Imports and Productivity*

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Abstract

Do firms importing more become more productive? We use product-level import data for a panel of Hungarian manufacturing firms from 1992 to 2001 to document several empirical regularities of import patterns across firms. To capture the main features of the data, we build a simple partial equilibrium model in which firms have to incur a sunk entry cost in order to start importing a given product. Our model leads to a simple production function formulation that allows for both the number of input varieties and the quality of inputs to affect productivity. Preliminary estimation results show a sizeable effect of imports on productivity. A firm importing 60% of its intermediate inputs is 50-100% more productive than the one using only domestic inputs.

1 Introduction

Understanding cross-country income differences has been one of the most pervasive questions in economics. Recent research suggests that productivity differences across countries are at least as important as differences in traditional factor usage (physical and human capital).1 The macro literature has also focused on the question of what are the sources of productivity

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1Hall and Jones (1999) is a seminal paper, or see Caselli (2003) for a recent survey.
differences and changes in productivity. Some, like Rodrik, Subramanian and Trebbi (2004), argue that institutional quality is the main source of productivity differences, while trade and geography play only a minor role. Others disagree, like Alcalá and Ciccone (2004), who argue that international trade has a considerable effect on productivity growth. In this project, we hope make progress in this debate by attempting to measure the effects of trade on productivity at the microeconomic level.

There are a number of channels through which trade could influence productivity. Export relations may be beneficial for explicit knowledge flows from buyers to suppliers. There may be indirect effects of export on productivity through economies of scale or increased competition in the export markets. Imported inputs can enhance productivity if they are of better quality than domestic inputs or if they are specialized varieties differing in important dimensions. Technology may be embodied in capital goods, in which case less restriction on imports leads to better production possibilities (as Eaton and Kortum (2001) empirically document). The role of R&D, both in the context of closed and open economies has been emphasized in the literature on endogenous and Schumpeterian growth (Grossman and Helpman (1991), Aghion and Howitt (1992)). Finally, productivity at the industry level is clearly influenced by industry composition, market structure, entry and exit (Hopenhayn (1992)).

Macro-level studies on technology spillovers have mainly been inconclusive. In a simple ordinary least squares regression we find that more open countries grow faster (see Barro (1997) as an example). Such results say little about causality, however. Frankel and Romer (1999) use geographic instruments to test whether openness causes more growth. Their affirmative finding is still subject to omitted variable bias, as it is likely that geographical variables are correlated with other important determinants of growth (institutions, legal origins, etc.) In a much-cited paper, Coe and Helpman (1995) find evidence that import-weighted foreign R&D has a significant positive impact on domestic productivity but Keller (1998) suggests that this result may be spurious.

In recent years, authors have started studying this question at the industry and the firm level (an excellent survey of firm- and plant-level studies can be found in Tybout (2003)). In terms of the export question, an extremely robust finding is that exporting firms are more productive than those selling only domestically (see Bernard and Jensen (1999), among others), though the direction of causality is that productive firms self-select into export markets. Results on the impact of imports are less conclusive, however (Van Biesenbroeck (2003)).

These studies improve upon the macro-level approach by allowing for firm heterogeneity in several dimensions: among others, one can control for the size, capital accumulation and labor composition of firms. However, it is exactly the variation in export and import experience of firms that remains hidden due to lack of data. Empirical studies typically use proxies for foreign exposure from the industry level.

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2 See Keller (2001) for a survey on technology spillovers.
In his survey of this literature, Tybout (2003, p. 36) notes that “theory has emphasized the effects of enhanced input variety—including both capital and intermediate goods—and, more recently, efficiency gains due to geographic agglomeration. But we have very little direct micro evidence on the importance of either.” We aim to directly contribute to this issue.

We estimate the effect of imports on productivity using a panel of Hungarian manufacturing firms from 1992 to 2001. The data is matched from two sources: the Hungarian Customs Statistics and the firms’ financial statements. The datasource is similar to that used by Eaton, Kortum and Kramarz (2004) to the extent that it measures trade flows at the level of the individual firm. However, there are two key differences. First, we can distinguish trade flows by product category (at the very disaggregate Harmonized System level). This enables us to look into the question of imported inputs. Second, the data span 10 years, allowing for a rich analysis of the dynamics of export and import market participation and productivity.

In the present paper, we ask the question of whether firms importing more become more productive. In order to answer this, we have to understand why firms import intermediate inputs. Some of these inputs may not be available in the home country. Alternatively, the ones available are an imperfect substitute (horizontal differentiation) or of inferior quality (vertical differentiation). In any of these cases, input usage should increase TFP, even in the absence of reverse engineering, knowledge spillovers etc.

We document that import patterns vary widely across firms. Some firms import nothing or very few products, whereas others import many different products, spending a majority of their material input budget on imported intermediates. We uncover several stylized facts relating import patterns to firm size, foreign ownership and firm growth. These stylized facts are all consistent with a framework in which firms have to incur a sunk entry cost in order to start importing a given product. We build a simple partial equilibrium model which is capable of capturing these features of the data.

Our model leads to a simple production function formulation that allows for both the number of input varieties and the quality of inputs to affect productivity. This production function provides the basis for estimation. However, standard OLS estimation of production functions is known to be inconsistent because of a simultaneity problem. Following Olley and Pakes (1996) and Levinsohn and Petrin (2003), we implement a procedure that accounts for this problem.

Preliminary results show a sizeable (although somewhat sensitive) effect of imports on productivity. A firm importing 60% of its intermediate inputs is 50-100% more productive than the one using only domestic inputs.

2 Data

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 the Customs Statistics and the firms’ balance sheets and earnings statements.
Table 1: Definition of sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery</td>
<td>All machinery except electric and data processing machines</td>
</tr>
<tr>
<td>Vehicles</td>
<td>Vehicles, (not railway, tramway, rolling stock); parts and accessories</td>
</tr>
<tr>
<td>Electronics</td>
<td>Household electronics (except &quot;white goods&quot;)</td>
</tr>
<tr>
<td>Computers</td>
<td>Automatic data processing machines</td>
</tr>
</tbody>
</table>

Table 2: Number of firms: machinery

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Foreign</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>131</td>
<td>90</td>
<td>221</td>
</tr>
<tr>
<td>1993</td>
<td>162</td>
<td>121</td>
<td>283</td>
</tr>
<tr>
<td>1994</td>
<td>165</td>
<td>145</td>
<td>310</td>
</tr>
<tr>
<td>1995</td>
<td>162</td>
<td>157</td>
<td>319</td>
</tr>
<tr>
<td>1996</td>
<td>186</td>
<td>187</td>
<td>373</td>
</tr>
<tr>
<td>1997</td>
<td>187</td>
<td>208</td>
<td>395</td>
</tr>
<tr>
<td>1998</td>
<td>185</td>
<td>218</td>
<td>403</td>
</tr>
<tr>
<td>1999</td>
<td>177</td>
<td>212</td>
<td>389</td>
</tr>
<tr>
<td>2000</td>
<td>184</td>
<td>198</td>
<td>382</td>
</tr>
<tr>
<td>2001</td>
<td>169</td>
<td>188</td>
<td>357</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>410</td>
<td>714</td>
</tr>
</tbody>
</table>

The Customs Statistics dataset contains the annual export and import traffic of the firms, both in value (forints and U.S. dollars) and in tons. The traffic is divided into product categories broken down to 6-digit Harmonized System (HS) level (5,200 categories). However, we aggregate the data up to the 4-digit level (1,300 categories) because the 6-digit classification of shipments seems to be very noisy.

The sample consists of 2,043 large exporting companies which exported more than 100 million forints 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%).

During this decade, one of the most important developments in Hungary was the growing number and market share of foreign firms.

We assign firms into four sectors based on their main export products (see Table 1). Tables 6 through 9 display the average firm size over time for each of the sectors. Apart from computers, where foreign firms tend to be bigger, there is no clear difference between domestic and foreign firms. This roughly corresponds to the median foreign ownership. By far the most common levels of foreign ownership are either 0 or 100%, so the choice of cutoff does not influence our results.

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.
the size of foreign and domestic firms. Note that firms enter and exit the sample and change ownership status so the trends in firms size are affected by these composition changes.

Firms in our sample cover the bulk of Hungarian exports, ranging from 47% in 1992 to a top of 76% in 1999. 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. Foreign firms are more export oriented for obvious reasons. The export orientation of the average Hungarian firm increased substantially over the sample period. There are three channels through which this took place: firms already in the sample increased their market share, entered new product markets, and new, more export oriented firms entered the sample.
3 Stylized Facts of Firm-Level Imports

This section documents some empirical regularities concerning the import patterns of firms.

Fact 1. There is substantial heterogeneity in the import patterns of firms within a sector. About 4 – 7% of firms do not import at all. Importing firms are 2-3 times as big as nonimporting ones.
Figure 1 displays the size distribution of firms in machinery that do and do not import a typical product, “gaskets and joints of metal sheeting.” The distribution of importing firms is shifted to the right, firms that import the product are 7 times as large as firms that do not.

Note that our sample is restricted to big exporting firms. Firms that have never exported more than 100 million HUF are excluded. Such firms are likely to be smaller and rely less on imports.

**Fact 2.** Foreign firms import more (both more product categories and as a share of total materials) and imports increase in size.

Figure 2 shows the number of imported products (HS4 categories) by firm size for foreign and domestic firms. The lines correspond to the LOWESS nonparametric estimate of the relationship between product number and employment. Product number sharply increases in size: doubling firm size would increase the number of imported products by 30%. However, even controlling for firm size, foreign firms tend to import 170% more products than domestic ones.

This pattern is consistent with a model where importing products entails a fixed cost (one needs to establish business connections, shop for the product abroad). Larger firms
profit more from buying the product and are more likely to overcome the fixed cost. It is also plausible that such a fixed cost is considerably lower for foreign firm as they already have their business networks abroad. Hence they import more products even at the same size.

We identify a product being imported if the total import shipment in the given HS4 category was positive. Note that the value of shipments is given in units of HUF (not rounded) so we do no underestimate the number of imported products.

**Fact 3.** Import intensity increases with firm size and foreign ownership.

The heterogeneity of imports with respect to firm size is further illustrated in Figure 3 which shows the share of imported inputs in total material costs. Bigger firms spend a bigger fraction of their intermediate input budget on imports. This is consistent with the fixed cost explanation: larger firms are already present in many import markets and they hence have the ability to spend a bigger fraction on imports. Again, foreign firms spend a much larger proportion on imports.

This means that there is a nontrivial demand for imports; firms do not view it as perfect substitute for domestic inputs.

Figure 3: Import share and firm size
Fact 4. Imports are concentrated on a few products, firms spend very little on the remainder of products.

The average firm spends 45% of its import budget on the largest product category and only 4% on the fifth largest category. (Some firms import less than five products.)

Figure 4 plots import intensity as a function of the number of imported products. Two observations stand out. First, the returns to additional imported products sharply diminish. This is because many of the products are small components with little contribution to overall material costs. This implies that we cannot treat product categories symmetrically as in a Dixit-Stiglitz model, we have to account for a diminishing love of variety.\(^6\)

Second, foreign firms have a somewhat higher demand for imports, even controlling for the number of products they import. This may be because they are better at using the imported inputs in production so they purchase relatively more of each product category.

Fact 5. There is a ranking of products by “importance”: if a product is imported by a firm, it is also likely to be imported by larger firms.

\(^6\)See Hummels and Lugovskyy (2004) for a model (and supporting evidence) where the marginal utility of additional varieties declines.
If the average firm imports a given product then about 40-65% of larger firms within the same industry will also import that product (depending on the industry considered). The narrower the definition of an industry, the higher the proportion of importing larger firms. This implies that a model with a size cutoff, where firms with sizes above the cutoff all import the product whereas firm below it do not, is a reasonable approximation.

**Fact 6.** Conditional on industry and firm size, import structures are similar.

In other words, most of the within-sector heterogeneity in import patterns is due to the heterogeneity in firm size. Other sources of heterogeneity may include differences in the technology used or differences in the prices faced by importers. To provide evidence on this regularity, we first sort firms by size and then predict a counterfactual import share for each product as a nonparametric function of firm size. More specifically, we take a local average of import share from firms with similar sizes. This size-predicted import share explains 51-58% of all the variation in import shares.

**Fact 7.** Growing firms enter into more new product markets whereas shrinking firms do not exit their existing markets.

Figure 5 plots the share of newly added products (relative to the number of products last year) and the share of products dropped from the product line against employment growth. Growing firms add more and more products. This is expected because it becomes easier for them to overcome the entry cost. Whether shrinking firms drop products depends on the nature of market entry costs. If entry costs are sunk and cannot be recovered upon exit (e.g., establishing business connections), firms will keep on importing their existing products even if they are shrinking in size. As shown in the Figure, very few products are dropped, even by firms that are drastically contracting.

### 4 A Model of Imports and Productivity

Here we introduce a partial equilibrium model consistent with the above stylized facts.

Firms use capital, labor and materials in their production process, where output is determined according to the production function

\[ Y = \Omega K^\alpha L^\beta X^\gamma, \tag{1} \]

with \( K \) denoting capital inputs, \( L \) labor inputs, \( X \) materials and \( \Omega \) is total factor productivity (TFP). We assume that materials is a fixed-coefficient aggregate good composed of a number of different intermediate products

\[ X = \min_i \{X_i/B_i\}. \tag{2} \]

\[^7\text{Halpern and Koren (2004) document how import prices vary across buyers.}\]
It takes $B_i$ units of good $i$ to produce a unit of $X$. Each good $X_i$ is assembled in the firm from a combination of two varieties, a foreign and a domestic one:

$$X_i = \left[(AX_{iF})^{\frac{\theta-1}{\theta}} + X_{iH}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}.$$  \hspace{1cm} (3)

Here the quantity of the foreign and domestic inputs are denoted by $X_{iF}$ and $X_{iH}$. Foreign goods are assumed to command an $A > 1$ quality advantage over domestic goods. We assume that this advantage is only partly reflected in prices, so the relative price of foreign and domestic goods is $p_{iF}/p_{iH} = A^\delta$, where $\delta \in [0,1]$. A $\delta$ of 0 means that quality is not reflected in the price of the input so all the gains from quality are reaped by the buyer of the input. A $\delta$ of 1 means that prices are proportional to quality so there are no gains from quality to the buyer. Note that it is worth to buy foreign goods even in this case, because they imperfectly substitute for domestic goods.

Notes that the production function does not necessarily exhibit constant return to scale. An alternative formulation could involve a Leontief aggregate of $K^\alpha L^\beta$ and $X$ but here we allow for some substitution between input purchases and labor/capital. For example, if labor is very cheap, the firm may opt to make the input instead of buying it at arm’s length. Without modelling the make or buy decision formally, we introduce a Cobb–Douglas production function with unitary elasticity of substitution.
The firm can only import positive amounts of $X_{iF}$ if it has paid a fixed cost of $f$ for product $i$. (Later on, we may model it as a sunk cost, payable only once. We will probably not have closed-form solutions for that case.)

As stated, the relative price of foreign and domestic goods depends on their relative qualities,

$$p_{iF}/p_{iH} = A^\delta.$$  \hspace{1cm} (4)

If the firm only buys the domestic variant of good $i$, it pays a price of

$$p_i = p_{iH}.$$  \hspace{1cm} (5)

On the other hand, if the firm buys both variants (note that they would always buy the domestic variant as it does not involve a fixed cost), the ideal price index of good $i$ becomes

$$p_i^* = p_{iH} \left[1 + A^{(\theta-1)(1-\delta)} \right]^{1/(1-\theta)}.$$  \hspace{1cm} (6)

The proportional decrease in the cost of acquiring one unit of good $i$ is a function of $A$,

$$\frac{p_i - p_i^*}{p_i} = 1 - \left[1 + A^{(\theta-1)(1-\delta)} \right]^{1/(1-\theta)} \equiv a.$$  \hspace{1cm} (7)

This cost advantage is increasing in $A$ (the quality advantage), and decreasing in $\delta$ (the price difference) and $\theta$ (the elasticity of substitution). Intuitively, if domestic variants are good substitutes of foreign variants, the benefit of using imports is lower. The ideal price index for the whole set of intermediate inputs is

$$P = \sum B_i \tilde{p}_i,$$ \hspace{1cm} (8)

where $\tilde{p}_i$ is either $p_i^*$ (if good $i$ is imported) or $p_i$ (if it is not). For tractability, we assume that the gain from foreign inputs, $a$ is the same across goods. Then the ideal price index is

$$P = P^{(0)} \left[1 - a \sum_{i \in \text{imp}} B_i p_i/P^{(0)} \right] \equiv \left[1 - a \sum_{i \in \text{imp}} b_i \right].$$ \hspace{1cm} (9)

The term $b_i \equiv B_i p_i/P^{(0)}$ is the share of good $i$ in total intermediate expenditure if none of the products are imported. If all firms use the same technology ($B_i$) and face the same prices ($p_i$) then $b_i$’s are the same across firms, too.

Because the set and composition of intermediate inputs varies across firms, the only meaningful measure of TFP can be derived from the inverse of marginal cost. The cost function is

$$\Omega^{-1} Y^{1/(\alpha+\beta+\gamma)} R^{\alpha/(\alpha+\beta+\gamma)} W^{\beta/(\alpha+\beta+\gamma)} P^{\gamma/(\alpha+\beta+\gamma)}.$$
If the firm can buy foreign products, it can provide the same composite of intermediate goods at a lower ideal price index, $P$. This decreases marginal cost for *given factor prices*.

Let $M = PX$ denote the total spending on intermediate inputs (observable from the earnings statement). Then, up to a constant $P^{(0)}$,

$$Y = c\Omega K^\alpha L^\beta M^\gamma \left[ 1 - a \sum_{i \in \text{imp}} b_i \right]^{-\gamma}.$$ (10)

That is, measured productivity is greater, the greater the set of imported products.

To express productivity as a function of observables, note that we can write the share of intermediate expenditure spent on imports as

$$S \equiv \frac{\sum p_i F x_i F}{\sum p_i x_i} = \left[ (1 - a) - (1 - a)^\theta \right] \frac{\sum_{i \in \text{imp}} b_i}{1 - a \sum_{i \in \text{imp}} b_i},$$ (11)

which implies

$$\left[ 1 - a \sum_{i \in \text{imp}} b_i \right]^{-1} = 1 + \frac{a}{(1 - a) - (1 - a)^\theta} S,$$ (12)

which is increasing in the import share ($S$) since $\theta > 1$ (foreign and domestic inputs are gross substitutes).

Taking logs of (10) and using the approximation $\ln(1 + x) \approx x$,

$$y = c + \alpha k + \beta l + \gamma m + \delta S + \omega,$$ (13)

where $\delta = a\gamma / [(1 - a) - (1 - a)^\theta]$ is positive. That is, TFP is increasing in the share of imports.

In a standard specification one would estimate

$$y = \alpha k + \beta l + \gamma m + \omega,$$

where capital, labor and material cost can be thought of as “traditional inputs,” and $\omega$ is total factor productivity (TFP). Here we go one step further and relate TFP to the share of imported inputs, $S$. The key parameter of interest is hence $\delta$.

The main challenge of estimating (13) is a well known endogeneity problem: firms with higher productivity ($\omega$) use more variable inputs ($l$ and $m$) so the error term is not orthogonal to the explanatory variables. Moreover, high-productivity firms are also more likely to enter more import markets, as we will show next.

### 4.1 Endogenous entry into import markets

When choosing which product markets to enter, the firm minimizes the sum of variable and fixed costs,

$$\min_{\{n\}} \Omega^{-1} Y^{1/(\alpha + \beta + \gamma)} R^{\alpha/(\alpha + \beta + \gamma)} W^{\beta/(\alpha + \beta + \gamma)} P^{\gamma/(\alpha + \beta + \gamma)} + nf,$$ (14)
where \( n \) is the number of products imported and \( f \) is the per-product fixed cost (assumed to be the same across firms and products).

Assume without loss of generality that products are ordered by decreasing share, \( b_i \). Then the first \( n \) products will be imported, where \( n \) is implicitly given by

\[
\frac{\gamma Y ab_n}{1 - a \sum_{i=1}^{n} b_i} = f.
\]

This follows directly from the FOC of the minimum problem. The left-hand side is monotonically declining in \( n \), this defines a unique \( n \) that is increasing in \( Y \) (sales), \( a \) (benefit from imports), and decreasing in \( f \) (fixed cost). Large firms with lower fixed costs (e.g., foreign-owned firms) import more product varieties.

This implies that conditional on \( k, l, \) and \( m \), TFP is positively correlated with the number of imported products and hence with the share of imports in material costs.

Moreover, as we argued above, there is enormous persistence in import market participation: once a firm starts importing a product, it very rarely stops. Hence we can assume that there are two observable firm specific state variables, capital \( k \) and the number of input varieties \( n \). The latter is a state variable because the firm is required to pay the sunk cost associated with using any particular variety only once.

The dynamics of the industry is assumed to be standard, as specified in Olley and Pakes. In particular, at each point in time, an incumbent firm has three decisions to make. First, it needs to decide whether to exit or continue in the industry. If it continues, it has to choose its variable factors (labor, materials, share of high quality inputs) as well as its investment in capital, and the number of new varieties it wishes to use in production. These latter two decisions, together with the current capital stock and number of inputs, will determine the levels of \( k \) and \( n \) next period.

5 Estimation Framework

As is well known, there is a severe endogeneity problem that plagues the OLS estimation of an equation like (13). Input demand and unobserved productivity are correlated, because more productive firms are expected to use more variable inputs. Because of that, simple OLS estimates would yield inconsistent estimates for the coefficients of variable inputs, which in our case includes labor \( l \), and material costs \( m \). Relatedly, if productivity is persistent over time, then more productive firms tend to accumulate more capital and enter a larger number of import markets; thus higher \( k \) and \( S \) will be associated with higher unobserved productivity in the cross section. Because of that, in a cross sectional OLS regression, the coefficients of \( k \) and \( S \) would not be estimated consistently.

To deal with this endogeneity problem, we implement an estimation methodology which is based on the approach followed by Olley and Pakes and Levinsohn and Petrin (2003).

Recall from (13) that for firm \( i \) in year \( t \),

\[
y_{it} = c + \alpha k_{it} + \beta l_{it} + \gamma m_{it} + \delta S_{it} + \omega_{it},
\]

15
and the endogeneity problem is that unobserved productivity, \( \omega_{it} \), is correlated with the explanatory variables.

However, we conjecture that, conditional on observable state variables \((k \text{ and } n)\), investment is a monotonic function of productivity,

\[
I_{it} = f(\omega_{it}, k_t, n_t),
\]

which is invertible in its first argument to get

\[
\omega_{it} = g(I_{it}, k_{it}, n_{it}).
\]

Hence

\[
y_{it} = \alpha k_{it} + \beta l_{it} + \gamma m_{it} + \delta S_{it} + g(I_{it}, k_{it}, n_{it}) + \varepsilon_{it},
\]

where \( \varepsilon_{it} \) is the part of productivity that is not observable to the firm (i.e. orthogonal to firm decisions).

From (18), we can control nonparametrically\(^8\) for \( I_{it}, k_{it} \) and \( n_{it} \) to obtain consistent estimates of \( \beta \) and \( \gamma \). However, because \( S \) deterministically depends on \( n \) and we do not know the function \( g(\cdot) \), we are unable to identify \( \alpha \) and \( \delta \) in the first stage.

We assume that unobserved productivity follows a first-order Markov process conditional on the observed state variables. In particular, we simplify by assuming that \( \omega \) is an AR(1) process with autocorrelation \( \rho \),

\[
E_t \omega_{i,t+1} = \rho \omega_{it}.
\]

For any given \( \alpha \), \( \delta \) and \( \rho \), we can subtract \( \rho \) times the lagged TFP from the current estimated TFP to obtain TFP innovations

\[
\omega_{it} = [y_{it} - \alpha k_{it} - \beta l_{it} - \gamma m_{it} - \delta S_{it}] - \rho g(I_{i,t-1}, k_{i,t-1}, n_{i,t-1}).
\]

These innovations are orthogonal to all information available at time \( t - 1 \). We use current and lagged capital, lagged employment, material cost and number of products as instruments.

Because of the linearity of the production function, the parameters \( \alpha \) and \( \delta \) can be estimated by a linear instrumental variables regression for any given \( \rho \).

The autocorrelation parameter, \( \rho \) is obtained from a grid search over \([0, 1]\) seeking to minimize the weighted squared sum of moments. The \( J \)-test of overidentification is not rejected in any of the specifications, meaning that TFP innovations are indeed orthogonal to all of the instruments.

Standard errors and significance levels are obtained from a 200-repetition bootstrap.

6 Results

Table 10 displays the estimation results. The “OLS” columns show the simple OLS estimates of (13) for comparison. Significance at 10, 5, and 1% are denoted by *, **, and ***.

\(^8\)In our implementation, this involves running multivariate locally weighted regressions.
respectively. We expect the OLS coefficients of freely adjustable inputs (labor, material) to be upward biased. Firm fixed effects are included in the “FE” columns.

Note that the dependent variable is total sales, not value added. Hence the large coefficients of material costs and the relatively small coefficients of capital and labor.

The “GMM1” columns report the results of the concentrated GMM procedure outlined in the previous section, when import share is treated as a capital good (state variable). We also report the significance level at which the coefficients differ from zero. These we obtain from 200-repetition bootstraps.

The “GMM2” columns show a variant in which the import share is treated as an adjustable input. Capital inputs still include physical capital and the number of imported products.

Overall, the following results stand out. First, the capital coefficients tend to be very low and imprecisely estimated. This may indicate that our measure of capital (book value of equipment) is a poor proxy for capital services.

Second, the great majority of OLS and fixed-effect regressions indicate a highly significant positive association between import share and productivity: those spending 0.10 more on imports typically produce 2-4% more output with the same amount of inputs. This corresponds to a 7-13% increase in their value added. Moving from 0 imports to 60% of material costs would increase value added by 50-100%. However, the causal interpretation of these relationships are limited by the endogeneity problems mentioned earlier.

Third, the import share coefficient is significantly positive in many of the GMM specifications, ranging from 0.15 to 0.4. These correspond to productivity effects similar in magnitude to the ones just described.

Fourth, productivity tends to be very persistent, very close to a random walk in most specifications.

7 Conclusion

The paper asks the question of whether firms importing more become more productive. Using product-level import data for a panel of Hungarian manufacturing firms from 1992 to 2001, we document several empirical regularities of import patterns across firms. We build a simple partial equilibrium model in which firms have to incur a sunk entry cost in order to start importing a given product. Our model leads to a simple production function formulation that allows for both the number of input varieties and the quality of inputs to affect productivity.

We implement a version of the Olley and Pakes (1996) estimation procedure to handle the standard simultaneity problem of adjustable inputs as well as the problem of endogenous entry into import markets. Preliminary results show a sizeable (if somewhat sensitive) effect of imports on productivity. A firm importing 60% of its intermediate inputs is 50-100% more productive than the one using only domestic inputs.
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