

Plants and Imported Inputs: New Facts and an Interpretation

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Plants and Imported Inputs: New Facts and an Interpretation

Maurice Kugler and Eric Verhoogen*

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 gains from 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 purely 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 given good as distinct varieties (see e.g. Paul Romer, 1994). But in empirical work one inherits the product categories and units of measurement in the data, and typically one must specify whether the greater-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 et al. (2006) and Pınelopi K. Goldberg et al. (2008), has tended to focus on changes in the number of input categories rather than in quality differences within those categories.

In this short paper, we draw on rich product-level information from the Colombian manufacturing census to present a set of new facts about importing plants and input prices — facts which we interpret as suggesting that the imported inputs purchased by Colombian plants are higher-quality than the domestic inputs purchased by the same plants. The Colombian manufacturing census is

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

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. The representative information on both domestic and imported input prices makes the Colombian data better suited to our research question than any other dataset we are aware of.

Our empirical work has been guided in part by a Melitz-type theoretical framework that we have developed in a related paper, Kugler and Verhoogen (2008). In that paper, we hypothesize a complementarity between input quality and plant productivity in generating output quality — we refer to this as the *quality-complementarity hypothesis* — and extend the Melitz model (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.² 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 symmetry of either inputs or outputs. The distinctive aspect of the current paper is the focus on the distinction between imported and domestic inputs, which is not addressed in Kugler and Verhoogen (2008).³

²To 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.

³This paper is related to recent work using unit-value information in trade flow data to argue that imports from richer countries appear to 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 Amity and Jozef Konings (2007), Hiroyuki Kasahara and Joel Rodrigue (2008), László Halpern et al. (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.

I. Data

The data are from the *Encuesta Anual Manufacturera* (EAM) [Annual Manufacturing Survey], collected by the *Departamento Administrativo Nacional de Estadística* (DANE), the Colombian national statistical agency. The dataset can be considered a census of manufacturing plants with 10 or more workers. In conjunction with this standard plant survey, DANE collects information 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. A unit value for each plant-product-year observation can then be calculated by dividing value by physical quantity; we refer to these unit values, somewhat loosely, as prices. As mentioned above, for the 1982-1988 period the survey collected information on expenditures and physical quantities separately for domestic and import purchases, which allows us to construct separate domestic and imported unit values for each input category. For this reason, we focus on the 1982-1988 period in this paper. The data do not contain information on the specific country of origin of imported inputs, nor separate unit values for exported and domestic outputs. The dataset is an unbalanced panel of approximately 4,700 plants in each year. Appendix Table 1 (available online) presents plant-level summary statistics, separately for importing and non-importing plants; the differences in raw means between importers and non-importers are similar to those between exporters and non-exporters documented in Kugler and Verhoogen (2008): importers tend to be larger and higher-wage, with production in more output categories and purchases in more input categories.⁴

II. Results

Fact 1: Importers are exceptional performers.

⁴For further details on the EAM dataset and our cleaning procedure, refer to Kugler and Verhoogen (2008).

We begin by showing that “performance” differences between importers and non-importers 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),⁵ respectively — on an indicator for whether the plant imported any inputs and flexible sets of additional controls. (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 plants become more productive when they begin importing. The coefficient on importer in Columns 3-4 of Panel C is no longer statistically significant from zero, suggesting that the positive coefficient on the importer indicator in Panel C, Columns 1-2 is due to selection of high-productivity plants into importing rather than a learning-by-importing effect. Caution is warranted in interpreting these results, however: if, as we have argued, outputs and inputs are heterogeneous in quality, standard methods of estimating TFP are likely to be misleading.⁶ 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 plant level or at the level of particular inputs.⁷ With such a fixed cost, one would expect

⁵Following Bernard and J. Bradford Jensen (1999), we calculate TFP as the residuals from industry-specific OLS regressions of log value-added (revenues minus input expenditures) on log employment and log capital stock.

⁶For more on the possible biases caused by product-level heterogeneity, see Katayama et al. (2006). A similar caveat applies to the result in Panel C, Column 4 that TFP appears to rise when plants become exporters.

⁷The introduction of a fixed cost of importing at the plant level has been proposed by Halpern et al. (2006) and Kasahara and Lapham (2007), among others.

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 non-importers 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 .6.⁸ These results are consistent with the idea that access to imports increases the availability of different types of inputs, as argued by Goldberg et al. (2008) and others.⁹

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

We now turn to results 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 variable 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 natural metric with which to compare prices across products. 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 can be thought of as percentage differences.

⁸Again, the inclusion of the exporter indicator has little effect on the coefficient on the importer indicator.

⁹We see our results as complementary to those of Goldberg et al. (2008): it may well be that there are gains from the availability of *both* a greater number of inputs and high-quality varieties of those inputs.

Table 1: Plant-level variables vs. importer status

	(1)	(2)	(3)	(4)
<i>A. Dependent variable: log real gross output</i>				
importer	1.357*** (0.040)	1.075*** (0.037)	0.113*** (0.016)	0.108*** (0.016)
exporter		1.253*** (0.043)		0.164*** (0.017)
<i>B. Dependent variable: log real annual earnings (per worker)</i>				
importer	0.222*** (0.009)	0.175*** (0.008)	0.017** (0.007)	0.016** (0.007)
exporter		0.207*** (0.011)		0.026*** (0.008)
<i>C. Dependent variable: total factor productivity</i>				
importer	0.168*** (0.018)	0.136*** (0.019)	0.008 (0.021)	0.007 (0.021)
exporter		0.144*** (0.023)		0.044** (0.022)
<i>D. Dependent variable: number of distinct input categories</i>				
importer	5.175*** (0.259)	4.066*** (0.238)	0.666*** (0.106)	0.650*** (0.106)
exporter		4.917*** (0.387)		0.515*** (0.143)
region effects	Y	Y	N	N
industry effects	Y	Y	N	N
plant effects	N	N	Y	Y
year effects	Y	Y	Y	Y
N (plant-year obs)	32697	32697	32697	32697
N (distinct plants)	7089	7089	7089	7089

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 29517, N (distinct plants) is 6605 because capital stock could not be constructed for all plants. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Column 1 includes product-year effects, 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 10 larger than the coefficient on the plant-level indicator in Panel B; importing plants pay higher prices especially for the inputs that they import.¹⁰ Column 2 includes plant effects to absorb purely 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 this is only possible 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 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 other inputs *within the same plant-year* that the plant does not import. 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 ideas 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*.

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 vs. imported). We treat the information on imported and domestic prices as separate observations, yielding two observations for a plant-product-year in

¹⁰Indeed, 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 plants pay lower prices for inputs when they begin to import other inputs. We plan to investigate this pattern in future work.

Table 2: Input-price regressions

	(1)	(2)	(3)	(4)	(5)
<i>A. Dependent variable: log real input price</i>					
importer (of relevant input)	0.197*** (0.013)	0.217*** (0.012)	0.089*** (0.011)	0.226*** (0.007)	
N (plant-product-year obs)	361942	361942	361942	361942	
N (distinct plants)	7089	7089	7089	7089	
<i>B. Dependent variable: log real input price</i>					
importer (of any input)	0.017** (0.008)	0.017** (0.008)			
N (plant-product-year obs)	361942	361942			
N (distinct plants)	7089	7089			
<i>C. Dependent variable: log real (domestic or imported) input price</i>					
imported indicator	0.249*** (0.013)	0.265*** (0.013)	0.047*** (0.008)	0.194*** (0.005)	0.199** (0.086)
N (plant-product-year-origin obs)	375342	375342	375342	375342	375342
N (distinct plants)	7089	7089	7089	7089	7089
<i>D. Dependent variable: log real domestic input price</i>					
importer (of relevant input)	0.031* (0.017)	0.050*** (0.017)	0.026** (0.011)	0.055*** (0.009)	
N (plant-product-year obs)	334451	334451	334451	334451	
N (distinct plants)	7076	7076	7076	7076	
<i>E. Dependent variable: log real imported input price</i>					
log real domestic price	0.478*** (0.025)	0.435*** (0.025)	0.250*** (0.024)	0.451*** (0.020)	
N (plant-product-year obs)	13400	13400	13400	13400	
N (distinct plants)	1526	1526	1526	1526	
region, industry effects	Y	N	N	N	N
product-year effects	Y	Y	Y	Y	N
plant effects	N	Y	N	N	N
plant-product effects	N	N	Y	N	N
plant-year effects	N	N	N	Y	N
plant-product-year effects	N	N	N	N	Y

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, 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). *10% level, **5% level, ***1% level.

which both an imported and a domestic input price are observed, and regress log input price on an indicator for whether the observation corresponds to imported or domestic purchases.¹¹ 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.¹² That is, *plants pay significantly more for imported than 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 for *domestic* varieties of the same inputs.

Even Fact 4 does not guarantee that imported inputs are of higher quality than domestic inputs in the same product category used by the same plant. It may be, for instance, that the imported varieties are of the same quality as domestic varieties but that their 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 for *domestic* varieties of the same inputs. It is hard to account for this fact with a model of purely horizontally differentiated varieties

¹¹There 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.

¹²Note that the coefficient in Column 5 is identified on the basis of the 13400 plant-product-years for which both imported and domestic input prices are observed; variation across plant-product-years for which only one price (either domestic or imported) is observed is absorbed by the plant-product-year effects.

that differ in transport costs.

Fact 6: Among importers, domestic input prices are positively correlated with import prices of the same products.

As a final piece of corroborative evidence, we look at the correlation between domestic and imported input prices in the set of plant-product-years for which both are observed. 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 particularly high input prices for a particular product in a particular year pay particularly high domestic prices for the same product, relative to other products in the same plant-year and/or other years for the same plant-product.

III. Conclusion: An Interpretation

Considering this set of six facts, along with the results in Kugler and Verhoogen (2008), a coherent picture begins to emerge. Facts 1, 2, and 3 are consistent with the ideas that more-productive plants select into the import market, plausibly because of a fixed cost of importing, and that more-productive plants purchase higher-quality inputs, as in the model of Kugler and Verhoogen (2008). Perhaps the most salient fact we have presented is Fact 4, that import prices are higher than domestic prices, even for the same input 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. Space constraints prevent us from presenting a fully specified formal model that can account for these new facts; we plan to present such a model in future work.

We end with a word of caution. Because product quality is not directly observed, there is no proverbial smoking gun for the importance of higher-quality imported inputs, and we must rely on indirect inferences from information on unit values and other observables. While we acknowledge the many possible concerns with such inferences, the accumulation of robust empirical patterns that are consistent with parsimonious models of quality differentiation 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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Appendix Table 1: Plant-level summary statistics

	non-importers	importers	all plants
	(1)	(2)	(3)
Output	1.74	8.76	3.86
	(0.03)	(0.15)	(0.05)
Employment	45.42	142.06	75.51
	(0.46)	(1.79)	(0.67)
Avg. earnings	2.88	4.18	3.27
	(0.01)	(0.02)	(0.01)
White-collar earnings	3.92	5.91	4.53
	(0.01)	(0.03)	(0.01)
Blue-collar earnings	2.57	3.35	2.81
	(0.01)	(0.01)	(0.01)
Number of output categories	3.13	4.03	3.41
	(0.02)	(0.04)	(0.02)
Number of input categories	9.00	15.90	11.08
	(0.04)	(0.14)	(0.05)
Fraction exporter	0.07	0.31	0.14
	(0.00)	(0.00)	(0.00)
Export share of sales	0.02	0.04	0.03
	(0.00)	(0.00)	(0.00)
Import share of input expenditures		0.29	0.09
		(0.00)	(0.00)
N (plant-year obs)	22837	9860	32697
N (distinct plants)			7089

Notes: Standard errors of means in parentheses. Importer defined as expenditures on imported inputs > 0. Import share is purchases of imported inputs as fraction of total purchases. Export share is fraction of total sales derived from exports. Output is annual sales, measured in billions of 1998 Colombian pesos. Earnings are annual, measured in millions of 1998 pesos. Average 1998 exchange rate: 1,546 pesos/US\$1. Number of output or input categories refers to number of distinct categories in which non-zero revenues or expenditures are reported.