and

[16] Note that although the export price is calculated as the ratio of revenues to quantity, this does not impose any restrictions on the sign of the correlations of price with revenues and quantity.
[17] For completeness, column 2 documents the negative correlation between f.o.b. prices and quantities across firms in a market. This is consistent with both efficiency and quality sorting and does not help differentiate between them.

revenues across firms in a market is indeed stronger for non-homogeneous products. We obtain similar results in columns 4 and 5 when we instead proxy the potential for quality differentiation with continuous measures of R&D intensity or combined advertising and R&D intensity. These variables come 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 have matched to the HS-8 products in our sample.

This interaction analysis serves another purpose as well. If export quantities are measured with error, the imputed unit values would also be. Since export price is the outcome variable, this could introduce classical measurement error that would not bias coefficients but may potentially limit precision. If the measurement error in quantities is also correlated with revenues on the right-hand side, however, coefficients could be biased either up or down. Exploring the variation across goods with different scope for quality differentiation addresses this concern since there is no *a priori* reason to believe that measurement error will vary systematically across products.

We find further support for quality sorting when we analyze firms' worldwide export revenues and number of export destinations. Heterogeneous firm models predict that more productive firms not only have bigger sales 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 implies that, across firms selling a given product, firms' average export price should be positively correlated with firms' worldwide revenues and number of destinations. Conversely, these correlations would be negative under efficiency sorting.

To test these predictions, we aggregate the data to the firm-product level by summing sales and quantities across destinations. We then take their ratio to construct firms' average export price, $price_{fp}$, and estimate the following specifications:

$$\log price_{fp} = \alpha + \beta \cdot \log revenue_{fp} + \delta_p + \varepsilon_{fp} \quad (2)$$

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

We include product fixed effects δ_p and cluster errors ε_{fp} by firm. Since the unit of observation is now at the firm-product level, the sample size in these regressions is reduced to 898,247 data points.

In line with quality sorting, we find that within a given product, firms that charge a higher average export price receive bigger worldwide revenues (Table 5). This result is highly statistically significant and is more pronounced for goods with greater scope for quality differentiation.[18] Similarly, Table 6 confirms that exporters which supply more countries charge a higher average export price. This fact is entirely driven by products with potential for quality upgrading. As columns 2-6 show, no such systematic pattern holds in the sample of homogeneous goods or products with zero R&D and advertising intensity. These findings for firms' worldwide revenues and number of trade partners are consistent with quality differentiation across firms and incompatible with efficiency sorting.

4.2 Variation across destinations within firms

To distinguish between different quality sorting models and learn more about the nature of firm competition, we next examine the variation in export prices within firms across destinations. Recall that when firms face linear demand, they optimally price discriminate across countries and set lower mark-ups and f.o.b. prices in tougher markets. With CES demand, by contrast, firms offer all trade partners the same price.

We explore the relationship between export prices and two proxies for market toughness in the importing country, size (GDP) and distance to China, with the following regression:

$$\log price_{fpd} = \alpha + \beta \cdot \log GDP_d + \gamma \cdot \log distance_d + \delta_{fp} + \varepsilon_{fpd} \qquad (4)$$

We include firm-product pair fixed effects, δ_{fp}.[19] The coefficients of interest β and γ are thus identified purely from the variation in f.o.b. export prices across destinations for a given firm and product line. We report results with errors conservatively clustered at the HS-8 product level, but note that our findings are robust to alternative clustering, such as by firm or firm-product.

Table 7 presents strong evidence that firms systematically charge higher f.o.b. prices for the same HS-8 product in bigger and more distant markets. These results are highly statistically

[18] While the interactions of export revenues with the dummy for product differentiation and with the combined advertising and R&D intensity enter positively, the coefficient on the interaction of export revenues with R&D intensity is negative. This R&D intensity measure is very unevenly distributed in the data, with many values in the 0.00-0.03 range and a few sectors above 0.07. When we group sectors into high- and low-R&D intensity, the interaction of export revenues with a dummy for high-R&D intensity is positive and significant at 1%.

[19] In all models we study, 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 goods produced by different firms. Firm-product pair fixed effects address this problem.

and economically significant. For example, a one standard deviation increase in GDP or distance is associated with a 2.7% (1%) rise in the firm-product specific price, or 6% (2%) of a standard deviation. Our findings are independent of the fact that firms set consistently higher prices in richer countries, as measured by GDP per capita (column 2). They are also not explained by firms extracting higher mark-ups because of greater market power, as they are robust to controlling for firms' market share in that country and product (columns 3 and 4).[20]

We also study the correlation between f.o.b. export prices and revenues within a firm across markets with the following regression:

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

Controlling for exporter-good pair fixed effects, δ_{fp}, we find that firms earn bigger revenues from a given product in markets where they set higher prices (column 1 of Table 9). This result is once again not driven by firms' market share, as shown in column 3.[21]

The results in Tables 7 and 9 are difficult to reconcile with existing models of either quality or efficiency sorting. Note first that, if firms export the same product to all their trade partners, the firm-product pair fixed effects in these regressions would capture the marginal cost and quality characteristics of the good. Any residual variation in f.o.b. prices across destinations would then have to be due to variable mark-ups.

Our findings, however, stand in sharp contrast to extant heterogeneous firm models, which predict either no systematic variation in f.o.b. prices across markets (CES demand and constant mark-up above marginal cost) or a negative correlation between f.o.b. prices and revenue, size and distance (linear demand with variable mark-ups). Thus, if firms sold an identical product to all destinations as all current models assume, export prices would not behave in the manner that we observe.[22]

Instead, we believe that firms respond to market competition not only by lowering their mark-up, but also by increasing product quality. If quality upgrading requires more expensive, higher quality inputs, it would raise marginal costs. When this effect is sufficiently strong, it could

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[20] We measure firm *f*'s market share with the share of *f*'s exports of product *p* in destination *d* in total Chinese exports of *p* in market *d*. *f*'s true market share is our measure, multiplied by the share of Chinese exports in total consumption of *p* in destination *d*, which is invariant across Chinese exporters.

[21] For completeness, column 2 documents the negative correlation between f.o.b. prices and quantities across markets within a firm. This is consistent with linear demand and both efficiency or quality sorting.

[22] Verhoogen (2008) studies heterogeneous firms that choose two quality levels, one for domestic production and one for exports abroad. Firms thus do not vary product quality across export destinations.

dominate the mark-up adjustment. We would then observe firms charging higher export prices in bigger and more remote destinations. As for the positive correlation between f.o.b. prices and destination GDP per capita, firms may offer higher quality or set higher mark-ups or both in richer countries because wealthier consumers have a lower marginal utility of income and greater willingness to pay for quality.[23]

If firms upgrade product quality in tougher markets, we would expect them to have a greater incentive to do so when consumers in those markets are willing to pay more for quality. We test this prediction in Table 8, where we expand specification (4) to include the interactions of GDP and distance with GDP per capita. Indeed, we find that market size and distance have a bigger effect on firm prices in richer countries. Both interaction terms enter positively and significantly at the 1% level. Moreover, this result holds only in the sample of Rauch (1999) differentiated products with scope for quality upgrading (column 3). By contrast, there is no systematic variation in firms' export prices for the subsample of homogeneous goods (column 2).

The positive correlation between f.o.b. prices and revenues across markets within a firm-product pair can also be attributed to firms adjusting product quality across destinations. Three factors might generate this pattern. First, higher quality products typically capture a bigger market share in models with quality in the utility function. Second, firms offer higher quality versions of a product in bigger markets, where firm revenues are higher. Finally, if firms both increase quality and lower mark-ups in tougher markets, their quality-adjusted price may actually fall. Thus, our results are consistent with firms varying quality across markets and earning higher revenues when they offer better quality. As further support for this explanation, columns 4-6 of Table 9 show that the positive correlation between export price and revenues across destinations within a firm is stronger for goods with greater scope for quality differentiation.

Finally, note that if our explanation is correct, our results capture the net effect of quality and mark-up adjustment on firm prices. Our estimates thus provide a lower bound for the response of product quality to market toughness.

We conclude this section with further corroborative evidence based on the number of firms' export destinations. If exporters adjust product quality across countries, we would expect that firms entering more markets would exhibit greater price dispersion across importers. The results in Table 10 confirm that this is indeed the case. We obtain the standard deviation of f.o.b.

[23] See Fajgelbaum, Grossman and Helpman (2009) and Simonovska (2009) who model these effects.

export prices across trade partners for each firm-product pair, and find that it is positively correlated with the number of destinations.[24, 25] Moreover, this pattern holds only for differentiated products (but not for homogeneous goods) and is more pronounced in R&D-intensive sectors.

To be precise, the fact that firms selling to more countries offer a broader menu of export prices does not by itself imply that firms vary quality across markets. The same pattern would emerge if firms offered the same quality, at the same marginal cost worldwide but adjusted mark-ups across importers. However, the earlier result that firms charging higher average prices export more to more markets (Tables 5 and 6) combined with the evidence for price dispersion is indicative of quality discrimination across countries.

5 Firms' Import Prices and Export Performance

The results we have presented so far are consistent with quality differentiation across firms and firms adjusting both mark-ups and product quality across destinations. This section uses information on firms' import prices to provide suggestive evidence that firms use inputs of varying quality to manufacture multiple quality versions of their output product.

To illustrate this mechanism, consider a Chinese shoe manufacturer. This manufacturer may choose cheap man-made upper and low quality soles to produce a cheap pair of shoes for export to Malaysia. The same shoe manufacturer 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 are not willing to pay a high price for quality and the market is not very tough because it is relatively small and proximate. By contrast, American and German consumers are wealthier and have lower marginal utilities of income. The shoe manufacturer faces more competition in those big and distant markets, but can increase profits by improving quality and charging a higher price. Moreover, the producer need not incur repeated fixed costs for each quality line, but could simply use different inputs and the same sewing technology.

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[24] This measure of price dispersion is only defined for firm-product pairs with more than one export destination, hence the smaller sample size in these regressions.

[25] The exact regression we run is $sd_{fp}(\log price_{fpd}) = \alpha + \beta \cdot \log \#destinations_{fp} + \delta_p + \varepsilon_{fp}$, where $sd_{fp}(\log price_{fpd})$ is the standard deviation of (log) f.o.b. export prices across destinations within a firm-product pair, δ_p are product fixed effects, and errors are clustered by firm.

This rationalization is similar to, but more flexible than, the quality sorting framework in Verhoogen (2008) and Kugler and Verhoogen (2008). They consider firms that choose a unique output quality level by selecting the quality of their inputs. To establish a link between input and output quality, it is thus sufficient for Kugler and Verhoogen (2008) to show that plant size in Colombia is positively correlated with plants' average input and output price. To argue that firms vary the quality of their product across destinations, we need to replicate this result but also demonstrate that firms source a range of input qualities to produce a range of output qualities.

In the absence of detailed information on firms' domestic intermediate input purchases, we use data on their import prices as an imperfect signal of the quality level and quality range of all their inputs. Of the 96,522 exporting firms in our dataset, 58,337 are also importers for whom we observe import revenues, quantities and unit prices by HS-8 product and country of origin. In the rest of this section, we examine the correlation between import prices and export performance for this subset of 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 export destinations 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 (firm, product, destination) prices which have been demeaned by their HS-8 product average, with export revenue shares as weights. The standard deviation of the (log) export price within a firm across destinations and goods is also based on demeaned export prices.

We first check whether more successful exporters use more expensive, higher quality inputs by estimating the following specification:

$$\log price_{fpo} = \alpha + \beta \cdot export\, performance_f + \delta_p + \varepsilon_{fpo} \tag{6}$$

where $price_{fpo}$ is the price that firm f pays for import product p from origin country o, $export\, performance_f$ is one of four firm-level measures and δ_p are product fixed effects. We conservatively cluster errors by firm, but our results are robust to clustering by product. As before, we view β as a conditional correlation since we expect that unobserved firm productivity is positively correlated with both input quality choice and export performance.

As hypothesized, we find that firms paying higher import prices do indeed have higher export prices, larger worldwide export revenues, and a bigger number of export destinations (Panel A of Table 10). This result is consistent with the idea that firms using more expensive, higher quality inputs produce pricier, better quality products and are above the quality cut-off for exporting in more destinations. As column 4 shows, exporters that vary prices more across markets also tend to buy more expensive imports. This suggests that more productive firms can more easily (i.e. efficiently) upgrade quality, which allows them to both export higher average quality and offer a broader quality range.

We then test the second part of our hypothesis and examine the spread (standard deviation) of prices that firms pay for a given imported product:

$$sd_{fp}(\log price_{fpo}) = \alpha + \beta \cdot export\ performance_f + \delta_p + \varepsilon_{fp} \qquad (7)$$

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

We find that firms paying a broader range of import prices for a given good export more to more markets and offer a broader menu of export prices across destinations (Panel B of Table 10). This is consistent with firms varying product quality across markets by varying the quality of their inputs. We obtain similar results in Panel C, where we collapse the data to the firm level and study the total variation (standard deviation) in import prices across all products and source countries within a firm.[26] In both cases, we also find that firms charging a higher average export price pay a wider range of import prices. This reinforces the notion that more successful exporters offer higher quality products on average and are better at varying product quality across markets.

To summarize, we interpret our results as evidence that there is quality differentiation across firms, and that firms adjust both mark-ups and product quality across destinations by using inputs of different quality levels. More productive firms are likely able to more efficiently upgrade quality and thus successfully enter more competitive markets. More productive firms thus have higher bilateral and worldwide export revenues, more trade partners and greater price dispersion across destinations. In addition, they import more expensive, higher quality inputs and export products of higher average quality at a higher average price.

[26] In particular, we estimate $sd_f(\log price_{fpo}) = \alpha + \beta \cdot export\ performance_f + \varepsilon_f$ in the cross-section of firms.

6 Alternative Explanations

Since we do not have access to direct measures of product quality, we cannot definitively establish our quality explanation. We can, however, consider other potential explanations and examine how well they can account for the stylized facts in the data. This section discusses four such alternatives. While each of them can match some of our results, none of them can rationalize all patterns in the data. This lends further support to the explanation we propose.

6.1 Efficiency sorting with per unit transportation costs

The models of efficiency and quality sorting we have considered assume iceberg transportation costs, which increase the cost of delivering a good to its final destination by a fixed percent of its marginal production cost. Under CES demand, firms charge a constant mark-up above the combined variable cost of manufacturing and transportation, and thus the same free on board price in all destinations. With linear demand, on the other hand, firms absorb some of the trade cost when they export to distant markets where competition is tougher, which results in lower f.o.b. prices to such countries.

When transportation costs are per unit instead of iceberg, they inflate the marginal cost of all traded goods by the same fixed (dollar) amount. With CES preferences and efficiency sorting, it then becomes optimal for firms to charge a higher mark-up when selling to more distant countries that have a higher per unit trade cost (Martin 2009). This would be consistent with our result that firms set higher f.o.b. export prices for the same product in remote destinations.

This model of spatial price discrimination, however, cannot account for any of our other findings. In particular, it cannot explain why firms charge higher prices in bigger and richer countries. It can also not generate a positive correlation between f.o.b. prices and revenues across firms in a given market, or across destinations within a firm. Finally, it would be inconsistent with the systematic patterns we find for firms' import prices.

6.2 Shipping the good apples out

In the presence of quality differentiation across firms, per unit transportation costs lower the relative price of and raise the relative demand for higher quality goods (Alchian and Allen

1964).[27] Firms offering a better quality product will therefore export relatively more to distant countries, leading to higher f.o.b. average export prices at the product level. Hummels and Skiba (2004) find exactly this pattern in aggregate data and attribute it to quality differentiation across firms.

The standard Alchian-Allen model assumes that each firm sells an identical product in all destinations and can thus not explain why *firm-level* f.o.b. export prices are higher in distant markets. An extended version of the model, however, could. Imagine, for example, that firms export multiple quality versions of an HS-8 product to each market but vary the quality mix with destination distance. Higher per unit transportation costs would incentivize each firm to export relatively more of its more expensive, better quality varieties, resulting in a higher price at the firm-HS-8 product level as we observe in our data.

Note that, like ours, this explanation would rely on quality differentiation across firms and across destinations within firms. It could thus account for the relationships between import prices, import price dispersion and export performance in the data, as well as for the positive correlation between price and revenues across firms within a market. However, firms would vary quality across countries in response to per unit trade costs as opposed to market toughness.

This extended Alchian-Allen framework could nevertheless not explain all of our results. It remains unclear why firms should charge higher f.o.b. prices in bigger countries, or why prices and revenues should be positively correlated within a firm across destinations, especially in goods with greater scope for quality differentiation.

6.3 Firm specific demand shocks

We interpret the positive correlation between price and revenues across firms in a given market as consistent with quality sorting across firms, and the positive correlation between price and revenues across destinations within a firm as indicative of 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 and more distant markets, unless these shocks also vary systematically across countries. This demand-based explanation can also not account for the relationships we find between import

[27] This phenomenon has been referred to as "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.

price levels, export prices and export performance. Finally, it is not obvious why the positive correlation between price and revenues should be more pronounced for goods with greater scope for quality differentiation.

6.4 Firm specific demand shocks and market power in input markets

The last scenario we consider combines firm-product-destination specific demand shocks with market power in input markets. As above, the former can generate the positive correlation between price and revenues across firms within a market, as well as across destinations with a firm. The latter, on the other hand, can match 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 generate a positive correlation between import and export prices and between import prices and export revenues. Similar patterns may emerge if input suppliers have market power: in that case, a positive demand shock could reduce exporters' elasticity of output and 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 f.o.b. prices in larger, richer and more distant markets. It also does not explain why the correlation between price and revenues is more positive for goods with a bigger scope for quality differentiation. Finally, it cannot rationalize the relationship between firms' range of import prices, range of export prices and export performance.

7 Conclusion

This paper examines the variation in export prices across firms, products and destinations to distinguish between alternative heterogeneous firm models of trade. We establish new stylized facts using detailed proprietary data on the universe of Chinese trading firms.

Our results are consistent with quality sorting across firms and firms varying both quality and mark-ups across destinations in response to market toughness. Evidence also suggests that firms produce multiple quality versions of a product by buying inputs of different quality levels. Since existing models assume either no quality differentiation across firms or no quality differentiation within a firm across trade partners, they are unable to explain the patterns we document. Our findings thus point to previously unexplored dimensions of firm heterogeneity and adjustments on the quality margin within firms across destinations.

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 adjusting trade volumes, product scope and export destinations, firms might also vary product quality within and across markets in response to trade liberalization. This would have implications for the effects of globalization on aggregate welfare and inequality.

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Table 1. Alternative Heterogeneous Firm Models

This table summarizes the predictions of different heterogeneous firm trade models. Each cell reports the predicted sign of the correlation between firm or average, product-level free on board prices with export revenues, export quantities, GDP or distance. 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	
	Relevant Papers	Export Revenue	Export Quantity	Export Revenue	Export Quantity	GDP	Distance	GDP	Distance
Efficiency sorting, CES demand	Melitz (2003)	-	-	0	0	0	0	+	-
Efficiency sorting, linear demand	Melitz-Ottaviano (2008)	-	-	-	-	-	-	-	-
Quality sorting, CES demand	Baldwin-Harrigan (2007), Johnson (2007), Kugler-Verhoogen (2008), Verhoogen (2008)	+	-	0	0	0	0	-	+
Quality sorting, linear demand	Kneller-Yu (2008), Antoniades (2008)	+	-	-	-	-	-	+/-	+/-
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 and distance 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 175 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	0.011	-0.002	0.016	-0.000	-0.026	-0.027
	(4.34)***	(-0.78)	(6.78)***	(-0.09)	(-6.55)***	(-6.87)***
(log) Distance	-0.015	-0.021	0.016	0.039	-0.096	-0.096
	(-3.07)***	(-4.15)***	(2.83)***	(6.71)***	(-12.16)***	(-11.83)***
(log) GDP per capita		0.027		0.067		0.003
		(9.34)***		(14.96)***		(0.44)
Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.853	0.854	0.854	0.855	0.876	0.876
# observations	242,311	242,065	162,011	161,765	80,300	80,300
# product clusters	6,879	6,879	6,774	6,773	5,857	5,857
# destinations	175	174	88	87	87	87

Table 4. Variation in Export Prices Across Firms in A Destination

This table examines the relationship between firm 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. All regressions include a constant term and destination-HS-8 product pair fixed effects, 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)
(log) Revenue	0.081 (70.07)***		0.036 (9.36)***	0.077 (54.61)***	0.065 (35.32)***
(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)***
Destination-Product FE	Y	Y	Y	Y	Y
R-squared	0.744	0.773	0.729	0.741	0.741
# observations	2,179,923	2,179,923	1,494,839	2,130,413	2,139,735
# dest-product pairs	258,056	258,056	163,873	247,867	249,874

Table 5. Firms' Export Prices and Worldwide Export Revenues

This table examines the relationship between firms' export prices and worldwide export revenues. 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 table also explores how the correlation between export price and revenues varies across products with different scope for quality differentiation. 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. 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)
(log) Revenue	0.094 (49.25)***		0.040 (14.15)***	0.097 (48.26)***	0.091 (47.14)***	0.085 (41.31)***
(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)***
Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.644	0.671	0.642	0.637	0.637	0.637
# observations	898,247	898,247	619,357	871,596	871,596	875,097
# products	6,908	6,908	4,276	6,182	6,182	6,252
# firm clusters	96,522	96,522	84,464	93,514	93,514	94,005

Table 6. Firms' Average Export Price and Number of Export Destinations

This table examines the relationship between firm export prices and number of destinations, by firm and HS-8 product. The outcome variable is the (log) average free on board export price, constructed as the ratio of worldwide revenues and quantities exported by firm and product. The table explores the variation across products with different scope for quality differentiation, as 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.

Dependent 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) Revenue x R&D Intensity					0.428 (2.43)**	
(log) Revenue 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

Table 7. Firm Export Prices and Destination Characteristics

This table examines the effect of destination market size, income and distance on firm export prices. It exploits the variation in prices across destinations within firm-product pairs, 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	0.012 (12.51)***	0.006 (6.61)***	0.014 (14.73)***	0.009 (9.27)***
(log) Distance	0.017 (6.75)***	0.017 (6.68)***	0.014 (5.16)***	0.013 (5.05)***
(log) GDP per capita		0.016 (11.04)***		0.016 (11.34)***
Market Share			0.065 (12.54)***	0.067 (13.08)***
Firm-Product FE	Y	Y	Y	Y
R-squared	0.954	0.954	0.954	0.954
# observations	2,098,551	2,098,228	2,098,551	2,098,228
# product clusters	6,879	6,879	6,879	6,879
# firm-product pairs	869,159	869,065	869,159	869,065
# destinations	175	174	175	174

Table 8. Firm Export Prices Across Destinations and Willingness to Pay for Quality

This table examines the differential effect of market size and distance on firm export prices across destinations at different income levels. It exploits the variation in prices across destinations within firm-product pairs, 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	-0.012	0.005	-0.009
	(-2.64)***	(0.38)	(-1.54)
(log) GDP x	0.001	0.000	0.001
(log) GDP per capita	(3.21)***	(0.34)	(1.90)*
(log) Distance	-0.131	-0.053	-0.154
	(-8.68)***	(-1.00)	(-7.55)***
(log) Distance x	0.016	0.007	0.019
(log) GDP per capita	(9.09)***	(1.20)	(7.88)***
(log) GDP per capita	-0.148	-0.047	-0.162
	(-8.27)***	(-0.93)	(-6.91)***
Firm-Product FE	Y	Y	Y
R-squared	0.954	0.958	0.949
# observations	2,098,228	125,455	1,315,367
# product clusters	6,879	1,311	2,951
# firm-product pairs	869,065	58,715	541,261
# destinations	175		

Table 9. Variation in Export Prices Across Destinations Within A Firm

This table examines the relationship between firm 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. 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)
(log) Revenue	0.021 (34.52)***		0.020 (34.37)***	0.015 (7.01)***	0.018 (24.09)***	0.017 (14.76)***
(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)***
Firm-Product FE	Y	Y	Y	Y	Y	Y
R-squared	0.954	0.957	0.954	0.950	0.953	0.953
# observations	2,179,923	2,179,923	2,179,923	1,494,839	2,130,413	2,139,735
# firm-product pairs	898,247	898,247	898,247	619,357	871,596	875,097

Table 10. Firms' Menu of Export Prices and Number of Export Destinations

This table examines the relationship between the menu of firm export prices and the number of destinations, by firm and HS-8 product. The outcome variable is the standard deviation of the (log) export price across destinations within firm-product pairs with more than one destination. The table explores the variation across products with different scope for quality differentiation, as 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.

Dependent 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) Revenue x R&D Intensity					0.248 (3.21)***	
(log) Revenue 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 11. Firms' Import Prices and Export Performance

This table examines the relationship between firm import prices, export performance and export prices for the subset of Chinese exporters that also import. 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 the (log) import prices across source countries within a firm and HS-8 product pair. All regressions in Panels A and B include HS-8 product fixed effects and cluster errors by firm. The dependent variable in Panel C is the standard deviation of the (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 (log) average 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 the (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	0.043 (11.08)***			
(log) # Export Destinations		0.031 (4.27)***		
(log) Average Export Price			0.059 (13.58)***	
St. Dev. of (log) Export Price				0.355 (24.01)***
Product FE	Y	Y	Y	Y
R-squared	0.689	0.688	0.671	0.690
# observations	1,553,199	1,553,199	513,508	1,475,008
# products	6,712	6,712	6,121	6,668
# firm clusters	58,337	58,337	15,419	52,508

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	0.018 (10.60)***			
(log) # Export Destinations		0.053 (17.22)***		
(log) Average Export Price			0.010 (4.81)***	
St. Dev. of (log) Export Price				0.101 (16.59)***
Product FE	Y	Y	Y	Y
R-squared	0.208	0.211	0.193	0.209
# observations	234,672	234,672	75,729	225,290
# products	5,117	5,117	4,175	5,068
# firm clusters	31,176	31,176	8,551	28,835

Table 11. Firms' Import Prices and Export Performance (cont.)

This table examines the relationship between firm import prices, export performance and export prices for the subset of Chinese exporters that also import. 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 the (log) import prices across source countries within a firm and HS-8 product pair. All regressions in Panels A and B include HS-8 product fixed effects and cluster errors by firm. The dependent variable in Panel C is the standard deviation of the (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 (log) average 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 the (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: st. dev. of (log) import prices within a firm across source countries and HS-8 products

	(1)	(2)	(3)	(4)
(log) Total Firm Exports	0.023 (18.04)***			
(log) # Export Destinations		0.044 (17.90)***		
(log) Average Export Price			0.057 (40.51)***	
St. Dev. of (log) Export Price				0.320 (69.23)***
R-squared	0.007	0.006	0.109	0.096
# observations (# firms)	49,934	49,934	13,407	45,203