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Plants and Imported Inputs: New Facts and an Interpretation

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Beginning with Wilfred J. Ethier (1979, 1982), an important current of research has emphasized gains to trade from the greater availability of intermediate inputs, as opposed to the greater availability of consumption goods emphasized by Paul R. Krugman (1979) and others. It has been standard in this literature to model input varieties as symmetric, differentiated horizontally but not vertically. In contrast, anecdotal accounts, especially from developing countries, often stress the importance of gaining access to high-quality inputs on the import market.[1] In theoretical discussions, the need to distinguish between the number of inputs and the quality of those inputs can be avoided by treating different qualities of a good as distinct varieties (see, e.g., Paul Romer 1994) or by redefining units of measurement. But in empirical work, one inherits the product categories and units in the data, and typically one must specify whether the availability-of-inputs mechanism is expected to operate through an increase in the number of input categories or through an increase in the quality of inputs within categories. Because of data constraints—in particular because of a lack of information on input and output prices in standard plant-level datasets—it has been difficult to investigate the role of input-quality differences, and recent empirical work, notably by Christian Broda, Joshua Greenfield, and David Weinstein (2006) and Pinelopi K. Goldberg et al. (2008), has tended to focus more on changes in the number of input categories than on quality differences within those categories.[2]

In this short paper, we draw on rich product-level information from the Colombian manufacturing census to present a new set of facts about importing plants and input prices. The dataset is unique in that it contains detailed, representative, consistently measured information on the unit values of all inputs and outputs of plants. For the 1982–1988 period, the dataset also contains unit values separately for domestic and imported purchases of each input. As we discuss in more detail below, we interpret the new facts as suggesting that Colombian plants purchase higher-quality inputs on the import market than on the domestic market, within narrow product categories.

Our empirical work has been guided in part by a theoretical framework from a related paper, Kugler and Verhoogen (2008). In that paper, we hypothesize a complementarity between input quality and plant productivity in generating output quality, and extend the model of Marc J. Melitz (2003) to accommodate it. The model predicts that, in equilibrium, more-productive plants are larger, use higher-quality inputs, produce higher-quality outputs, and are more likely to enter the export market than less-productive plants in the same industry.[3] Using the Colombian plant census, we show that the cross-sectional correlations between a number of observable variables—output prices, input prices, plant size, and export status—as well as differences in those correlations across sectors,—are consistent with our theoretical framework and difficult to reconcile with alternative models that impose

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[1] See e.g., David Morawetz (1981), a classic case study that remains relevant.

[2] The method of constructing aggregate price indices used in Broda et al. (2006) and Goldberg et al. (2008) takes into account changes in prices and expenditures within existing input categories, but does not link these explicitly to changes in input quality.

[3] To be precise, the model predicts these patterns in sectors in which the scope for quality differentiation is greater than zero; refer to Kugler and Verhoogen (2008) for further discussion.

symmetry of either inputs or outputs. The distinctive aspect of the current paper is the focus on the distinction between imported and domestic inputs.[4]

I. Data

The data are from the *Encuesta Anual Manufacturera* (EAM) [Annual Manufacturing Survey], which can be considered a census of Colombian manufacturing plants with ten or more workers. In conjunction with this standard plant survey, information is collected on the value (revenues or expenditures) and physical quantity of each output and input of each plant in approximately 4,000 eight-digit product categories. Unit values are calculated by dividing value by physical quantity; we refer to these unit values, somewhat loosely, as prices. Separate information on expenditures and physical quantities was collected only in 1982–1988, and here we focus on that period. The data to which we have access do not contain information on the specific country of origin of imported inputs, nor on unit values of exported and domestic outputs separately, nor on which plants belong to which firms, nor on foreign ownership of firms. The dataset is an unbalanced panel of approximately 4,700 plants in each year. Appendix Table 1 (available at http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.2.501) presents plant-level summary statistics.[5]

II. Results

FACT 1: *Importers are exceptional performers.*

We begin by showing that "performance" differences between importers and nonimporters that have been documented in other plant-level datasets (in particular, see Andrew Bernard et al. 2007) also hold in Colombia. Panels A–C of Table 1 present regressions of plant-level indicators of performance—gross output (i.e., revenues), wages, and total factor productivity (TFP),[6] respectively—on an indicator for whether the plant imported any inputs and flexible sets of additional controls.[7] (In all regressions in this paper, errors are clustered at the plant level, allowing for arbitrary correlation within plants.) In the column 1 regressions, which control for region, industry, and year effects but not plant effects, the importer indicator is significantly associated with the three measures of performance. Column 2 shows that these results are not due solely to the fact that importing plants are more likely to be exporters; while the indicator for exporting is also significantly associated with the performance variables, the coefficients on the importer indicator are not much affected by its inclusion. Columns 3 and 4 include plant effects and show that, for gross output and wages, the positive relationship holds even within plants, albeit with smaller magnitudes. For TFP, by contrast, there is no evidence that importers are more productive once plant effects are included, suggesting that the positive correlation between importing and TFP in columns 1–2 is due primarily to selection of high-productivity plants into importing. Caution is warranted in interpreting these results, however: if outputs and inputs are heterogeneous in quality, then standard methods of estimating TFP are likely to be misleading (see e.g., Hajime Katayama, Shihua Lu, and James R. Tybout 2006). With respect to the theoretical framework of Kugler and Verhoogen (2008), a natural way to accommodate Fact 1 would be to add a fixed cost of importing, either at the

[4] This paper is related to recent work using unit-value information in trade flow data to argue that imports from richer countries appear to be higher-quality (Peter K. Schott 2004; David Hummels and Peter J. Klenow 2005). The advantage of this paper is that we are able to compare import prices to domestic prices, and to do so within individual plants. This paper is also related to a number of recent papers on imported inputs and plant productivity, several of which acknowledge the possibility that imported inputs are higher-quality than domestic inputs: Adriana Schor (2004), Mary Amiti and Jozef Konings (2007), Hiroyuki Kasahara and Joel Rodrigue (2008), László Halpern, Miklós Koren, and Adam Szeidl (2006) and Marc-Andreas Muendler (2004). None of these papers has access to data on the unit values of domestic inputs, which limits their ability to draw inferences about the role of quality.

[5] For further details on the EAM dataset and our cleaning procedure, refer to Kugler and Verhoogen (2008).

[6] Following Bernard and J. Bradford Jensen (1999), we calculate TFP as the residuals from industry-specific OLS regressions of log value added (revenues minus material input expenditures) on log employment and log capital stock.

[7] In this short paper, we abstract from complex dynamic considerations that might arise, for instance, from sunk costs of importing.

Table 1—Plant-Level Variables versus Importer Status

	(1)	(2)	(3)	(4)
Panel A: Dependent variable: log real gross output				
Importer	1.357***	1.075***	0.113***	0.108***
	(0.040)	(0.037)	(0.016)	(0.016)
Exporter		1.253***		0.164***
		(0.043)		(0.017)
Panel B: Dependent variable: log real annual earnings (per worker)				
Importer	0.222***	0.175***	0.017**	0.016**
	(0.009)	(0.008)	(0.007)	(0.007)
Exporter		0.207***		0.026***
		(0.011)		(0.008)
Panel C: Dependent variable: total factor productivity				
Importer	0.168***	0.136***	0.008	0.007
	(0.018)	(0.019)	(0.021)	(0.021)
Exporter		0.144***		0.044**
		(0.023)		(0.022)
Panel D: Dependent variable: number of distinct input categories				
Importer	5.175***	4.066***	0.666***	0.650***
	(0.259)	(0.238)	(0.106)	(0.106)
Exporter		4.917***		0.515***
		(0.387)		(0.143)
Region effects	Yes	Yes	No	No
Industry effects	Yes	Yes	No	No
Plant effects	No	No	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
N (plant-year observations)	32,697	32,697	32,697	32,697
N (distinct plants)	7,089	7,089	7,089	7,089

Notes: Gross output is total value of production, defined as sales plus net transfers plus net change in inventories. Importer takes value 1 if plant imported any input, 0 otherwise. Errors clustered at plant level. *N* (plants) reports number of clusters (i.e., distinct plants that appear in any year). For panel C, *N* (plant-year observations) is 29,517; *N* (distinct plants) is 6,605 because capital stock could not be constructed for all plants. Robust standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

plant level or at the level of particular inputs.[8] With such a fixed cost, one would expect more-productive plants in each industry to select into the import market.

FACT 2: *Importers use more distinct categories of inputs.*

Panel D of Table 1 presents regressions using an outcome variable that is typically not available in plant-level datasets: the number of distinct input categories used in production. Columns 1–2 show that, within industries, importers use 4 to 5 more input categories than nonimporters on average—perhaps not surprising, given their larger size. Columns 3–4 show that this effect holds even within plants, with smaller magnitude: when plants become importers the number of distinct input categories rises on average by about 0.6. These results are consistent with the idea that access to imports increases the availability of different types of inputs.

FACT 3: *Importers pay higher prices for inputs, on average, within narrow product categories.*

[8] The introduction of a fixed cost of importing has been proposed by Halpern, Koren, and Szeidl (2006) and Kasahara and Beverly Lapham (2007), among others.

We now turn to the new facts using product-level information on input prices. Panels A and B of Table 2 present regressions of input prices on indicators of importer status. In panel A, the importer variable takes a value 1 if a plant imports the input in question and 0 otherwise (call this the *input-specific* importer indicator); in panel B, the importer variables takes the value 1 if a plant imports *any* input and 0 otherwise (call this the *plant-level* importer indicator). Note that input price in panels A and B is an average price for imported and domestic inputs. Note also that all regressions include a full set of product-year effects. These effects absorb all differences in units of measurement across products; this is necessary because we have no metric with which to compare prices in different product categories. The remaining variation in input prices reflects relative prices—that is, input prices relative to other plants purchasing the same input in the same year. Because prices are in logs, these relative price differences approximately represent percentage differences.

Column 1 includes product-year effects and region and industry effects, but omits plant effects. The results show that importers pay significantly more for inputs, using either definition of importer status. The coefficients on the input-specific importer indicator in panel A are a factor of ten larger than the coefficient on the plant-level indicator in panel B; importing plants pay higher prices, especially for the inputs that they import.[9] Column 2 includes plant effects to absorb the cross-sectional variation across plants; results are consistent with those in column 1. Column 3 includes plant-product effects and column 4 includes plant-year effects; note that the latter is possible only with the input-specific importer indicator. Intuitively, column 3 compares the relative price paid by a plant that imports an input to the relative price paid by the same plant for the same input in years in which it does not import that input; column 4 compares the relative price paid by a plant that imports an input to the relative prices of nonimported inputs *within the same plant-year.* The estimates are positive, significant, and statistically indistinguishable from the estimates in columns 1–2. With respect to our theoretical framework, Fact 3 is consistent with the idea that importers tend to be more-productive plants and that more-productive plants purchase higher-quality inputs.

FACT 4: *Importers pay higher prices for imported inputs than they pay for domestic inputs* in the same product category.

The previous fact (fact 3) does not necessarily imply that imported inputs are of higher quality than the domestic inputs purchased by a given firm. More-productive plants may simply buy higher-quality varieties of both domestic and imported inputs. To further investigate this issue, we draw on the information on input prices by origin (domestic versus imported). We treat the information on imported and domestic prices as separate observations and regress log input price on an indicator for whether the observation corresponds to imported or domestic purchases.[10] Panel C of Table 2 reports the results. We see that the indicator for imported varieties is significantly positively associated with the input price, and that this relationship is robust across specifications. In particular, when including a full set of plant-product-year effects in column 5, the price premium for imported products is 20 log points and significant at the 95 percent level.[11] That is, *plants pay significantly more for imported than for domestic inputs, even within a given product category within a given plant within a given year.* It appears that the higher input prices paid by importers (Fact 3) are not fully explained by the selection of plants purchasing high-quality inputs into importing.

FACT 5: *Plants that import inputs pay higher prices than nonimporters for* domestic *varieties of the same inputs.*

[9] Indeed, when both the input-specific and the plant-level importer indicators are included simultaneously, the coefficient on the plant-level indicator is negative and significant, even when plant effects are included. This suggests that importing a particular input leads plants to pay lower prices for other inputs. We plan to investigate this pattern in future work.

[10] There are 13,400 plant-product-years for which both an imported and a domestic price are observed, hence the number of observations in panel C of Table 2 exceeds that of panels A and B by that amount.

[11] Note that the estimate in column 5 is based on the 13,400 plant-product-years for which both imported and domestic input prices are observed; variation across plant-product-years for which only one price is observed is absorbed by the plant-product-year effects.

Table 2—Input-Price Regressions

	(1)	(2)	(3)	(4)	(5)
Panel A: Dependent variable: log real input price					
Importer (of relevant input)	0.197***	0.217***	0.089***	0.226***	
	(0.013)	(0.012)	(0.011)	(0.007)	
N (plant-product-year observations)	361,942	361,942	361,942	361,942	
N (distinct plants)	7,089	7,089	7,089	7,089	
Panel B: Dependent variable: log real input price					
Importer (of any input)	0.017**	0.017**	0.015**		
	(0.008)	(0.008)	(0.006)		
N (plant-product-year observations)	361,942	361,942	361,942		
N (distinct plants)	7,089	7,089	7,089		
Panel C: Dependent variable: log real (domestic or imported) input price					
Imported indicator	0.249***	0.265***	0.047***	0.194***	0.199**
	(0.013)	(0.013)	(0.008)	(0.005)	(0.086)
N (plant-product-year-origin observations)	375,342	375,342	375,342	375,342	375,342
N (distinct plants)	7,089	7,089	7,089	7,089	7,089
Panel D: Dependent variable: log real domestic *input price*					
Importer (of relevant input)	0.031*	0.050***	0.026**	0.055***	
	(0.017)	(0.017)	(0.011)	(0.009)	
N (plant-product-year observations)	334,451	334,451	334,451	334,451	
N (distinct plants)	7,076	7,076	7,076	7,076	
Panel E: Dependent variable: log real imported *input price*					
Log real domestic price	0.478***	0.435***	0.250***	0.451***	
	(0.025)	(0.025)	(0.024)	(0.020)	
N (plant-product-year observations)	13,400	13,400	13,400	13,400	
N (distinct plants)	1,526	1,526	1,526	1,526	
Region, industry effects	Yes	No	No	No	No
Product-year effects	Yes	Yes	Yes	Yes	No
Plant effects	No	Yes	No	No	No
Plant-product effects	No	No	Yes	No	No
Plant-year effects	No	No	No	Yes	No
Plant-product-year effects	No	No	No	No	Yes

Notes: "Importer (of relevant input)" is input-specific indicator, "Importer (of any input)" is plant-level indicator; see text for details. "Imported" indicator takes value 1 for import purchases, 0 for domestic purchases. Columns 1 and 5 from OLS regressions, with errors clustered at plant level and robust standard error estimates. Columns 2–4 calculated using Stata a2reg procedure (from Amine Ouazad) with bootstrapped standard errors, using 50 replications with draws on distinct cross-sectional units (plants).

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Even Fact 4 does not guarantee that imported inputs are of higher quality than domestic inputs in the same product category. It may be, for instance, that the imported varieties are of the same quality as domestic varieties but that their higher prices reflect higher transportation costs. To investigate this possibility, we look at the relationship between the prices plants pay for *domestic* inputs and their importer status. Our idea is that if more-productive plants import inputs because those inputs are high-quality, we would expect those same plants to purchase high-quality domestic varieties. We use the subset of plant-product-year observations for which a domestic price is observed and the input-specific definition of importer status. Panel D of Table 2 reports the results. Although the estimates are small in magnitude relative to the estimates for average input prices and importer status in panel A, they are positive, fairly robust across specifications, and tell a consistent story: plants that import inputs pay higher prices than nonimporters for domestic varieties of the same inputs. It is hard to account for this fact with a model of purely horizontally differentiated varieties that differ in transport costs.

FACT 6: *Among importers, domestic input prices are positively correlated with import prices.*

We observed above that importers pay a price premium on imported varieties relative to domestic varieties in the same input category (Fact 4). It would be worrisome for our story if that premium were negatively correlated with the domestic price. If the higher input prices reflect input quality, we would expect plants purchasing particularly high-quality domestic varieties of a given input also to purchase particularly high-quality imported varieties of the input. Panel E of Table 2 presents regressions of imported prices on domestic prices for the 13,400 plant-product-years for which both are observed. The coefficients on domestic prices are positive, significant, and robust across specifications. Plants that pay a particularly high input price for a particular input in a particular year pay particularly high domestic prices for the same input relative to other inputs in the same plant-year and/or other years for the same plant-input.

III. Conclusion: An Interpretation

Considering this set of six facts, along with the results in Kugler and Verhoogen (2008), the outlines of a coherent picture begin to emerge. Facts 1, 2, and 3 are consistent with the ideas that more-productive plants select into the import market, and that more-productive plants purchase higher-quality inputs. Perhaps the most salient fact we have presented is Fact 4: import prices are higher than domestic prices, even for the same input category in the same plant in the same year. While this fact could potentially be explained by greater transport costs for imports, the facts (a) that importing plants also pay higher *domestic* prices for the inputs that they import (Fact 5), and (b) that within the set of importers domestic prices are positively correlated with import prices (Fact 6) suggest to us that quality differences between imported and domestic inputs are the most plausible and parsimonious explanation. We leave the development of a formal model that can account for these new facts to future work.

We end with a word of caution. Because product quality is not directly observed, there is no proverbial smoking gun for the existence of quality differences between domestic and imported imports, and we must rely on indirect inferences from information on unit values and other observables. While we acknowledge the concerns with such inferences, the accumulation of robust empirical patterns that are consistent with parsimonious quality models and difficult to explain with alternative models raises our confidence that quality differences within input categories are playing an important role, especially in the context of a developing country such as Colombia.

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