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Pricing to Firm: an Analysis of Firm- and Product-level Import Prices*

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Abstract

We use Hungarian Customs data on product-level imports of manufacturing firms to document that the import price of a particular product varies substantially across buying firms. We relate the level of import prices to firm characteristics such as size, foreign ownership, and market power. We develop a theory of "pricing to firm" (PTF), where markups depend on the technology and competitive environment of the buyer. The predictions of the model are confirmed by the data: import prices are higher for firms with greater market power, and for more essential intermediate inputs (with a high share in material costs). We take account of the endogeneity of the buyer's market power with respect to higher import prices and unobserved cost heterogeneity within product categories. The magnitude of PTF is big: the standard deviation of price predicted by PTF is 21.5%.

1. Introduction

This paper analyzes the variation of import unit values of particular goods across different importing firms. We use the Hungarian Customs Statistics to construct a rich panel dataset of the product-level export and import flows of Hungarian manufacturing firms. This enables us to identify the use and pricing of imported goods directly at the firm level.

A first look at our data reveals several interesting features. First, import prices vary hugely across buyers (the standard deviation of log price within products is 1.37), the more so, the more differentiated the product is. Secondly, a significant part of this variation is specific to buyers. That is, some firms buy most of their inputs at a higher price than others. Across the whole range of products, 14% of the total variance is explained by firm fixed effects. In contrast, market and year fixed effects account for only 6% of the variance. In other words, knowing *who* buys the product is more than twice as informative of its price as knowing *when and where* the trade originates. This means that micro information at the firm level is at least as important as macro phenomena (e.g. exchange rate movements, monetary and fiscal policy) in explaining import prices. Thirdly, the variation across firms relates meaningfully to observable firm characteristics, such as firm size, ownership, use of intermediates, and performance. In particular, the relationships conform to our theory of buyer-specific product differentiation.

In contrast to most international trade models that postulate organized goods markets with anonymous buyers and sellers, we build a model in which sellers choose

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to differentiate their goods across buyers and charge different markups based on the observable characteristics of the buyer. We term the phenomenon of buyer-specific markups "pricing to firm" (PTF).

It is standard practice to assume that products are differentiated by producers, for example, Budweiser is an imperfect substitute for Heineken. (See an excellent survey in Helpman, 1999.) Intuitively, producers are motivated to develop different brands so that they can extract monopolistic rents from consumers. According to Rauch (1999, p. 16), differentiated goods comprised 65%–67% of world merchandise trade in 1990.

However, most of international trade takes place in a setting where not only buyers are able to identify the producers but producers also see who they sell their product to. A growing body of literature documents the empirical relevance of buyer–seller relationships in trade. As Egan and Mody (1992, p. 326) document, the relationship between buyers and cross-border sellers lasts for an average of eight to 12 years in five developed economies. Existing theoretical (McLaren, 1999; Antràs and Helpman, 2004; Grossman and Helpman, 2005) and empirical works (Gereffi, 1999; Hummels et al., 2001; Hanson et al., 2005) on this topic usually focus on developed-country producers outsourcing some of their activities to developing countries. The main themes of the literature are (i) why and when producers choose global outsourcing over domestic production, and (ii) how the buyer–supplier link enables suppliers to keep up with quality requirements of their buyers. To the best of our knowledge, this paper is the first to look at firm-level import data to uncover patterns of buyer-specific product differentiation. An additional difference of our approach to previous studies lies in our focus on transition economy firms as buyers and (plausibly) industrial-country suppliers,[1] that have the potential to price-discriminate across buyers.

We focus on a particular aspect of buyer–seller relationships, namely, on how sellers price their products. Obviously, in order to be able to charge different prices for different buyers, the supplier needs to segment its output markets effectively. Otherwise, arbitrage across buyers would prevent any price differential. We believe that a wide range of products entering international trade is actually tailored for the buyer's needs, preventing profitable resale. Buyer-specific elements may include customization, installation, and after-sales services.[2]

We then test the implications of the model by looking at how various firm characteristics affect the price at which they acquire their imports. One obvious reason for the wide dispersion of product prices across buyers is the heterogeneity within product categories. Even in the six-digit Harmonized System classification that we use, products with very different unit values can be grouped together. Several recent papers (Schott, 2004; Hummels and Klenow, 2005; Hallak, 2006) document that export prices vary across exporting countries even within narrowly defined product categories. In particular, high-income countries tend to export any given product at higher prices, possibly because these countries specialize in high-quality variants of the product.

A key question in our empirical strategy is how we can distinguish cost differences (quality heterogeneity) from markup differences (pricing to firm). In particular, we need to make sure that the buying firm's demand for quality is not correlated with the characteristics that we focus on. We employ two alternative identification strategies. First, we look for instrumental variables that are not correlated with the demand for quality. More specifically, we use measures of the intensity of Hungarian and European competition within each product category as instruments. Secondly, we assess the performance of our model in a "control group" of homogeneous products. These exhibit substantial quality and cost heterogeneity but are not subject to PTF because of the competitive nature of their markets. If the demand for quality is similar in the control group of homogeneous products and in the treatment group of differentiated products, then the differences in estimates for the two groups reflect the presence of PTF.

Our results can be summarized as follows. First, both the market power and the technology (e.g. share of the particular input among intermediates) of the buyer have a significant impact on the import price. Importantly, we distinguish two concepts of market power with very different consequences: the share of the firm in the import market lowers the import price, whereas its power in the export market raises the price of inputs. Secondly, the magnitude of the effect on the import price is big. The standard deviation of price predicted by PTF is 21.5%. Finally, we show that even if unobserved cost heterogeneity within product categories is substantial, it is uncorrelated with our variables of interest. In other words, we only find evidence of PTF in differentiated product markets and not in homogeneous product categories.

The result that the buyer's technology has an impact on import prices can be understood in the context of third-degree price discrimination and pricing to market. The demand for inputs that are essential in production will be less elastic and sellers can hence charge a higher markup for these. The result that the buyer's market power in its output market raises the import price is a manifestation of *double marginalization*. Monopolistic buyers will have highly inelastic input demand and hence incur a high markup on their import purchases.

2. A Model of Pricing to Firm

In explaining the observed price differences across buyers, we allow for three channels: (i) differences in production costs (e.g. due to quality), (ii) differences in transport costs, and (iii) differences in markups (e.g. due to price discrimination). First, some firms may buy higher-quality products (within the same product category) than others. Importantly, the demand for quality may be related to particular characteristics of the firm (export orientation, size, etc.). Secondly, *ad valorem* transport costs may depend on the quantity being shipped and are likely to be lower for bulk buyers. Thirdly, the price sellers charge may depend on the demand elasticity of specific buyers. In particular, buyers with less elastic demand will face higher markups and higher prices.

In what follows, we introduce a simple model that incorporates these three channels of price dispersion.

Buyers

Buyers decide on input purchases, taking input prices as given. They decide on two aspects of an input: the *quality* and *quantity* they wish to purchase. We treat these decisions as two separate but potentially related decisions.

On the one hand, we discuss these decisions separately, because we do not want to restrict our attention to any particular model of quality. On the other hand, we allow quality decisions to be *correlated* with decisions on quantity, because the demand for input quality may vary with the size of the firm, its market power, and technology, variables which clearly influence how much the firm is willing to buy of certain inputs.

We can derive the firm's demand for inputs from its profit-maximization problem. In general terms, the firm is maximizing revenue minus costs subject to the demand function it faces and the technology to produce its output in a given quantity and quality. The firm is a price taker in the input markets but may have nonzero market power in its output market. In other words, its sale price may depend on its output.

The demand for the output of firm k depends on its price (P_k), quality (μ_k), and exogenous market conditions (ω_k), leading to an inverse demand function $P(Q_k, \mu_k, \omega_k)$. The firm maximizes profits, sales minus the wage bill, and spending on intermediates (we abstract from capital for brevity):

$$\max_{Q_k, \mu_k, L_k, \{X_{ik}, \mu_{ik}\}} P(Q_k, \mu_k, \omega_k)Q_k - w_k L_k - \sum_i R_{ik} X_{ik}, \tag{1}$$

subject to a quantity and a quality production function,

$$Q_k = \left[(1-\beta_k)^{1/\phi} L_k^{1-1/\phi} + \beta_k^{1/\phi} X_k^{1-1/\phi}\right]^{\phi/(\phi-1)}, \tag{2}$$

$$X_k = \left[\sum_i b_{ik}^{1/\theta} X_{ik}^{1-1/\theta}\right]^{\theta/(\theta-1)}, \tag{3}$$

$$\mu_k = \min\{\mu_{1k}, \ldots, \mu_{Nk}\}. \tag{4}$$

Output (Q_k) is produced using labor (L_k) and intermediate inputs (X_k). The firm combines labor and intermediate inputs with elasticity of substitution ϕ. Intermediate input is, in turn, a constant-elasticity-of-substitution composite of the individual inputs, X_{ik}'s, with a substitution elasticity of θ. We assume that $\theta > \phi$; that is, an intermediate input is a closer substitute of another input than of labor. The share of intermediates in total cost is governed mainly by the parameter β_k, which may vary across firms. The positive technology parameters b_{ik}'s act as demand shifters for inputs and may vary across products and firms.[3] The wage rate is denoted by w_k, the price of an individual input i is R_{ik}. In general, this price will be firm-specific.

Production technology is the same irrespective of the quality of inputs.[4] The quality of output (μ_k), on the other hand, only depends on the quality of the individual components (μ_{ik}) but not on the quantities used. More specifically, the quality of the output is as good as that of its worst component. This reflects the enormous complementarities of the qualities of individual inputs, which is suggested by the many examples in Kremer (1993). In optimum, the firm will only purchase inputs that are *exactly* of quality μ_k (it would be useless to purchase a higher quality component). That is, $\mu_{ik} = \mu_k$ for all $i = 1, \ldots, N$.

We can measure the quantity choice (output, employment, input usage) quite extensively. The obvious empirical challenge is that quality choices are unobserved. This is important because we want to be able to distinguish variations in input price (R_{ik}) that are due to variations in the input's quality (μ_{ik}) from those due to strategic pricing by the seller of the input.

Demand is isoelastic, so that the inverse demand function is

$$P(Q_k, \mu_k, \omega_k) = A(\mu_k, \omega_k) Q_k^{-1/\varepsilon(\mu_k, \omega_k)}. \tag{5}$$

Here $A(\mu_k, \omega_k)$ is a multiplicative demand shifter and $\varepsilon(\mu_k, \omega_k)$ is the price elasticity of demand. Both may depend on the quality of the product (μ_k) and market conditions (ω_k).[5]

Taking logs of the first-order condition with respect to X_{ik} (lower-case letters denote logs of their upper-case counterparts) and substituting in marginal revenue from (5),

$$r_{ik} = \ln\left(1 - \frac{1}{\varepsilon_k}\right) + \frac{1}{\phi}(\ln\beta_k + \ln b_{ik}) + a_k + \left(\frac{1}{\phi} - \frac{1}{\varepsilon_k}\right)q_k + \left(\frac{1}{\theta} - \frac{1}{\phi}\right)x_k - \frac{1}{\theta}x_{ik}. \tag{6}$$

To derive the price elasticity of input demand, we log-differentiate equation (6) with respect to x_{ik}:

$$\frac{\partial r_{ik}}{\partial x_{ik}} = \left(\frac{1}{\phi} - \frac{1}{\varepsilon_k}\right)\frac{\partial q_k}{\partial x_{ik}} + \left(\frac{1}{\theta} - \frac{1}{\phi}\right)\frac{\partial x_k}{\partial x_{ik}} - \frac{1}{\theta}$$
$$= \left(\frac{1}{\phi} - \frac{1}{\varepsilon_k}\right)\alpha_{ik} + \left(\frac{1}{\theta} - \frac{1}{\phi}\right)s_{ik} - \frac{1}{\theta}, \quad (7)$$

where $\alpha_{ik} = R_{ik}X_{ik}/(w_k L_k + \Sigma_j R_{jk}X_{jk})$ is the share of input i in the total cost of firm k, and $s_{ik} = R_{ik}X_{ik}/\Sigma_j R_{jk}X_{jk}$ is the share of input i in total spending on intermediates. The last equation follows from the fact that the firm is a price taker in its *input* markets, so it pays the factors the value of their marginal products. This implies that the elasticity of production with respect to an input equals its cost share.

We can then express the inverse elasticity of demand for input i, $1/\sigma_{ik}$, as:

$$\frac{1}{\sigma_{ik}} = \frac{1}{\theta} + \left(\frac{1}{\phi} - \frac{1}{\theta}\right)s_{ik} - \left(\frac{1}{\phi} - \frac{1}{\varepsilon_k}\right)\alpha_{ik}. \quad (8)$$

The elasticity of demand for input i depends on

(i) whether other intermediates are good substitutes (θ);
(ii) the share of input i among intermediates (s_{ik});
(iii) the share of input i in total cost (α_{ik});
(iv) the elasticity of demand for the firm's output (ε_k).

First, if it is easier to substitute away from input i, the buyer will cut its demand more in response to a given price increase. Highly substitutable inputs will generate highly elastic demand.

Secondly, the demand elasticity depends on the share of an input among intermediates. In the special case when the share of input i is negligible ($s_{ik} = \alpha_{ik} = 0$), we obtain the usual Dixit–Stiglitz result that the elasticity of demand equals the elasticity of substitution, $1/\sigma_{ik} = 1/\theta$. However, this is not the case if the input represents a non-negligible share of production costs, because then a change in the input's price also changes the demand for the basket of intermediate inputs. As long as $\theta > \phi$, that is, intermediate inputs are closer substitutes than other factors of production, we anticipate demand for more important inputs (high s_{ik}) to be less elastic. This is because, for high s_{ik}, a rise in the input's price also raises the price of the input basket substantially, therefore the *relative* price increase, which determines the demand for this particular good relative to overall spending on intermediates, is smaller.

Thirdly, if the input constitutes a non-negligible share of total cost (α_{ik} is big), then a rise in input price also raises marginal cost. A rising marginal cost results in a decline of demand for the final-good producer's output, hence a decline of demand for intermediate inputs. This makes the demand for high-α_{ik} inputs more elastic than that for low-α_{ik} inputs.

Finally, the stiffer the competition in the output market (ε_k is higher), the higher the elasticity of input demand. At one extreme, perfectly competitive firms cannot tolerate any (firm-specific) change in their marginal cost so their input demand will be highly elastic. At the other extreme, if the buyer has considerable market power, it can pass on large swings in its marginal cost to consumers without changing its output too much. Such a firm will be less price-sensitive in its input markets.

Suppliers

Inputs are classified in two categories: *differentiated* products (D) and *nondifferentiated* products (N). Differentiated inputs are produced by a single producer (for example, an IBM computer is an imperfect substitute for a Dell computer) *and* the costs of arbitrage/resale across buying firms are sufficiently large. In contrast, nondifferentiated inputs are sold by atomistic suppliers with no market power.

Differentiated inputs Differentiated input suppliers price their buyers individually according to third-degree price discrimination. When supplier i sells to buyer k, he faces an inverse demand function $R_{ik}(X_{ik}, \ldots)$ specified in equation (6). This input demand function depends on the actions of other suppliers. Differentiated product suppliers engage in Cournot competition; that is, they take the quantities sold by other suppliers as given.[6]

The supplier maximizes profit taking competitors' quantities as given:

$$\max_{X_{ik}} R_{ik}(X_{ik}, X_{-ik})X_{ik} - \tau_i(X_{ik}) - \mu_{ik} Z_i X_{ik}. \tag{9}$$

The price of the input (R_{ik}) depends on the quantities sold by all suppliers. This is a c.i.f. (cost, insurance, freight) price, which includes all shipping costs. These shipping costs (τ_{ik}) have to be subtracted to obtain the revenue received by the supplier. Note that shipping costs may depend on the quantity sold. The supplier then subtracts the production cost of the input, $\mu_{ik}Z_i$ per unit, where μ_{ik} denotes the input's quality. That is, better quality inputs have a proportionately higher marginal cost of production.[7]

The first-order condition for (9) implies that the price charged to buyer k will follow the "inverse elasticity rule." The markup over marginal cost (including marginal shipping costs) depends on the inverse of the price elasticity of input demand, $1/\sigma_{ik}$. The higher the elasticity of demand of a particular buyer, the lower the price for that buyer:

$$R_{ik} = \frac{1}{1 - 1/\sigma_{ik}}[\tau_i'(X_{ik}) + \mu_{ik} Z_i].$$

Taking a log-linear approximation,

$$r_{ik} = \frac{1}{\sigma_{ik}} + \ln \mu_{ik} + z_i + \frac{\tau_i'(X_{ik})}{\mu_{ik} Z_i} \equiv \frac{1}{\sigma_{ik}} + \ln \mu_{ik} + z_i + \omega_{ik}, \tag{10}$$

where $\omega_{ik} = \tau_i'(X_{ik})/(\mu_{ik}Z_i)$ denotes the *ad valorem* marginal cost of shipping good i to buyer k.

This formula suggests that there may be three reasons for price heterogeneity across buyers of a given product: (i) their demand elasticity is different, (ii) they purchase variants with different quality,[8] or (iii) they face different *ad valorem* shipping costs. We will discuss each of these explanations for price dispersion below.

Nondifferentiated inputs Nondifferentiated inputs, in turn, are priced at marginal cost (including shipping costs). In logs,

$$r_{ik} = \ln \mu_{ik} + z_i + \omega_{ik}. \tag{11}$$

Buyers may pay different prices for a particular product for two reasons: First, they may purchase variants with different marginal costs. More specifically, products may differ in terms of their quality (and hence their marginal cost) even within narrowly defined product categories. So, in this sense, the product is not *homogeneous* (there may be different variants within a product category) but is *nondifferentiated*, hence it is priced at marginal cost. Secondly, buyers may face different transport costs, for example, depending on the quantity they purchase. This difference will also be reflected in c.i.f. prices.

Empirical Implications and Specification

From equations (8), (10), and (11), we can express the price of a given product i as

$$r_{ik} = \begin{cases} \mu_{ik} + z_i + \omega_{ik} + \dfrac{1}{\theta} + \left(\dfrac{1}{\phi} - \dfrac{1}{\theta}\right) s_{ik} - \left(\dfrac{1}{\phi} - \dfrac{1}{\varepsilon_k}\right) \alpha_{ik} & \text{if } i \in D, \\ \mu_{ik} + z_i + \omega_{ik} & \text{if } i \in N. \end{cases} \tag{12}$$

We observe the cost shares of a particular input (s_{ik} and α_{ik}) and we can provide proxies for the elasticity of demand (ε_k). However, quality (μ_{ik}), marginal cost (z_i), and shipping cost (ω_{ik}) are unobserved, and are potentially correlated with observables. We can control for variation in z_i across products by introducing product fixed effects.[9] We also know from (4) that the quality of inputs at a firm are identical, be they differentiated or nondifferentiated. As for shipping costs, we assume that all differences across firms arise from the fact that they purchase different quantities.[10] We can then control for ω_{ik} by controlling for the quantity purchased.

Our preferred regression specification for the log import price of product i sold in year t to firm k is then

$$p_{ikt} = e_i + \nu_t + \gamma_1 s_{ikt} + \gamma_2 \alpha_{ikt} + \gamma_3 m_{kt} + \gamma_4 x_{ikt} + \gamma_5 \mathbf{z}_{kt} + u_{ikt}. \tag{13}$$

Here e_i is a product, ν_t is a year fixed effect, m_{kt} is a proxy for the output demand elasticity of firm k in year t, x_{ikt} is the quantity purchased by the firm (scaled by total Hungarian imports of product i to make different products comparable), $\mathbf{z}_{kt}$ is a vector of firm-level controls (firm size, dummy for foreign ownership), and u_{ikt} is an idiosyncratic error term representing unobserved heterogeneity in marginal costs and shipping costs ($z_{it} + \omega_{ikt}$).

As proxies of the (inverse) elasticity of demand in output markets, we include two measures of market power:

(i) the firm's export unit value relative to the Hungarian average, averaged across products;
(ii) the ratio of sales to labor and material costs.

As discussed above, the key econometric issue is that u_{ikt} is likely correlated with the explanatory variables, especially with the firm's market power, m_{kt}. For example, if high-quality products can be sold at higher markups, markup will be correlated with the unobserved quality of input purchases, introducing an upward bias in the coefficient of m_{kt}. This problem is especially pronounced when we look at export prices as a measure of demand conditions, as higher-quality products are indeed likely to be more expensive.[11] However, it is not so clear that higher input quality would be correlated with higher markups *above costs*. Theoretically, the correlation can go either way, so the direction and magnitude of the bias is less clear in this case.[12]

We pursue two identification strategies to address this problem. First, we use market-specific competitiveness indicators (such as the importance of Hungarian and European competitors) as instruments. We calculate

(i) the Herfindahl–Hirschman index (HHI) of concentration of Hungarian firms exporting the same products as the firm;

(ii) the average share of total Hungarian exports in the EU imports of the given products.

These instruments are correlated with the firm's markup in its European export market but are unlikely to be correlated with firm-specific errors in import prices.[13]

Our second identification strategy is to compare regression results for *differentiated* and *nondifferentiated* inputs. Nondifferentiated inputs have zero markup, so our model of PTF should not apply to them (see (12)). Any potential correlation between the price of a nondifferentiated input and the buyer's market power (as well as the technological variables) only captures the correlation between these measures and the input's *quality*. Moreover, (4) implies that the quality of differentiated and nondifferentiated inputs purchased by a particular firm are the same. Hence, if the unobserved quality of inputs represents an omitted variables bias, we should see significant correlations of the price of nondifferentiated inputs with our right-hand-side variables.

For differentiated products, we expect γ_1 to be positive as inputs with a bigger share among intermediates tend to have less elastic demand. On the other hand, γ_2 should be negative, since inputs with a higher share in total cost significantly affect the marginal cost of production, thereby having a more elastic demand. Higher output markups mean lower elasticity, which should lead to higher input prices, $\gamma_3 > 0$, as less competitive firms are more inert in the input markets, too. We anticipate γ_4 to be negative because firms buying more of a certain product would face lower per-unit shipping costs.

For nondifferentiated products, we generally expect insignificant coefficients, with the exception of γ_4, which should remain negative, because nondifferentiated products are also subject to nonlinear shipping costs.

3. Data and Specification Issues

The dataset consists of a panel of Hungarian exporting companies from 1992 to 2001. It has three major dimensions: firms, products, and time. Data were matched from three different sources: the Customs Statistics, the firms' balance sheet and earnings statement data, and Eurostat's Extra-EU Trade Statistics.

The Customs Statistics dataset contains the annual export and import traffic of the firms, both in value (forints) and in tons, so we are able to calculate unit value measures. We use unit value as a proxy for price. The traffic is divided into product categories broken down to the six-digit Harmonized System (HS) level. In addition, we observe whether the shipment originated in (or went to) one of the 15 countries of the pre-2004 European Union (EU-15). Other than that, we do not have information on the partner countries. The Data Appendix provides detailed information on the variables we use.

The sample consists of 2043 large exporting companies which exported more than 100 million forints (HUF) in any of the years. These were further broken down into two categories: domestic (less than 33% foreign ownership) and foreign-owned firms (foreign ownership exceeds 33%). Table 1 displays how these firms are represented in each of the years of this unbalanced panel. The average spell in the sample is 5.38 years for domestic firms and 6.52 years for foreign firms.[14] During this decade, one of the most important developments in Hungary was the growing number and market share of foreign firms. This may have important implications for our study because, arguably, foreign firms have better access to international markets, hence both their export and import market powers are vastly different from those of domestic firms.

Table 1. Firms in the Sample

Year	*Domestic*	*Foreign*	*Total*
1992	504	387	891
1993	584	528	1112
1994	645	614	1259
1995	653	675	1328
1996	701	762	1463
1997	745	828	1573
1998	746	878	1624
1999	725	834	1559
2000	729	800	1529
2001	689	795	1484
Total	1249	1089	2043
Average spell (years)	5.38	6.52	6.77

Notes: The table displays the number of domestic- and foreign-owned firms in the sample. Firms with more than 33% of foreign ownership are classified as foreign. Since firms may change ownership status over the sample, the total number of firms is smaller than the sum of those ever classified as foreign or domestic.

Based on the Broad Economic Classification (BEC) of products, we restricted our sample to products that are most likely to be intermediate inputs, namely primary and processed industrial supplies (BEC 21 and 22), primary and processed fuels (BEC 31 and 32), capital good components (BEC 42), and transport equipment components (BEC 53). We hence excluded food, consumer products, transport equipment, and capital goods from the analysis. This resulted in 2764 products. The group of differentiated products includes processed industrial supplies (BEC 22), capital good components (BEC 42), and transport equipment components (BEC 53). Nondifferentiated products comprise primary industrial supplies (BEC 21) and primary and processed fuels (BEC 31 and 32).

As Table 2 shows, firms in our sample cover the bulk of total Hungarian exports (ranging from 47% in 1992 to a peak of 76% in 1999) and imports (ranging from 31% to 62%). We have data on exports for each firm from two sources: their financial statement and disaggregated customs statistics. The correlation between these two measures across firms is reassuringly high: 0.953.

On average, firms in the sample source 61% of their intermediates from abroad (see Table 3). Import intensity is increasing over time and is about twice as high for foreign-owned firms as for domestic firms. This stark difference in the import intensity of foreign and domestic firms motivates us to analyze their import prices separately.

Import prices vary quite substantially across buyers even within six-digit HS categories in any given year. Table 4 reports the standard deviation of log unit values within a six-digit category for various aggregate product categories. In the full sample, the within-product standard deviation is 1.37, with technology-intensive products displaying a higher price dispersion. Nevertheless, even seemingly homogeneous products such as meat and vegetable products, foodstuff, and minerals command a widely dispersed unit value. This suggests that there is substantial product heterogeneity within HS categories, probably due to quality differences.[15] Overall, 14% of the

Table 2. Sample Coverage

	Share in total Hungarian	
Year	*Exports (%)*	*Imports (%)*
1992	47	31
1993	57	31
1994	58	37
1995	67	45
1996	69	53
1997	75	58
1998	74	60
1999	76	62
2000	66	56
2001	72	57

Note: The table reports the sample's share in total Hungarian exports and imports.

Table 3. Share of Imported Inputs

Year	*Domestic (%)*	*Foreign (%)*	*Total (%)*
1992	24	51	31
1993	26	43	33
1994	29	50	39
1995	36	47	42
1996	39	63	53
1997	34	68	58
1998	44	73	67
1999	48	76	71
2000	42	81	73
2001	35	67	62
Total	37	70	61

Notes: The table reports the average ratio of intermediate input imports to total material costs. Firms are weighted by their material costs.

within-product variation is explained by firm × year fixed effects; that is, this fraction is attributable to firm-specific shocks to prices. In contrast, market-specific (EU vs non-EU) year dummies account for only 6% of the variation. Not surprisingly, the importance of firm-specific factors is higher for differentiated products, whereas market factors are more important for relatively homogeneous products. This variation will prove useful in our identification strategy.

4. Results

The first part of Table 5 contains the results of pooled OLS regressions. Columns (1) and (2) contain regressions for differentiated products. As predicted by our model of PTF, products having a higher share in intermediate costs trade at a higher price,

Table 4. Within-product Price Dispersion

Product category	*Price dispersion*	*Market-specific shocks (%)*	*Firm-specific shocks (%)*
Section I: Animal Products	0.832	13	0
Section II: Vegetable Products	0.882	12	0
Section III: Animal or Vegetable Fats	0.970	16	0
Section IV: Prepared Foodstuff, Beverages, Tobacco	0.907	11	1
Section V: Mineral Products	1.293	5	5
Section VI: Chemicals	1.188	9	8
Section VII: Plastics	1.305	6	12
Section VIII: Leather and Products	1.144	10	12
Section IX: Wood and Products	1.282	2	11
Section X: Paper and Products	1.391	5	6
Section XI: Textile and Apparel	1.013	11	11
Section XII: Footwear	1.070	13	6
Section XIII: Stone and Glass	1.400	2	14
Section XIV: Jewelry	1.556	5	14
Section XV: Metals	1.377	5	15
Section XVI: Machinery	1.547	4	17
Section XVII: Vehicles	1.338	5	17
Section XVIII: Instruments	1.553	4	15
Section XIX: Arms and Ammunition	1.119	3	6
Section XX: Miscellaneous	1.390	7	17
Section XXI: Works of Art	1.377	0	45
Total	1.374	6	14

Notes: The 21 sections correspond to the Harmonized System classification. For each section we report unweighted average values for six-digit products. Price dispersion is measured as the within-product standard deviation of the log unit value. The second column reports the share of the total price variation explained by market times year dummies. The third column reports the share explained by firm times year dummies.

whereas share in total costs lowers the price. Both measures of markup have a highly significant and large impact on the import price: a firm with 10% higher markup pays 1.0%–1.4% more for its imports. Imported quantity has a large negative effect on import prices, potentially because firms buying more can economize on shipping costs.

Columns (3) and (4) contain the same specification for the control group of homogeneous products. We see that cost shares and the markup are unrelated to import price. A higher export price, on the other hand, is associated with a higher import price, suggesting that there is within-product *cost heterogeneity* even for homogeneous goods. Nonetheless, column (4) confirms that buyer markups are uncorrelated with the cost of imported products. Note that the within-group variation of import unit values is not significantly smaller for homogeneous products, indicating a large role for unobserved cost heterogeneity. What is important, though, is that this heterogeneity is orthogonal to our explanatory variables.

More formally, we can look at the difference between differentiated and nondifferentiated product coefficients. The coefficient of export price is higher for nondifferentiated products, reflecting the fact that much of the variation in export price may be correlated with the quality (and hence price) of imported inputs. The

Table 5. Determinants of Import Price (pooled sample)

	OLS estimates				*IV estimates*			
	Differentiated		*Homogeneous*		*Differentiated*		*Homogeneous*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Share in intermediates	0.518***	0.520***	–0.582	–0.445	0.393***	0.142	–0.566	0.261
	(0.040)	(0.041)	(0.696)	(0.698)	(0.042)	(0.095)	(0.707)	(0.975)
Share in costs	–0.518***	–0.517***	1.181	1.005	–0.441***	–0.260**	1.160	0.305
	(0.068)	(0.068)	(0.867)	(0.870)	(0.070)	(0.091)	(0.881)	(1.145)
Average relative export price	0.137***		0.154***		0.546***		0.136	
	(0.003)		(0.019)		(0.025)		(0.137)	
Markup		0.096***		0.009		0.996***		–2.854
		(0.006)		(0.044)		(0.203)		(2.177)
Share in HU imports	–0.605***	–0.615***	–0.252**	–0.258**	–0.564***	–0.577***	–0.252**	–0.183
	(0.024)	(0.024)	(0.082)	(0.082)	(0.024)	(0.026)	(0.082)	(0.111)
Origin: EU-15	–0.095***	–0.105***	0.096**	0.086**	–0.067***	–0.115***	0.095**	0.155*
	(0.005)	(0.005)	(0.030)	(0.030)	(0.005)	(0.005)	(0.031)	(0.063)
Foreign firm	0.019***	0.016***	0.081**	0.086**	0.001	–0.073***	0.082**	0.420
	(0.004)	(0.004)	(0.029)	(0.029)	(0.004)	(0.021)	(0.029)	(0.256)
Employment (log)	0.109***	0.116***	0.022*	0.031**	0.094***	0.127***	0.023	–0.016
	(0.001)	(0.001)	(0.010)	(0.010)	(0.002)	(0.003)	(0.012)	(0.037)
Exports same product	–0.294***	–0.286***	–0.142**	–0.130**	–0.314***	–0.279***	–0.141**	–0.104
	(0.005)	(0.005)	(0.045)	(0.045)	(0.005)	(0.005)	(0.046)	(0.056)
Observations	561,085	561,085	12,231	12,231	561,085	561,085	12,231	12,231
Product FEs	2,523	2,523	241	241	2,523	2,523	241	241
Year FEs	10	10	10	10	10	10	10	10
R-squared	0.02	0.02	0.01	0.01				
$\sigma(\log P_i)$	1.380	1.380	1.376	1.376	1.380	1.380	1.376	1.376

Notes: Dependent variable is log import unit value. Standard errors are in parentheses. Significance at 5%, 1%, and 0.1% is denoted by *, **, ***, respectively. Constant and fixed effects not reported. $\sigma(\log P_i)$ denotes the within-product standard deviation of log import price. In columns (5) through (8) measures of markup are instrumented with an HHI concentration index of Hungarian exporting firms and Hungarian share in EU imports for the given products. See the Data Appendix for variable definitions.

coefficient of our markup measure is significantly lower (and not significantly different from zero) for nondifferentiated products. This suggests that the causal impact of a 10% higher markup on import price is at least $10 \times (0.096 - 0.009) = 0.87\%$.

Among the additional control variables, we see that size and foreign ownership increase the import price, though (as expected) this effect is less significant for homogeneous products. Interestingly, if the firm both exports and imports the "same" product, it tends to pay a lower price, especially for differentiated products. This is consistent with a story of *processing trade*: these firms buy the product at a lower grade (hence cheaper) to re-export it after some labor-intensive processing.

Columns (5) through (8) of Table 5 contain the instrumental variables (IV) estimates, where both measures of markup are instrumented with the Herfindahl–Hirschman concentration index of Hungarian exporting firms and their overall share in the EU. The predictions of PTF remain true in this specification, too. More importantly, once export prices and markups are instrumented, we do not see any impact of cost shares and markups on the import prices of homogeneous products; that is, these are indeed uncorrelated with cost differentials. The difference between the differentiated and nondifferentiated good coefficients suggests that a firm that operates in a less competitive market and is able to charge a 10% higher export price will expect to pay $10 \times (0.546 - 0.136) = 4.1\%$ more for its inputs. The difference between the markup coefficients is even bigger but it is not statistically significant. The control variables remain robust in the IV specification.

Foreign firms are typically more externally oriented than domestic firms. We are therefore interested in whether import prices behave differently in these two subgroups. Tables 6 and 7 contain regression results for domestic and foreign firms, respectively. In general, the coefficients are very robust across the two subsamples, suggesting that PTF is prevalent for both domestic- and foreign-owned firms.

A notable difference is that the import price of domestic firms is almost twice as sensitive to the purchased quantity as that of foreign firms. That is, a percentage point increase in the import market share of a domestic firm lowers its import price by 0.7%–0.8%, while this number is only 0.4%–0.5% for foreign firms. In all other respects (technology parameters, the impact of markup, intraindustry trade), the two groups are remarkably similar.

5. Concluding Remarks

We documented that the import price of a particular product varies substantially across Hungarian manufacturing firms. We related the level of import prices to firm characteristics such as size, foreign ownership, and market power. We developed a theory of "pricing to firm" (PTF), where markups depend on the technology and competitive environment of the buyer because they affect the elasticity of input demand.

We distinguished two concepts of market power with very different consequences. On the one hand, the share of the firm in the import market lowers the import price (buyers of bigger quantities face lower prices) because the buyer can economize on trade costs. Nonlinear pricing schemes or differences in bargaining power may also be at play. On the other hand, firms with big market power in their export market face higher input prices because their price sensitivity is lower.

The predictions of the model were confirmed by the data: import prices are higher for firms with greater output market power, especially for intermediate inputs with a high share in total costs, and lower for firms with a bigger share in Hungarian imports. We took account of the endogeneity of the buyer's market power and the unobserved

Table 6. Determinants of Import Price (domestic firms)

	OLS estimates				*IV estimates*			
	Differentiated		*Homogeneous*		*Differentiated*		*Homogeneous*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Share in intermediates	0.768***	0.714***	–1.242	–1.021	0.612***	–0.226	–0.635	–1.128
	(0.073)	(0.074)	(1.901)	(1.894)	(0.077)	(0.198)	(1.974)	(2.096)
Share in costs	–0.591***	–0.537***	1.978	1.732	–0.495***	0.209	1.224	1.720
	(0.128)	(0.128)	(2.480)	(2.472)	(0.131)	(0.199)	(2.571)	(2.730)
Average relative export price	0.144***		0.101**		0.527***		–0.206	
	(0.004)		(0.031)		(0.043)		(0.222)	
Markup		0.306***		0.736***		2.851***		–2.988
		(0.016)		(0.132)		(0.493)		(4.382)
Share in HU imports	–0.816***	–0.842***	–0.006	0.004	–0.735***	–0.813***	0.000	–0.035
	(0.043)	(0.043)	(0.134)	(0.134)	(0.045)	(0.047)	(0.136)	(0.155)
Origin: EU-15	–0.011	–0.014	0.235***	0.225***	0.004	0.013	0.220***	0.249***
	(0.008)	(0.008)	(0.049)	(0.049)	(0.008)	(0.010)	(0.051)	(0.061)
Employment (log)	0.074***	0.088***	0.024	0.034	0.055***	0.152***	0.041	0.013
	(0.003)	(0.003)	(0.018)	(0.018)	(0.003)	(0.013)	(0.022)	(0.031)
Exports same product	–0.258***	–0.254***	0.038	–0.047	–0.274***	–0.275***	0.009	–0.046
	(0.009)	(0.009)	(0.078)	(0.077)	(0.009)	(0.011)	(0.081)	(0.139)
Observations	176,460	176,460	3,826	3,826	176,460	176,460	3,826	3,826
Product FEs	2,370	2,370	198	198	2,370	2,370	198	198
Year FEs	10	10	10	10	10	10	10	10
R-squared	0.02	0.02	0.01	0.02				

Notes: Dependent variable is log import unit value. Standard errors are in parentheses. Significance at 5%, 1%, and 0.1% is denoted by *, **, ***, respectively. Constant and fixed effects not reported. In columns (5) through (8) measures of markup are instrumented with an HHI concentration index of Hungarian exporting firms and Hungarian share in EU imports for the given products. See the Data Appendix for variable definitions.

Table 7. Determinants of Import Price (foreign firms)

	OLS estimates				*IV estimates*			
	Differentiated		*Homogeneous*		*Differentiated*		*Homogeneous*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Share in intermediates	0.423***	0.430***	–0.472	–0.312	0.310***	–0.251*	–0.500	0.465
	(0.049)	(0.049)	(0.785)	(0.787)	(0.050)	(0.121)	(0.798)	(1.132)
Share in costs	–0.512***	–0.514***	0.900	0.695	–0.445***	–0.062	0.937	–0.084
	(0.081)	(0.081)	(0.957)	(0.960)	(0.083)	(0.113)	(0.976)	(1.301)
Average relative export price	0.131***		0.175***		0.577***		0.210	
	(0.003)		(0.023)		(0.031)		(0.182)	
Markup		0.060***		–0.064		1.588***		–2.579
		(0.007)		(0.047)		(0.244)		(2.164)
Share in HU imports	–0.490***	–0.492***	–0.352**	–0.360***	–0.471***	–0.393***	–0.350**	–0.263
	(0.029)	(0.029)	(0.108)	(0.108)	(0.030)	(0.035)	(0.108)	(0.151)
Origin: EU-15	–0.137***	–0.150***	–0.017	–0.027	–0.101***	–0.182***	–0.015	0.054***
	(0.006)	(0.006)	(0.039)	(0.039)	(0.006)	(0.008)	(0.040)	(0.083)
Employment (log)	0.122***	0.127***	0.020	0.028*	0.107***	0.140***	0.018	–0.026
	(0.002)	(0.002)	(0.012)	(0.012)	(0.002)	(0.003)	(0.015)	(0.049)
Exports same product	–0.313***	–0.305***	–0.149**	–0.134*	–0.335***	–0.280***	–0.151**	–0.114
	(0.006)	(0.006)	(0.056)	(0.056)	(0.007)	(0.008)	(0.058)	(0.068)
Observations	384,625	384,625	8,405	8,405	384,625	384,625	8,405	8,405
Product FEs	2,459	2,459	213	213	2,459	2,459	213	213
Year FEs	10	10	10	10	10	10	10	10
R-squared	0.03	0.02	0.02	0.01				

Notes: Dependent variable is log import unit value. Standard errors are in parentheses. Significance at 5%, 1%, and 0.1% is denoted by *, **, ***, respectively. Constant and fixed effects not reported. In columns (5) through (8) measures of markup are instrumented with an HHI concentration index of Hungarian exporting firms and Hungarian share in EU imports for the given products. See the Data Appendix for variable definitions.

quality heterogeneity within product categories. As expected, PTF is prevalent for differentiated products but not for homogeneous products.

Given that PTF is so important in explaining import prices, we see two avenues for further research in this area. First, we may need to rethink a number of questions about relative prices in international macro, such as the exchange rate passthrough debate or the real exchange rate debate. Recently, Imbs et al. (2005) demonstrated how aggregation conceals important time-series properties of relative prices (e.g. a fairly quick mean reversal to the law of one price). We believe that the firm-level analysis can contribute to these debates.

Secondly, there may be a nontrivial interaction between the quality of a product and the pricing decision of its supplier. Recent analysis of product-level world trade flows (Schott, 2004; Hallak and Schott, 2005; Hummels and Klenow, 2005; Hallak, 2006) identifies variations in unit values with variations in quality. We show that, even at the firm level, a substantial part of the variation is due to variable markups. Explaining both sources of price variation in a unifying framework would be desirable.

Data Appendix

The definitions of variables used are below. The source(s) for each variable are given in square brackets.

- **Import price:** the c.i.f. unit value (HUF/ton) of total import shipments to the firm in a given year in a given six-digit HS category. [Customs Statistics]
- **Foreign ownership:** a firm is considered foreign-owned (dummy = 1) if foreign ownership exceeds 33% of equity and regarded domestic otherwise. [Balance Sheet]
- **Employment:** average annual employment. [Balance Sheet]
- **Share of good among intermediates:** the total HUF value of import shipment of the good divided by total material cost. [Customs Statistics, Financial Statement]
- **Share of good in total costs:** the total HUF value of import shipment of the good divided by total cost. [Customs Statistics, Financial Statement]
- **Relative export price:** the free-on-board (f.o.b.) export unit value of the good relative to the average EU unit value. [Customs Statistics, Eurostat]
- **Average relative export price:** the relative export price averaged across all the products exported by the firm. [Customs Statistics, Eurostat]
- **Import share:** the share of the firm in the HUF value of total Hungarian imports of the given product in the given year. [Customs Statistics]
- **Export HHI:** the export Herfindahl–Hirschman index of product k in year t is constructed from the firm's share in total Hungarian exports as $HHI_{kt} = \Sigma_i(X_{ikt}/X_{HU,kt})^2$. [Customs Statistics, Hungarian Statistical Office]
- **Differentiated product:** product classified as processed industrial supplies, capital, and transport equipment components are called *differentiated*, while primary supplies and fuels are *nondifferentiated*. [Broad Economic Categories]

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Notes

1. Although we do not observe the source country of imports at the firm level, we have to note that, in 2001, 69.4% of Hungarian imports originated from developed countries.
2. Theoretically, it is in the best interest of the producer to provide customization to erode the value of outside alternatives and to lock-in the buyer in a long-term relationship.
3. This is a flexible way to introduce heterogeneity across products. Clearly, firms will purchase different quantities from different products and a symmetric production function will not be appropriate.
4. We only require that the elasticity of substitution across inputs does not vary with quality.
5. In what follows, we suppress the dependence on (μ_k, ω_k) in notation, referring to A_k and ε_k, but the reader should keep in mind that these may be correlated with both quality and market conditions.
6. We make the assumption of Cournot competition for analytical convenience. In an Appendix available from the authors on request, we show that the qualitative results survive if we assume Bertrand competition among sellers; however, the optimal price can only be expressed with a highly nonlinear function in that case.
7. This is just a convenient definition of *unit*s *of quality*.
8. Note that we attribute all differences in factory-gate marginal costs across suppliers to quality differences.
9. This is necessary, because different products have different units of measurement, so their prices are not directly comparable.
10. Given the small size of the country and the high concentration of import-intensive firms in industrial cities close to the border, geography is unlikely to play a large role in input price variations across firms.
11. Furthermore, given the big variations in relative prices, the relative export price is likely to suffer from a measurement error.

12. In fact, with Cournot competition, high-cost firms have lower market shares and hence lower markups. A similar pattern holds with any demand system where the elasticity of residual demand rises with price (for example, with linear demand curves).
13. We construct the HHI and market share for each product and then take the average for each firm across the products it exports. Similar results would be obtained by taking the HHI and market share for the largest export product of each firm.
14. Note that some firms change ownership status during the sample. This typically means a domestic firm being bought by foreign investors. Hence, the relatively short spell of domestic firms.
15. Even crude oil prices vary substantially with grade.