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FIRM HETEROGENEITY, IMPORTED INPUT QUALITY, AND EXPORT PRICING IN INDIA

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ABSTRACT

Using a novel dataset we examine the pricing behavior of Indian exporters, in particular looking at the relationship between export prices and firm capability (productivity) conditioning on the quality of imported inputs that firms use. Conditioning on firm productivity among firms that directly import, higher quality (higher price) imports are associated with higher quality (higher price) exports. We also find that export prices fall with firm capability, decrease with distance and increase with remoteness.

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I. Introduction

Our paper contributes to the literature on firm heterogeneity and export pricing by analyzing the behavior of Indian manufacturing firms. We extend an earlier paper (Anderson, Davies, Signoret, and Smith, 2016) by including the imported input choices made by Indian exporters to examine the relationship between export pricing and productivity, conditioning on the quality of imported inputs that firms choose.

Our analysis contributes to a small literature that includes analyses of Manova and Zhang (2012) and Kugler and Verhoogen (2012), both of which examine export pricing and input quality choice. This is a subset of a broader literature which examines the pricing behavior of exporters (Harrigan, Ma, and Shlychkov, 2015; Bastos and Silva, 2010; Görg, Halpern, and Muraközy, 2010; Martin, 2012; Anderson, Davies, Signoret, Smith, 2016).

It is well known that exporting firms are different than non-exporters. As a group they are more productive, larger in size, and more capital intensive—see, for example, Bernard *et al* (2007). We find that, among our sample of Indian exporters, a similar set of distinctions exist between firms that import (that is, directly purchase goods from abroad) and firms that export but do not directly import (though perhaps purchasing foreign-sourced goods from a domestic wholesaler). In Table 1 we see that exporters that also import (what we call “two-way traders”) are substantially more productive (by a factor of 15 percent), larger (by a factor of 200 percent), and have a 46 percent higher level of value added per dollar of wage bill than firms that only export. Moreover, we find that two-way traders sell more goods, to more destinations, and to more rich (OECD) destinations than firms that do not directly import (see Table 2).

There are a number of possible reasons for this distinction. Instead of buying from a domestic wholesaler, these firms directly source products from abroad, an expensive activity involving searching for suppliers, working at a distance to contract for products of particular characteristics, and bearing the contracting risk that comes from those activities. The costs are presumably balanced by expected benefits that may include greater input variety, higher quality and more control over quality. The purpose of this paper is to examine this distinctive group of Indian exporters in our sample, and in particular to examine the relationship between the quality of their directly-sourced imports and the quality of their exports.

We measure the overall quality of a firm's imported inputs with an index based on prices of the goods it imports. We calculate an annual z-score for the price the firm pays for each imported input, based on the distribution of prices paid for that input across all firms in a given year. Our index number for the firm is then the import value-weighted mean z-score (across the firm's entire import bundle) in a given year, which we call its sigma score. In addition to capturing the relative value (i.e. quality) of a firm's imported inputs, this measure, we believe, proxies the quality of the firm's total input bundle from both domestic and international sources.

We find evidence that exporting firms that also directly import have economically important differences in the quality (higher price) of their exported goods; moreover, export quality (prices) rise with the quality of imported inputs. It is important to note that these results control for firm productivity. We find that for constant productivity, firms that import higher quality inputs charge higher export prices; but keeping imported input quality constant, high productivity firms charge lower prices. In future analysis we will examine more closely how firm capability interacts with the firm's choice of input and output quality.

The paper proceeds as follows. The next section is a short literature review and Section III discusses the theory. We describe our data in Section IV, Section V presents results which are discussed in Section VI. Section VII concludes.

II. Literature Review

This paper fits into a new and vibrant literature that examines the relationship between firms' inputs quality choices and their exporting behavior.

Using data from the Colombian manufacturing census, Kugler and Verhoogen (2012) find a positive correlation between both output and input prices and plant size; this positive correlation is also evident for export status. Using an industry index of advertising and research and development (R&D) intensity as a measure of the scope for quality differentiation, they find a positive relationship between output prices and plant size, and input prices and plant size, which is stronger for sectors in which the scope for quality differentiation is higher. They match these empirical findings to a modification of the Melitz (2003) model which incorporates endogenous choice of output and input quality, which predicts the matching of more capable producers and higher quality inputs to produce higher quality outputs.

Bastos, Dias, and Timoshenko (2016) introduce a temporal dimension and propose a dynamic model in which firms make adjustments to input and output quality choices as they learn about demand in a particular destination. Using Portuguese manufacturing data, they find that firms with more export experience in a destination ship larger quantities at lower prices to that destination, and that firms with more overall export experience buy more expensive inputs. They also find that revenue growth declines with export experience within a destination, and input prices and quantities increase with revenue growth for firms. They explain these results as follows: as an average surviving firm learns and updates its demand expectations upwards it upgrades the quality of its outputs using higher quality inputs. Higher quality inputs are more expensive leading input prices to rise with export experience. Output prices may increase or decrease, as quality-upgrading leads to higher prices because of more expensive inputs, however higher demand increases profitability which can lead to price reductions.

Bastos, Silva, and Verhoogen (2016) propose and find support for what they call the income-based quality-choice hypothesis using Portuguese data, which states that firms increase the average quality of their goods, purchasing higher-quality inputs in response to an exogenous increase in average destination income. Since export prices may reflect mark-ups as well as quality, they focus on how input prices, which do not have markups, respond to exogenous increases in the destination country's income. The positive relationship between input prices and destination income holds when controlling for export share, distance, and total firm sales, and this in interpreted as using higher-quality inputs firms sell higher-quality goods to richer countries.

Bas and Strauss-Kahn (2016) look at the effect of input trade liberalization on imported input prices and exported good prices. Using Chinese data they find that following the input trade liberalization firms increase the number of varieties of imported inputs and the prices they pay for them, and also that firms increase export prices. This suggest that firms use input tariff reductions to upgrade to higher quality inputs so they can produce higher quality exports, and thus that there is positive relationship between imported input and export prices.

Hallak and Sivadasan (2013) add an extra dimension to firm heterogeneity including not only the usual measure, called “process productivity,” but also “product productivity” which reflects a firm’s ability to quality upgrade with a fixed outlay. Conditioning on size, and assuming that iceberg trade costs decrease with quality, their model predicts that exporters sell high quality goods and charge higher prices, pay higher input prices and wages, and are more capital intensive. They find support for their model using data from the U.S., Chile, India, and Colombia.

Using Chinese firm and product data at the HS 8-digit level, Manova and Zhang (2012) find that successful exporters earn more revenue in part by charging higher unit prices and by exporting to more destinations than less successful exporters. Even within narrowly-defined product categories, firms charge higher unit prices to more distant, higher income, and less remote markets. Manova and Zhang argue that firms’ product quality is as important as production efficiency in determining these outcomes.[1]

Whang (2014) looks at the role of product quality differences to explain opposing spatial patterns across destinations of within-product export unit values for four countries. He finds that unit prices of goods exported from the U.S. and Korea increase with distance and decrease with destination market size, while for China and India these relationships have the opposite sign. He explains this pattern with a Melitz-style model that included products differentiated by quality, and skill differences for workers with higher skill more productive at improving product quality, and a wage schedule that varies across countries. The model predicts that skill-abundant

[1] Manova and Zhang (p.2) present evidence that not only do successful exporters produce higher quality goods (with higher quality inputs), but that firms adjust product quality according to characteristics of the destination market. In particular, they find that the higher unit values associated with higher distance to destination markets and with serving more destinations are due to compositional shifts within narrow product categories towards higher product quality and higher quality inputs.

countries are more competitive in high-quality products and export at higher prices to more competitive countries, while skill-scarce countries are more competitive in low-quality products and export lower priced goods to less competitive locations.

Grazzi and Tomasi (2016) explore how firms' productivity is associated with direct and indirect exporting, and direct and indirect importing. Using data across a wide range of countries they find that that act of trading directly, exporting and importing, has a strong positive association with firm productivity. Moreover they find that two-way traders that both directly export and import are the most productive of all firms.

III. Theory

Kugler and Verhoogen (2012) model endogenous input and output quality choice by extending Melitz (2003). They do this by adding an intermediate-input sector which transforms labor into intermediate inputs which vary by quality. They set up the intermediate good sector so that the price of each intermediate input equals its marginal cost, so that the price per unit of quality for each good is unitary.

They provide two variants to describe how plant capability and input quality relate. In Variant 1 they assume the relationship to be complementary. This implies that the "marginal increase in output quality for a given increase in input quality is greater for more capable producers" (p. 322). In the second variant, it is assumed that high-quality output requires the use of high-quality inputs and that there is a fixed cost of quality upgrading. Because firm capability and firm size are assumed to be perfectly correlated, high capability firms produce at a higher scale and can spread the fixed costs of quality over more units than smaller / less capable plants.

In both variants the authors assume that the scope for quality differentiation is high, meaning that the relationship between prices and productivity is positive. Thus, higher capability plants use higher-quality inputs and produce higher-quality outputs. The restriction that the scope for quality differentiation is high is a drawback and makes the model less suitable for our purposes because the result for India in Anderson *et al.* (2016) suggests a negative relationship between output prices and productivity.

We propose to modify the theoretical framework of Antoniades (2015) to include input choice. This would give additional flexibility over Kugler and Verhoogen's model, which restricts the scope for quality differentiation to high, imposing that the relationship between export prices and firm capability is positive. Since the result in our previous work finds a negative relationship between productivity and price, a more flexible framework is required.

IV. Data

Tests of the theoretical literature discussed above require detailed trade data at the level of the individual firm. One contribution of our paper is that we have constructed such a detailed firm-level price, good, destination and firm characteristics dataset for Indian trade. We present an overview here of the sources and procedures we used, and refer interested readers to Data Appendix 1 for details.

We assemble our data from several sources. Detailed firm-level daily transactions data for Indian exporters come from TIPS, a database collected by Indian Customs. TIPS contains detailed export data including the identity of the exporter, the date of transaction, the product type by 8-digit HS code, destination country, exit and destination port, and the quantity and the value of the export. We have useable data for four full fiscal years, 2000-2003, which cover the transactions at eleven major Indian seaports and airports.[2,3] For the purpose of our analysis we aggregate the data to fiscal-year shipment values and quantities by firm and product.

We measure export prices as unit values: export revenue by product category divided by the number of units exported in that category. Though the TIPS data are reported at an HS 8-digit level of detail, our data allows us to define a "product" at a much finer detail than that, a level we refer to as "HS 8-plus." At this fine level of differentiation, the rich detail of the TIPS side of our merged data allows us to distinguish a firm's pattern of prices for an identical good across different destination countries.

For firms that import intermediate inputs, we measure the relative quality of those imports with the sigma index discussed in the introduction. Using TIPS import data—aggregated as described above for export data—we calculate an annual z-score[4] for the price a firm pays for each imported input (relative to the universe of prices paid for that good by all importing firms in TIPS), and then calculate an annual import value-weighted mean z-score across the firm's import bundle each year. The higher is sigma, the higher is the relative price (and, by implication, the quality) of the firm's imported inputs. In what follows we use two versions of sigma: one calculated on the firm's imports overall, the other on capital goods imports only.

Detailed firm-level data comes from Prowess, a proprietary database of Indian firm characteristics.[5] The dataset contains time series information on approximately 23,000 large- and medium-sized firms in India, and includes all companies traded on India's major stock

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[2] Indian fiscal years run from April 1 through March 31; the actual data run from April 1999 through March 2003.
[3] All told, TIPS records more than 5.8 million export transactions over 1999-2003.
[4] That is, the standardized value of the price, (realized value minus mean)/standard deviation.
[5] Previous firm-level research for India using the Prowess database include Goldberg, Khandelwal, Pavcnik, and Topalova (2010b), Topalova and Khandelwal (2011), and Ahsan (2013).

exchanges as well as other firms, including the central public sector enterprises. Its broad swath of Indian firms pay around 75 percent of all corporate taxes and over 95 percent of excise duties collected. From Prowess we derive information on employment, labor and capital use, expenses on intermediates, and other firm-level variables for manufacturing firms (our sector of interest). We use this information to estimate annual firm productivity with the Levinsohn-Petrin technique, which we convert to index form (by NIC 4-digit industry) using the Aw, Chen and Roberts (2001) method.

While Prowess contains information on overall foreign sales, it lacks information as to the products exported, their destination markets, and their export unit prices. Matching firms between TIPS and Prowess brings these additional dimensions.[6] The results in this paper are based on matched dataset of 1,098 unique manufacturing firms. All of these firms export at least one good to one destination every year. But not all of them import; we call a firm a "two-way trader" in a particular year if it imports at least one good from one destination. There are 898 two-way traders and 310 exporter-only firms in the sample, where these counts include 110 firms that switch status from one year to another.

From the online appendix of Kugler and Verhoogen (2012) we obtain a measure of industry advertising and R&D intensity based on Sutton (1995). We match the authors' 4-digit ISIC industry classification to the Indian 4-digit NIC by visual inspection. Finally, we use country characteristic data (income, population, and distance from India) from the publicly available CEPII Gravity database (Head, Mayer, and Ries, 2010) to control for features of import sources and export destinations. Table 3 summarizes the data in the final estimating sample.

[6] This trade-by-enterprise-characteristics database is part of a wider effort by USITC staff to examine trade and firm dynamics in the context of rapidly emerging economies.

V. Results

First results are presented in Table 4. The dependent variable in all regressions is the natural log of the export price, and all regressions include product-level (HS8+) fixed effects and standard errors clustered by destination market. All are estimated in double-log form in OLS, though the selection correction involves a non-linear step prior to the regressions reported here.

The top panel presents destination and firm characteristics. The vector of destination characteristics (X_d) includes GDP per capita, GDP, distance to India, and destination remoteness; the vector of firm characteristics includes (X_f) includes total factor productivity, capital-labor ratio, and size as proxied by the wage bill. The second panel presents our measure of whether a firm is an importer, and a variety of measures of import prices (quality) discussed below. The bottom panel of the table presents economic significance calculations for the importer indicator variable and for the sigma variables; this is, in each case when the beta-hat on the sigma variable is statistically significant, a calculation of the predicted percentage change in export prices for a one-standard-deviation change in the measure of the prices paid for imports.

Column 1 is a baseline regression; it includes X_f , X_d, and our selection correction variable.[7] This first regression includes the entire sample of firms, two-way traders (exporters that also import) and firms that only export.

There is clear evidence here, and in subsequent regressions, that more productive exporters have lower prices than less-productive firms: the coefficient on the log of TFP bears a

[7] All presented regression results are corrected for the decision of a firm to enter into an export market, the procedure for which is detailed in Appendix 2. Non-corrected results are available from the authors.

negative sign. Moreover, prices decline with distance and rise with remoteness (the coefficient on the log of distance bears a negative sign, and that on the log of remoteness a positive sign). These results stand in contrast with a broad literature that finds the opposite signs for these variables when exporters from other countries are examined. When the scope for quality differentiation is low the relation between prices and productivity is negative, as seen here, and when it is high, as seen elsewhere in the literature, the relationship between quality and productivity is positive. See Anderson *et al.* (2016) for more detailed empirical results and theoretical context for these results.[8]

In the baseline and subsequent regressions firm size (log labor) is positively associated with export prices, and there is evidence that destination market characteristics are related to export prices; coefficients on the log of GDP per capita and GDP both bear a positive sign. The results on labor and the GDP variables are common across the literature on firm export prices.

Column 2, also estimated on the entire sample, augments column 1 with a dummy variable for a firm's "two-way" status each year. The other coefficients in the regression are not much affected by the inclusion, but there is strong evidence that the status as an importer is related to export prices. Exponentiated, the beta-hat at 0.296 predicts a 34 percent increase in export price. One puzzle here is that the result is very sensitive to the definition of who is an importer. The variable two-way takes on a value of one only if a firm, in a given year, is an importer in our dataset. If we instead define the variable to take on a value of 1 if the firm is an importer in any year, the variables loses statistical significance.[9]

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[8] The scope for quality differentiation reflects the firm's ability to recoup the cost of quality upgrades.

[9] In our data we measure import status from a sample of ports available to the firm, so it makes sense to us to say that any evidence that the firm is ever an importer (if there are data on importing for any year in the sample) means

Columns 3 through 6 present regressions that include one or another measure of import quality, and each column presents results estimated only on firms that both export and import. These results are the main contribution of this paper. Column 3 includes sigma_overall, which is our firm-level measure of the price paid by the firm for imports. Recall that this variable is the firm's import-share-weighted Z-score of the prices paid for imports, our measure of import-product quality. Column 4 includes the weighted sigma_overall variable (labelled "weighted_s_o") defined as the product of sigma_overall and the share of the firm's imports in its value added, to reflect the scale of the firm's imported inputs. Both measures are statistically significant and economically important. Unweighted, a one-standard-deviation change in sigma_overall is associated with a 9.9 percent increase in export prices; weighted by imports to value-added (column 4) the effect is a 4.4 percent change in export prices. [10] By themselves these results suggest that import quality matters for export quality (export prices).[11]

We next include our measures of the quality of imported capital goods (unweighted and weighted) in columns 5 and 6. This variable is perhaps more closely linked to direct imports of the firm's inputs than is the sigma_overall variable because it is less likely to measure imports

the firm should be treated as an importer. We are therefore puzzled by the dramatic change in statistical significance between one measure and the other.

[10] Note that a one-standard deviation in any of our sigma measures is a one standard deviation move in the distribution of sigmas, not literally a one-unit move in this sigma.

[11] Our use of sigma (weighted or unweighted) is subject to two critiques: First, our estimate of sigma's relationship with export prices will be biased if our measure of firm productivity is itself a biased measure of firm capability. Firms with higher productivity will source higher quality inputs from abroad, and only by controlling for productivity can we claim to measure the relationship between export quality (price) and import quality. If, for example, firms are more capable (more productive) than our TFP index indicates, then our sigma variable will act as a proxy for the unmeasured component of productivity, leading to an upward bias in the beta-hat on sigma. While it is possible that our approach suffers from this problem, there are only two extant approaches to solving the TFP estimation problem (Levinsohn-Petrin, and Olley-Pakes (1996) with its associated literature) and we choose the former. Second, sigma measures the quality of directly imported inputs. Firms will also import inputs indirectly, through local wholesalers, and they will also source inputs domestically. The quality, or price, of firm exports is plausibly linked to these indirectly or domestically sourced imports. Moreover, we suspect that firms that source high quality inputs directly from abroad also purchase high-quality inputs from other sources, and thus sigma in our regressions should be thought of as a proxy for the quality of inputs generally.

for other purposes (like resale to consumers or other firms). In column 5 our measure of imported capital goods prices (sigma_overall_c) is statistically and economically significant. A one-standard-deviation change in this variable is associated with a 6.6 percent change in export prices. When weighted by the firm's share of imported capital goods in value added, we again see a relationship with export prices. A one-standard-deviation change in this version of capital goods quality is associated with an 8.1 percent increase in export prices.

In Table 5 we break our firms into three groups according to their respective industry's ranking in advertising and R&D intensity according to the Sutton index referenced earlier. This variable is a measure of the scope for quality differentiation for firms in a given industry, which determines a firm's ability to recoup the cost of quality upgrades. As the scope for quality differentiation increases quality ladders become steeper as firms choose larger quality upgrades.[12] In this table, then, we examine how the effect of imported-input quality on export prices is itself affected by an industry's capacity for quality upgrading.

Column 1 presents the results for firms whose industries are in the bottom quartile of this variable, column 2 firms are in industries that inhabit the inter-quartile range, and column 3 firms are from industries in the top quartile. Columns 1-3 all include our measure of import quality, sigma_overall. Columns 4-6 repeat the order of firms and industries (bottom quartile, IQR, top quartile) and we replace the unweighted sigma with weighted sigma_overall.

Columns 1-3 in Table 5 should be compared to column 3 in Table 4; columns 4-6 in Table 5 should be compared to column 4 in Table 4. What is immediately apparent is that Table 4's results are driven by firms contained in top quartile industries for advertising and R&D

[12] The larger is the Sutton index the greater is the capacity for quality upgrading. Defined at an industry level, it applies to all firms in an industry and therefore to the whole set of products those firms produce.

intensity. Column 3 (top quartile industries) shows an economically and statistically significant relationship between sigma_overall and export prices; the economic significance of this variable rises from the overall value of 9.9 percent (Table 4 column 3) to 27.8 percent. Interestingly, we also see a much larger effect of TFP on export prices in this subset. There is no economically or statistically significant relationship between TFP and export prices, nor between weighted imported input prices and export prices, for firms in industries with a lower scope for quality upgrading (according to results in column 1 (first quartile) and column 2 (IQR)).

Columns 4-6, using the weighted version of sigma_overall, are less informative about the relationship between imported input prices and export prices. The weighted sigma_overall variable is statistically insignificant in all three cases. Interestingly, column 6 (top quartile) again shows the largest effect of TFP on export prices.

Table 6 repeats the experiment of Table 5, this time using imported capital goods prices in the weighted and unweighted sigmas. The results are very similar to what we say in Table 5, namely that firms in the top quartile of industries for advertising and R&D spending seem to drive the results for the unweighted measure of capital goods prices – column 3 shows a very large economic relationship where a one-standard deviation in imported capital goods prices is associated with a 23 percent increase in final-goods prices. Here also we find a very large association between firm TFP and export prices. Finally, columns 4-6 do not show a similar pattern as 1-3, though in column 6 we do again see the large association between firm TFP and export prices.

VI. Discussion

There are a number of clear patterns that emerge from the regressions that include both productivity and import prices. Our main finding: the relationship between export prices and imported input prices (sigmas) is positive and significant, and this matches evidence from Kugler and Verhoogen (2012), Manova and Zhang (2012), Bas and Strauss-Kahn (2016), Bastos, Dias, and Timochenko (2016) and Bastos, Silva, and Verhoogen (2016). This suggests that higher quality outputs require higher quality inputs for Indian firms as much as for firms in China, Columbia and Portugal. These results are consistent with a Kugler and Verhoogen's (2012) modified version of the Melitz (2003) model that includes input quality choice. [13] In addition, export prices are negatively correlated with productivity, conditioning on our measure of input quality.

We also find that the coefficient on distance is consistently negative and the coefficient on remoteness is positive. This does not fit with Manova and Zhang (2012) or Harrigan *et al* (2015) who find that prices are increasing in firm capability, increasing in distance and decreasing in remoteness. Both sets of results can be explained by the relationship between prices and quality. In Manova and Zhang (2012) and Harrigan *et al* (2015) prices are increasing in quality. Since prices per unit of quality are falling as quality increases, the most competitive goods are the highest-priced goods, so they make it to the most distant and least remote markets. In this paper and also in Anderson *et al.* (2016), prices are decreasing in quality, and so the most

[13] In future work with this data, we will directly explore the extent to which more capable firms use higher quality (higher priced) inputs.

competitive goods have the lowest prices, and thus the lowest-priced goods make it to the most distant, and least remote, markets.

The coefficients on TFP are negative and significant. This stands in contrast to results in Kugler and Verhoogen (2012) and Manova and Zhang (2002), however this fits with the results and theoretical model in Bastos, Dias, and Timochenko (2016). It should be noted that in Kugler and Verhoogen (2012), and Manova and Zhang (2002), firm capability is measured by firm size whereas here it is measured by TFP. Like those studies we find that the coefficient on firm size is consistently positive and significant. Since firm size is correlated with firm capability, overall this evidence supports the notion the more capable firms are choosing higher quality inputs.

One of the puzzles in these results is that as the scope for quality differentiation (as measured by the Sutton index) increases the coefficient on TFP becomes more negative. This can be seen in Tables 5 and 6 comparing columns (1) and (2) with column (3). This is counter to results from Kugler and Verhoogen (2012) but can be explained by Bastos, Dias and Timochenko (2016). In these tables we are sorting firms according to the scope for quality differentiation in their industries. As the scope for quality differentiation increases firms are able to choose larger quality upgrades and quality ladders steepen. This would suggest that the coefficient on TFP should become more positive. Here is one possible answer to the puzzle: if firms in the industries with the highest scope for quality differentiation are also the most productive then while they are choosing larger quality upgrades they also have lower costs, and it is the latter effect which dominates, leading to lower prices overall.

VII. Conclusion

Using a novel dataset we examine the pricing behavior of Indian exporters, in particular looking at the relationship between export prices and firm capability (productivity) conditioning on the quality of inputs that firms use. We find that for firms that directly import there is a positive relationship between the quality (price) of their imported inputs and the quality (price) of their exports. We also find that export prices increase with firm capability, decrease with distance and increase with remoteness. These latter results contrast with those found in Manova and Zhang (2012), Harrigan *et al* (2015) and are consistent with Anderson *et al.* (2016).

Table 1. Firm Characteristics by Import Status

Characteristic	Mean, Two-Way Traders, n = 898	Mean, Exporters Only, n = 310	Ratio, Two-Way Traders to Exporters-Only
Employment	141.8	47.4	2.99
Capital-Labor Ratio	18.2	17.7	1.03
TFP (index)	133.2	115.6	1.15
Value Added/Employment	11.2	7.7	1.46

Table 2. Exporter Behavior by Import Status

Category	Two-Way Trader Median	Two-Way Trader Mean	Exporter Only Median	Exporter Only Mean
Number of Products Exported	5	12.0	3	6.0
Number of Destinations	4	7.4	3	5.0
Number of OECD Destinations	1	2.7	1	1.4

Table 3A. Descriptive Statistics on Estimating Sample, in Levels

n = 25,962 unless otherwise noted

Variable	Label	Mean	St. Dev.	Min.	Max.
Capital, $1,000	K	2,059	11,701	0.49	252,860
Labor	L	190	848	0.06	16,673
TFP Index	tfp	147	94	21	552
K/L ratio, $1,000 per person	Klabor	13.8	17.3	0.2	584.1
Distance to export destination, km	dist_d	5,826	3,562	683	16,937
Remoteness of export destination	remote_d	0.0002	0.0001	0.00003	0.0004
GDP of export destination, $1,000,000	gdp_d	1,225,705	2,747,877	147	10,400,000
GDP per capita of export destination, $	gdppc_d	13,255	12,285	86	50,987
Export price, $	xPrice	822	10,838	0.00000004	970,000
Sutton R&D-Advertising intensity index	S	0.06	0	0.002	0.166
Rauch industry differentiation index	R	0.71	0	0	1
Sigma overall	sigma_overall	0.62	2	-4.76	12
Sigma overall, capital goods	sigma_overall_c	0.25	1.52	-6.09	8.89
Import-weighted sigma overall	weighted s_o	867	14,793	-256,708	393,537
Import-weighted sigma overall, capital goods	weighted s_o_c	-122	14,135	-301,282	396,046
"Two-way trade" dummy	two_way	0.87	0.33	0	1

Note: n = 22,672 for sigma_overall and weighted_s_o, and n = 22,047 for sigma_overall_c and weighted_s_o_c.

Table 3B. Descriptive Statistics on Estimating Sample, in Natural Logs

Variable	Label	Mean	St. Dev.	Min.	Max.
Capital, $1,000	k	6.06689	1.62658	-0.71784	12.44059
Labor	l	3.89142	1.60307	-2.79902	9.72154
TFP Index	ln_tfp	4.79768	0.64094	3.03994	6.31287
K/L ratio, $1,000 per person	ln_klabor	2.17547	0.92203	-1.65401	6.37007
Distance to export destination, km	ln_dist_d	8.48775	0.61696	6.52704	9.73723
Remoteness of export destination	ln_remote_d	-8.96888	0.69421	-10.44488	-7.89826
GDP of export destination, $1,000,000	ln_gdp_d	11.85817	2.22786	4.99269	16.15732
GDP per capita of export destination, $	ln_gdppc_d	8.59892	1.64917	4.45465	10.83932
Export price, $	ln_xPrice	1.65935	3.07118	-16.97723	13.78505

Table 4. Export Prices and Importer Characteristics/Behavior

Dependent Variable: ln(Export Price)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
ln_gdppc_d	0.154***	0.162***	0.0966***	0.146***	0.148***	0.146***
	(0.0286)	(0.0297)	(0.0238)	(0.0284)	(0.0279)	(0.0273)
ln_gdp_d	0.270***	0.291***	0.145***	0.271***	0.285***	0.273***
	(0.0462)	(0.0501)	(0.0239)	(0.0462)	(0.0491)	(0.0470)
ln_dist_d	-0.364***	-0.396***	-0.174***	-0.377***	-0.379***	-0.363***
	(0.0697)	(0.0749)	(0.0423)	(0.0671)	(0.0698)	(0.0672)
ln_remote_d	0.359***	0.391***	0.122***	0.338***	0.352***	0.336***
	(0.0726)	(0.0779)	(0.0447)	(0.0730)	(0.0758)	(0.0729)
ln_tfp	-0.210***	-0.216***	-0.221**	-0.168*	-0.206**	-0.204**
	(0.0798)	(0.0806)	(0.102)	(0.0973)	(0.0972)	(0.0968)
ln_klabor	0.0974	0.0834	0.109	0.101	0.0843	0.0863
	(0.0606)	(0.0593)	(0.0738)	(0.0729)	(0.0785)	(0.0787)
ln_labor	0.219***	0.215***	0.134***	0.214***	0.217***	0.215***
	(0.0384)	(0.0401)	(0.0370)	(0.0464)	(0.0470)	(0.0481)
two_way		0.296***				
		(0.0896)				
sigma_overall			0.0459**			
			(0.0176)			
weighted_s_o				2.29e-06**		
				(1.15e-06)		
sigma_overall_c					0.0424**	
					(0.0206)	
weighted_s_o_c						2.74e-06***
						(9.10e-07)
selection	0.230***	0.230***	0.249***	0.250***	0.249***	0.248***
	(0.0455)	(0.0455)	(0.0486)	(0.0487)	(0.0492)	(0.0492)
Observations	25,962	25,962	22,672	22,672	22,047	22,047
R-squared	0.869	0.869	0.871	0.871	0.870	0.870
Economic significance†	n.a.	34.4	9.9	4.4	6.6	8.1

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
† Defined as follows: (a) for the sigma variables, the percent change in export price for a one standard deviation increase in sigma; for two_way, the percent increase in export price for a firm that both imports and exports in a given year, compared to exporting but not importing.

Table 5. Effect of Import Behavior on Export Prices, by Industry Quartiles of R&D and Advertising Intensity

Using Sigma Overall in levels (sigma_overall) and weighted (weighted_s_o)

Dependent variable: ln(Export Price)

VARIABLES	Q1 (lowest) (1)	IQR (2)	Q4 (3)	Q1 (lowest) (4)	IQR (5)	Q4 (6)
ln_gdppc_d	0.0858***	-0.0230	0.109***	0.178***	-0.0337	0.110***
	(0.0253)	(0.0413)	(0.0295)	(0.0370)	(0.0408)	(0.0304)
ln_gdp_d	0.105***	0.217***	0.132***	0.260***	0.185***	0.124***
	(0.0247)	(0.0360)	(0.0329)	(0.0499)	(0.0341)	(0.0327)
ln_dist_d	-0.212***	-0.150*	-0.178***	-0.496***	-0.0931	-0.174***
	(0.0557)	(0.0855)	(0.0593)	(0.0960)	(0.0843)	(0.0604)
ln_remote_d	0.165**	0.159*	0.0837	0.391***	0.0988	0.0795
	(0.0685)	(0.0936)	(0.0721)	(0.101)	(0.0909)	(0.0729)
ln_tfp	0.0577	-0.0865	-0.547***	0.126	-0.0977	-0.521***
	(0.0922)	(0.199)	(0.151)	(0.0933)	(0.203)	(0.151)
ln_klabor	0.0375	-0.122	0.0748	0.0498	-0.117	0.0658
	(0.0523)	(0.180)	(0.105)	(0.0521)	(0.178)	(0.105)
ln_labor	0.152***	0.101	0.138**	0.226***	0.0816	0.178***
	(0.0512)	(0.0836)	(0.0573)	(0.0536)	(0.0827)	(0.0587)
sigma_overall	0.00376	0.0233	0.111***	-	-	-
	(0.0189)	(0.0228)	(0.0297)			
weighted_s_o	-	-	-	1.26e-07	6.28e-06	1.23e-06
				(9.47e-07)	(1.09e-05)	(1.50e-06)
selection	0.0823***	0.258***	0.329***	0.0823***	0.258***	0.329***
	(0.0150)	(0.0296)	(0.0772)	(0.0150)	(0.0295)	(0.0782)
Observations	7,804	5,046	9,822	7,804	5,046	9,822
R-squared	0.904	0.923	0.883	0.904	0.923	0.882
Economic significance†	-	- 4.4	27.8	0.2	6.8 -	3.0 -

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
† Defined as the percent change in export price for a one standard deviation increase in the level of the sigma variable, reported for statistically significant sigma coefficients only.

Table 6. Effect of Import Behavior on Export Prices, by Industry Quartiles of R&D and Advertising Intensity

Using sigma of capital goods imports, in levels (sigma_overall_c) and weighted (sigma_o_c)

Dependent variable: ln(Export Price)

VARIABLES	Q1 (lowest) (1)	IQR (2)	Q4 (3)	Q1 (lowest) (4)	IQR (5)	Q4 (6)
ln_gdppc_d	0.136***	-0.118***	0.0976***	0.179***	-0.0465	0.114***
	(0.0333)	(0.0384)	(0.0302)	(0.0394)	(0.0388)	(0.0304)
ln_gdp_d	0.194***	-0.00291	0.0889***	0.268***	0.181***	0.139***
	(0.0417)	(0.0298)	(0.0272)	(0.0539)	(0.0330)	(0.0357)
ln_dist_d	-0.349***	0.247***	-0.105*	-0.483***	-0.0770	-0.190***
	(0.0788)	(0.0885)	(0.0622)	(0.0994)	(0.0850)	(0.0608)
ln_remote_d	0.299***	-0.291***	4.87e-05	0.405***	0.0719	0.0982
	(0.0966)	(0.0837)	(0.0721)	(0.112)	(0.0899)	(0.0754)
ln_tfp	0.0817	-0.213	-0.612***	0.116	-0.145	-0.555***
	(0.0915)	(0.198)	(0.142)	(0.0932)	(0.200)	(0.142)
ln_klabor	0.0284	-0.100	0.0458	0.0368	-0.124	0.0432
	(0.0586)	(0.186)	(0.106)	(0.0591)	(0.184)	(0.108)
ln_labor	0.185***	-0.0359	0.113*	0.220***	0.0733	0.197***
	(0.0484)	(0.0780)	(0.0590)	(0.0516)	(0.0821)	(0.0575)
sigma_overall_c	0.0125	-0.0415	0.142***	-	-	-
	(0.0185)	(0.0348)	(0.0401)			
weighted_s_o_c	-	-	-	1.06e-06	1.99e-06	2.11e-06†
				(8.39e-07)	(4.42e-06)	(1.51e-06)
selection	0.0833***	0.257***	0.325***	0.0826***	0.258***	0.325***
	(0.0158)	(0.0293)	(0.0782)	(0.0154)	(0.0294)	(0.0794)
Observations	7,508	4,866	9,673	7,508	4,866	9,673
R-squared	0.908	0.920	0.882	0.908	0.920	0.881
Economic significance††	-	-	23.0	-	-	8.6

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; † p < 0.1, one-tailed test.

††Defined as the percent change in export price for a one standard deviation increase in the level of the sigma variable, reported for statistically significant variables only.

Appendix 1. Data construction and "HS 8-plus" level of product detail

Our main analysis relies on a merged dataset built by a firm-by-firm match of TIPS and Prowess data. TIPS data required considerable preparation for this merge, over and above simply aggregating its daily data to a fiscal year basis.

Consider firm names, which are recorded by hand at the point of collection (ports) with occasional spelling errors and frequent variants. We use two fuzzy-logic routines, Levenshtein distance and bigram comparisons, to match firm names in the sample. Some matches were done by hand based upon values in the fuzzy-logic comparisons.

Wholesalers are excluded for the sake of focusing on the trading behavior of production firms, which require several data-filtering criteria. If the firm name contains "EXIM" or other key words it is removed from the sample.[14] In addition, we exclude firms that export goods in more than nine two-digit HS chapters.

Although the TIPS data are reported at the 8-digit HS level, we use the firm's own product labels to obtain the actual product lines used in this study. For example, to take a non-manufacturing example, instead of looking at the unit value of 8-digit HS code 09101020 that includes a variety of spices, we are able to use the product labels to obtain the unit value, or price, of "curry powder" and "ginger" and other similar fine-grained prices. The result is something much more detailed than 8-digit data.[15] When this process is complete the mean

[14] The entire list of key words is: Exporter, Importer, Trading, Trader, Export, Import, IMPEX, and EXIM.
[15] In brief, here is how we obtained that information: Within each of the 16,109 8-digit categories, the median number of (reported) individual product lines is 8, and the mean is 166. In some cases the product-level labels are variants of names for the same product, differing only in punctuation, capitalization, or word order. Sometimes these differences are present along with changes in the product description; thus we may see "Curry Powder" and "SPICE CURRYPOWDER" describing what appear to be the same product. By contrast, in other cases the product names reflect substantively different products within a particular HS line. We used a computerized matching algorithm to match product names, to say (in the example above) that "Curry Powder" and " SPICE CURRYPOWDER" are the same product, but "Curry Powder" and "Ginger" are different products, even though all of these are inside the same

number of individual product lines in an HS category is 11, with a median of 3. We refer to this level of disaggregated data as HS 8-plus.

Finally, inside of an HS8 or HS 8-plus code the quantity units can vary widely. This matters. The dependent variable in our empirical work is the export product price, defined as an export unit value and calculated as the relevant total value of exports divided by quantity. So, for instance, a firm's average price for selling a particular product to the United States in any given year would be the value of sales divided by, say, the metric tons sold. But in many of the single firm-product-destination categories, export values are reported in several different units, such as "buckles," kilos, pounds and boxes, the sum of which yields the total value of exports for that firm-product-destination observation. It is not possible to make meaningful unit value comparisons, or aggregations, across different units in these instances.

We therefore drop all observations that are measured in units that are not official units recognized by Indian Customs (see http://www.cybex.in/International-Trade-Resources/Unit_Quantity_Code.aspx). Further, we aggregate and "harmonize" the remaining values where there are well-established conversion factors for the units. Therefore in many instances we convert pounds to kilos, and tons to metric tons, and so on, prior to calculating unit values. However, there remain thousands of lines of data where the conversion factors are unknown, or for which the reporting of separate lines based on different quantity measures strongly suggests that there are in fact underlying differences between the goods reported in those lines (even when they are in the same 8-digit HS category). Accordingly, for the analysis

HS-8 code. We then aggregate together the quantity and value information for those product labels that our algorithm deems as the same product (from the same firm).

reported here we keep only the top three units in each HS line, by value, and drop the others, a trim which costs approximately 2.5 percent of all observations.

The sigma index of the quality of imported inputs is constructed from TIPS import data (aggregated and harmonized as described above). We calculate an annual z-score for the price a firm pays for each imported input (relative to the universe of prices paid for that good by all importing firms in TIPS), and then calculate an annual import value-weighted mean z-score across the firm's import bundle each year. The higher the sigma, the higher the relative price (and, by implication, the quality) of the firm's imported inputs. The sigma for capital goods imports uses the HS-based definition of capital goods developed in Bakht, Yunus, and Salimullah (2002).

Merging the TIPS and Prowess databases presents further technical problems in matching firm names, rooted in the fact that the names initially recorded in TIPS do not necessarily correspond to firms' names in Prowess. But after this merge and a final merge with CEPII destination market characteristics we have a data set with 25,962 individual firm-product-destination-year observations over fiscal 2000-2003 for exporters including matched information on the prices these firms paid for imports (if any), drawn from 1,098 unique firms. Although by name alone we are able to match more firms than this, many observations are lost because they are not manufacturing firms (e.g., wholesalers), have incomplete information (e.g., missing input information in Prowess or TIPs), or do not survive our procedures to clean the data.

We calculate TFP using the Stata implementation of the Levisohn and Petrin (2003) technique, following Topalova and Khandelwal's (2011) approach (pp.998–999) to put each firm's productivity into index form (which itself depends on Aw, Chen and Roberts, 2001), which allows productivity comparisons within and between industries. We measure firm output with value-added (Topalova and Khandelwal, 2011, use sales). Capital is measured as the size of each firm's gross fixed assets, and labor is proxied by the wage and salary bill (the number of employees is not included in Prowess). Note that this is the measure of labor used both in the TFP calculation and directly (in log form, "ln_labor") on the right hand side of our regressions reported in Tables 4-6 as our proxy for firm size; we also calculate the capital/labor ratio used in the regressions ("ln_klabor)") from these capital and labor variables.

We estimate TFP at the 4-digit National Industrial Classification (NIC) code level where possible, and at the 3-digit level when necessary due to a small number of firms at the 4-digit level (less than 20). We use Prowess data on firms' spending on raw materials and electric power as the proxy for productivity shocks. All variables are expressed in real terms: output is deflated by two-digit industry-level wholesale prices indices from Ahsan (2013); capital expenditures are deflated by a capital goods wholesale price index we construct from several sub-industry wholesale price indices (including machine tools, electric machinery, and other capital goods); materials and power are likewise deflated with separate materials and power wholesale price indices we construct; and finally the wage and salary bill is deflated by the Economist Intelligence Unit's Indian labor cost index.

We calculate remoteness as in Harrigan, *et al.* (2015): the GDP-weighted distance of an export partner from all other export partners. So, for example, when we observe a transaction with the Philippines we sum the GDP-weighted distances between the Philippines and India's other export partners. Therefore $R_d = \left[\sum Y_0 dist_{od}^{-1} \right]^{-1}$, where R_d is the remoteness of country d, Y_0

is the GDP of country 0, a member of the set of India's trading partners, and $dist_{od}$ is the distance between d and a given country 0.

Appendix 2: Controlling for Destination Market and Firm Characteristics

As in Harrigan, *et al*. (2015), we consider the possibility of selection bias because firm prices are only observed if firms choose to export to particular destinations, and we implement their three-stage estimator, itself an extension of Wooldridge (1995). The first stage is a Probit of entry (of a firm in a particular destination in a particular year) on all exogenous export-market characteristics (X_d), firm characteristics (X_f), and a year-specific intercept α. Omitting time subscripts we have:

$$(1) \qquad \Pr\left(Y_{fpd} > 0\right) = \Phi\left(\alpha + \delta_1 X_d + \delta_2 X_f\right)$$

Equation (3) is estimated over an expanded sample of all possible firm-destination-year combinations; that is, it is applied to a "rectangularized" data set with zeros added. The inverse Mills ratio $\hat{\lambda}_{fpd}$ is then included in the second stage which explains observed (i.e., positive) firm-product-destination revenue based upon export-market and firm characteristics and product fixed effects (α_p):

$$(2) \qquad \ln Y_{fpd} = \alpha_p + \zeta_1 X_d + \zeta_2 X_f + \gamma \hat{\lambda}_{fpd} + u_{fpd}$$

Quasi-residuals, formed as the actuals residuals plus the estimate term for the inverse Mills ratio, $\hat{\eta}_{fpd} = \hat{u}_{fpd} + \gamma\hat{\lambda}_{fpd}$, from this second stage are then entered as a selection control in the price regression:

(3) $$\ln P_{fpd} = \alpha_p + \beta_1 X_d + \beta_2 X_f + \psi\hat{\eta}_{fpd} + \epsilon_{fpd}$$

This approach is more flexible than the two-step Tobit approach proposed by Wooldridge (1995) in that the estimated effects on entry, the δ's in equation (3), are allowed to differ from the effects on export intensity, the ζ's in equation (4).[16]

[16] The Wooldridge (2015) approach would fit a Tobit regression of revenues in the expanded data with zero revenues. The residuals from this estimation would then be used to control for selection bias in the price regressions.

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