Preliminary Draft

Product Quality, Productive Efficiency, and International Technology Diffusion:

Evidence from Plant-Level Panel Data

Aart Kraay
The World Bank

Isidro Soloaga
The World Bank

James Tybout
Pennsylvania State University and NBER

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I. Overview

A casual tourist can confirm that technologies often make their way from the developed world to the less developed countries (LDCs). However, despite the critical importance of technology diffusion for economic development, the evidence on many aspects of this process remains sketchy: What mechanisms most frequently transmit foreign technologies to LDC firms? Do these foreign technologies affect both productive efficiency and product quality in the recipient firms? Under what circumstances do firms pursue activities that give them access to foreign knowledge? This paper develops a new methodology for addressing these issues and applies the framework to plant-level panel data from Colombia, Mexico and Morocco.

A. The existing literature

Our limited understanding of international knowledge diffusion does not derive from neglect of the topic. In the empirical economics literature alone, at least three different methodological approaches have been deployed. First, at the very micro level, a number of analysts have used case studies and qualitative surveys to generate descriptions of learning processes at individual firms (e.g., Hobday, 1995; Lall, 1987; Katz, 1987; Pack, 1987; Rhee, Ross-Larson and Pursell, 1984). As Pack (1999) observes, this literature provides invaluable details concerning firms' efforts to absorb technology. But it has to little to say quantitatively about the results of these efforts in terms of productive efficiency or product quality. There are some exceptions (e.g., Pack, 1987), but they are too few and based on such small samples that they provide little basis for generalization.

At the other extreme, studies based on aggregated data have correlated cross-country patterns of productivity growth or productivity levels with various proxies for countries' exposure to foreign knowledge and/or their ability to absorb it. These proxies include capital goods imports (e.g., de Long and Summers, 1991; Keller, 2000), trade with countries possessing large R&D stocks (Coe and Helpman, 1995; Keller, 1998; Keller 2000), foreign direct investment inflows (Blomstrom, Lipsey and Zejan, 1994), and domestic patent stocks (Eaton and Kortum, 1996).[1] Unlike case studies and descriptive surveys, cross-country regressions document broad patterns of association, and in that sense they provide a basis for generalization. However, most are subject to a variety of econometric criticisms, including aggregation bias, omitted variable bias, measurement error bias, and simultaneity bias.

Finally, plant or firm-level econometric studies correlate proxies for firms' exposure to foreign knowledge with their productivity levels or growth rates. To cite a few examples, Aitken and Harrison (1999), Haddad and Harrison (1993), and Djankov and Hoekman (2000) study foreign direct investment; and Chen and Tang (1987), Aw and Hwang (1995), Clerides *et al* (1998), Kraay (1997), and Bigsten *et al* (1999) study exports.[2] By sacrificing the nuance and detail provided by case studies, these micro econometric studies gain the ability to treat large numbers of producers and make statistical inferences. They also do better than the macro studies in terms of identifying the specific correlates of productivity and avoiding aggregation bias.

1 Unlike the other studies mentioned here, Eaton and Kortum (1996) do not attempt to empirically isolate a conduit for knowledge transfer

2 A more extensive literature review may be found in Tybout (2000)

Nonetheless, the plant-level econometric studies have significant shortcomings too. One common problem is a failure to disentangle causality. For example, contemporaneous correlation between exports and efficiency tells us nothing about what caused what. Even studies that use lagged exports to predict current efficiency may miss the knowledge transmission mechanism, as Westphal (2001) has emphasized. A second problem is that productivity is almost always poorly measured.[3] Manufactured products are quite heterogeneous, even within narrowly defined industries, so there is no single measure of output that can be compared across firms. Real revenue is typically used as a stand-in for physical product, but this variable responds to product-specific price adjustments as well as fluctuations in physical volume. Productivity measures consequently confound productive efficiency and market power. Further, when technology diffusion leads to product innovation rather than process innovation, these productivity measures may miss the effect entirely. Finally, like the cross-country regressions, studies in this literature usually focus on a single conduit for international technology diffusion and ignore the others, opening the door to omitted variable bias.

B. The contribution of this paper

This paper is an econometric study based on plant-level data, so it falls squarely in the third category mentioned above. But we attempt to improve on existing methodologies in two respects. First, we abandon the standard approach to measuring productivity in favor of an alternative approach that treats the observed plant-level data

[3] Few studies in the other literatures do better, but Pack (1987) is an exception. He uses detailed information on machines and workers at a sample of plants to calculate high quality productivity indices.

on revenues, costs and market shares as reflecting equilibrium in a differentiated product market. By using a new normalization and imposing sufficient demand-side structure, we avoid the problem of distinguishing real revenue from physical product. We are also able to separately measure *process* innovations, which are manifest in marginal cost reductions, and *product* innovations, which are manifest in heightened demand for a product at a given vector goods prices. Accordingly, we can study the joint evolution of these processes and investigate whether improvements in one dimension are complemented or offset by changes in the other.

Second, we treat multiple channels for international technology diffusion in a single integrated framework. This would not be important if the various activities that transmit technology were unrelated to one another. But because of complementarities and indivisibilities, they tend to come in bundles and/or in predictable sequences.[4] Hence econometric models that treat any one of them as the unique source of foreign technology run considerable risk of misattribution.

Table 1 below lists the main knowledge-transmitting activities identified by the case study literature. It is not hard to identify reasons why firms' decisions regarding these activities will be related to one another. Exporters are relatively likely to use imported capital and intermediate goods because they are granted preferential access to foreign exchange, or because the product characteristics needed for exporting are best manufactured with these goods. Similar input and capital good requirements may

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4 Milgrom and Roberts (1990) make a similar point in their paper on the adoption of new technologies and organizational strategies. They do not consider international trade in goods, ownership, or information, so their list of activities differs somewhat from those that we focus on. Nonetheless, their basic analytical point translates to our setting, *mutatis mutandis*—when non-convexities and complementarities characterize the profit function, it may well be optimal to adopt bundles of new activities at once.

accompany licensing agreements. Firms with FDI are relatively likely to use imported intermediates because the parent company can internalize some costs by doing so. Multinationals sometimes locate plants abroad to exploit low wages while protecting their intangible assets like proprietary knowledge and product reputation, so FDI and exporting can also be complementary activities.

Table 1: Alternative ways to acquire foreign technologies

- Foreign direct investment in domestic enterprises;
- joint ventures;
- outsourcing;
- licensing arrangements;
- importation of intermediate and capital goods;
- learning from exporting to knowledgeable buyers;
- learning from final goods imported, and reactions to changes in domestic market structures as these goods enter the country.

II. Methodology

A. The Conceptual Framework

To motivate our empirical model, we begin by sketching a dynamic model of industrial evolution in which firms makes optimal decisions concerning their activity bundles. In turn, these bundles influence their future performance. Although we shall not get very formal about this model, our discussion will allow us to be explicit about the causal relationships that we assume have generated the data.

Performance determinants:

Let us begin with a representation of performance determinants. From the perspective of managers, the activities in Table 1 generate revenues by improving a firm's unit production costs (c_{jt}) or the appeal of its product (a_{jt}), which we combine to form the performance vector $\boldsymbol{\omega}_{jt} = (a_{jt}, c_{jt})$ for the j^{th} firm in period *t*. Then, presuming that the elements of $\boldsymbol{\omega}_{jt}$ evolve according to auto-regressive processes, conditioned on exogenous firm characteristics (hereafter $\boldsymbol{x}_{jt}$) and the firm's history of activity bundles (hereafter $\boldsymbol{B}_{jt-1}$), we write:

$$\boldsymbol{\omega}_{jt} = g_{\omega}(\boldsymbol{x}_{jt}, \boldsymbol{B}_{jt-1}, \boldsymbol{\Omega}_{jt-1}, \varepsilon_{jt}), \tag{1}$$

where $\boldsymbol{\Omega}_{jt} = (\boldsymbol{\omega}_{jt}, \boldsymbol{\omega}_{jt-1}, \boldsymbol{\omega}_{jt-2}, \ldots)$, $\boldsymbol{B}_{jt} = (\boldsymbol{b}_{jt}, \boldsymbol{b}_{jt-1}, \boldsymbol{b}_{jt-2}, \ldots)$, $\boldsymbol{\varepsilon}_{jt}$ is a serially uncorrelated vector of unobserved innovations in the $\boldsymbol{\omega}_{jt}$ process, and the column vector of dummies $\boldsymbol{b}_{jt}$ indicates which activity bundle the j^{th} firm is pursuing at time *t*, if any.[5]

Activity determinants

Of course, the activities themselves are endogenous. We envision firms weighing four kinds of effects on their profit streams when choosing which combination to pursue. First, as described by equation (1), activities influence future realizations on the performance trajectories, $\boldsymbol{\omega}_{jt}$. Second, in so doing they may also affect the future activity choices and performance of competing firms. Third, given the $\boldsymbol{\omega}_{jt}$ realization, activity

5 That is, the k^{th} element of $\boldsymbol{b}_{jt}$ takes a value of one in period *t* if the firm is engaged in the k^{th} possible *bundle* of activities during that period, and otherwise takes a value of zero. In a country where there are K possible activities, $\boldsymbol{b}_{jt}$ has 2^K elements.

bundles can affect net operating profits by changing demand conditions—e.g., providing access to foreign markets—or by affecting the share of operating profits retained by the firm's majority owners. Finally, the initiation of activities generally involves start-up or adjustment costs.

The specifics of these effects on profits depend upon the activity in question. For example, joint ventures, subcontracting and FDI may transmit knowledge and/or improve a firm's access to inputs, thereby affecting the evolution of its performance vector, $\boldsymbol{\omega}_{jt}$. These activities may also affect its operating profits by creating new markets for its products, by branding its products, by creating profit-sharing obligations, and/or by diluting corporate control. Finally, joint ventures, subcontracting and FDI involve up-front research costs and legal fees when they are initiated.

Similar observations apply to the other activities in table 1. Firms that import intermediate or capital goods improve their performance trajectories by using higher quality inputs and by extracting knowledge from these foreign goods. But they also incur higher material or capital costs and, prior to importing, they must research foreign suppliers and learn about customs procedures. Firms that employ high quality workers typically improve their processes and their products, but they also incur higher labor costs, and they bear the sunk costs of attracting and screening job applicants for these positions. Finally, firms that export improve their earnings by tapping new markets, and they may learn from knowledgeable buyers abroad. But to begin exporting, firms must establish distribution channels, research foreign markets, and re-package and/or even re-design their products.

When managers understand these linkages and correctly anticipate the behavior of their rivals, the activity choices of the j^{th} firm in period t can be represented as determined by the decision rule:

$$\boldsymbol{b}_{jt} = g_b(j, \boldsymbol{Z}_t, \boldsymbol{X}_t, \boldsymbol{\Omega}_{t-1}, \boldsymbol{B}_{t-1}, \Gamma_{jt}) \qquad (2)$$

Here the arguments of $g_b(\cdot)$ include everything that helps firms predict the future pay-offs from each possible bundle: current and past exchange rates and demand levels, $\boldsymbol{Z}_t$, the set of previous realizations on $\boldsymbol{\omega}$ for *all* industry participants, $\boldsymbol{\Omega}_{t-1} = (\boldsymbol{\Omega}_{1t-1}, \cdots, \boldsymbol{\Omega}_{jt-1}, \cdots, \boldsymbol{\Omega}_{Nt-1})$, previous activity choices for all industry participants, $\boldsymbol{B}_{t-1} = (\boldsymbol{B}_{1t-1}, \cdots, \boldsymbol{B}_{jt-1}, \cdots, \boldsymbol{B}_{Nt-1})$, the exogenous characteristics of all industry participants, $\boldsymbol{X}_t = (\boldsymbol{x}_{1t-1}, \cdots, \boldsymbol{x}_{jt-1}, \cdots, \boldsymbol{x}_{Nt-1})$, and a set of beliefs, Γ_{jt}, about the decision rules that will be used by all of the other firms. (When the industry is in equilibrium, these beliefs must be consistent with observed behavior.) Finally, while the information set is common to all firms, $g_b(\cdot)$ depends upon j because the j^{th} firm's own characteristics and history affect its pay-offs asymmetrically from those of all other firms.

Inference

Our basic objective is to quantify the relationships described by equations (1) and (2). We shall view significant associations between $\boldsymbol{B}_{jt-1}$ and $\boldsymbol{\omega}_{jt}$ in equation (1) as evidence that the international activities Granger-cause performance. Similarly, in equation (2) when $\boldsymbol{\Omega}_{jt-1}$ helps predict $\boldsymbol{b}_{jt}$, we shall view performance as Granger-causing activities. In both equations, the fact that we treat activities as bundles will allow to determine whether particular combinations of bundles are relatively potent performance determinants. Also, given that we shall examine the joint evolution of productive efficiency and product quality, we will be able to make inferences about the nature of the performance effects induced by international contacts.

Given sufficient variation in the data, this approach to inference should pick up most instances where knowledge acquired through observable activities enhances future product quality or productive efficiency. However, there are some types of linkages between activities and performance that it will fail to detect. For example, suppose a foreign corporation subcontracts with a particular plant to become a supplier for one its products, and it transmits the necessarily technical information to that plant. It may be years before the plant actually begins to export the product to the buyer (e.g., Kim, 1997) so when the associated exports show up in the data, the plant's performance trajectory will have already responded to the new knowledge and no association will be detected. In fact, this scenario would generate the misleading econometric impression that the outsourcing activity responded to a productivity shock rather than vice versa.

Equation (1) will also miss technology diffusion that does not occur at the firm level. For example, if firms acquire imported intermediate or capital inputs through an intermediary rather than by purchasing directly from foreign suppliers, the associated improvement in performance will not be attributed to foreign sources. Similarly, if firms that learn by engaging in international business serve as valuable examples for others, the knowledge spillovers they generate will not be attributed to foreign sources. For all of these reasons, the results of the exercise that follows should be viewed as suggestive rather than definitive.

B. An Empirical Model

To render equations (1) and (2) empirically useful, we must surmount several obstacles. Our first problem is to measure the performance vector, $\boldsymbol{\omega}$. Somehow we must measure unit production costs (c_{jt}) and product attractiveness (a_{jt}) concepts using plant-level data on revenues, intermediate input costs, market shares, labor costs, and crude capital stock proxies.

To render unit production costs observable we make two key assumptions. First, we define one unit of the j^{th} plant's product to be whatever that plant can produce with a dollar's worth of intermediate inputs. Since products are differentiated this does not imply that a plant using a relatively large amount of intermediate inputs is producing a relatively valuable output. However, if firms were to differ in the efficiency with which they convert intermediate goods into final output, this assumption would have the undesirable implication that efficiency gains reduce output when the physical volume of final production doesn't change.[6] Thus our second key assumption is that firms exhibit constant returns homothetic technologies, and that these technologies differ across producers only because of differences in *primary* factor efficiency. That is, some firms use labor and capital more effectively than others, and this is the *only* reason marginal cost schedules differ across firms. With these assumptions we can calculate unit (variable) production costs and output prices at the j^{th} plant in year t as $c_{jt} = \frac{C_{jt}}{I_{jt}}$ and $p_{jt} = \frac{R_{jt}}{I_{jt}}$, where C_{jt} is total variable costs (labor, intermediates, and energy), I_{jt} be intermediate input costs, and R_{jt} be revenues. Our assumptions also imply that unit variable production costs correspond to marginal costs.

Measuring product appeal or quality is more difficult. Our approach is based on the notion that, given the vector of prices for all available products in an industry (including a composite imported variety), large market shares imply high quality. Of course, market shares reflect more than product characteristics, so one should think of "quality" as a broad measure of product appeal that responds to reputational effects and advertising as well as physical characteristics of the products.

To impute this quality notion from prices and market shares we need a demand system and a market equilibrium concept. For these we use Lu and Tybout's (2000) adaptation of Berry's (1994) representation of a differentiated product market, which in turn is based on McFadden's (1974) nested logit demand system and the generalizations developed by Berry, Levinsohn ad Pakes (1995). The following paragraphs paraphrase Lu and Tybout's (2000) deployment of Berry's (1994) model.

The Demand System

We begin by assigning each producer in the industry of interest to one of G geographic regions ("nests"). Producers in all regions compete with one another and with a composite imported good, but consumers view products within a region as closer substitutes than products coming from distinct regions. The price of the composite imported good is exogenously determined by the real exchange rate. There are N domestic establishments, indexed by $j \in \{1, \ldots N\}$, each supplying its own unique variety.

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[6] Variation in factor prices across plants will also undermine our basis for inference. We controlled for regional variation in factor prices using regional dummies and never found significant effects, so we dropped them for the results reported herein.

So counting the composite imported good (identified by j = 0) there are *N+1* available varieties. Finally, Θ_j is the set of product varieties included in product j's nest (including product j itself).

Domestic consumers have heterogeneous tastes, indexed by the real number $\ell \in (0, L_t]$. Each period, each consumer in the market chooses a single unit of the variety that yields him or her the largest net indirect utility, where variety j yields consumer ℓ net utility:

$$u_{\ell jt} = \overline{u}_{jt} + \varsigma_{\ell g_j t} + \nu_{\ell jt} \ . \tag{3}$$

Here $\overline{u}_{jt} = \xi_{jt} - \alpha \ p_{jt}$ for the N domestic varieties and $\overline{u}_{0t} = \xi_{0t} - \gamma \cdot r_t$ for the imported variety, where ξ_{jt} indexes the "quality" of good j and p_{jt} and r_t are the prices of the N domestic goods and the domestic currency price of the imported composite good, respectively.

The last two terms on the right hand side of (3) are unobserved error components that capture individual taste differences. The first component, $\varsigma_{\ell g_j t}$, varies across nests but not within them, while $\nu_{\ell jt}$ exhibits within-nest variation. By assumption, both $[\varsigma + \nu]$ and ν are distributed type-I extreme value across consumers, with variances $(\pi\mu_1)^2/3$ and $(\pi\mu_2)^2/3 < (\pi\mu_1)^2/3$, respectively. The indirect utility function parameters are identified only up to a scalar multiple so we impose μ_1 = 1.[7] Also, we define

7 Anderson, de Palma and Thisse (1992) show that one can think of these error components as reflecting heterogeneous tastes over unobserved product characteristics. From that perspective, Ackerburg and Rysman (2001) suggest that μ_1 and μ_2 be made functions of the number of products, since the addition of more products to a market is likely to crowd product space and effectively reduce the dispersion in tastes across products. We experimented with this generalization and found no cross-nest dependence of the error component variances on the number of products locally available.

$\sigma = 1 - \mu_2 / \mu_1$ $(0 < \sigma < 1)$ to index the degree of substitutability among, versus within, the nests.[8]

Integrating over domestic consumers yields the standard nested logit expression for the demand for the j^{th} domestic variety as a fraction of total domestic demand for varieties in the j^{th} product's nest:

$$s_{j|g,t} = \frac{\exp[(\bar{u}_{jt} - \bar{u}_{0t})/(1-\sigma)]}{\sum_{k \in \Theta_j} \exp[(\bar{u}_{kt} - \bar{u}_{0t})/(1-\sigma)]}, \quad j = 1,2,\ldots, N_t \ . \tag{4}$$

Similarly, total demand for group g varieties as a share of total domestic consumption is

$$s_{g,t} = \frac{D_{gt}^{1-\sigma}}{\sum_{k=1}^{G} D_{kt}^{1-\sigma} + 1}, \textit{ where } D_{gt} = \sum_{k \in \Theta_g} \exp[(\bar{u}_{kt} - \bar{u}_{0t})/(1-\sigma)], \quad g = 1, \ldots, G, \tag{5a}$$

and the demand for the imported variety as a share of total domestic consumption—i.e., the import penetration rate—is:

$$s_{0,t} = 1 - \sum_{g=1}^{G} s_{g,t} = \frac{1}{\sum_{k=1}^{G} D_{kt}^{1-\sigma} + 1} \tag{5b}$$

Hence demand for the j^{th} variety as a fraction of total units sold is $s_{jt,} = s_{j|g,t} \cdot s_{g,t}$.

Given our normalization rule, we can measure the market shares that appear in (4), (5a) and (5b) as $s_{j|g,t} = \dfrac{I_{jt}}{\sum_{i \in \Theta_j} I_{it}}$, $\quad s_{g,t} = \dfrac{\sum_{i \in \Theta_g} I_{it}}{\sum_{i=1}^{N_t} I_{it} + M_t}$, $\quad$ and $s_{o,t} = 1 - \sum_{g=1}^{G} s_{g,t}$, where M_t is the dollar value of imports converted to pesos at the same real exchange rate for all

8 As σ goes to zero, the within-group correlation of utilities goes to zero, and as σ goes to unity, within-group correlation goes to unity.

years.[9] Then, using these equations and the definition of $\bar{u}_{jt}$, it is possible to solve for the quality of domestic good *j* by using the expressions for mean utility:

$$\xi_{jt} = \alpha p_{jt} - \sigma \ln(s_{j|g,t}) + \ln\left({s_{jt}}/{s_{0,t}} \right) \quad j = 1,\ldots,N \quad t = 1,\ldots T$$

Finally, we obtain our quality/appeal measure, a_{it}, by expressing ξ_{jt} relative to the quality of imports. Specifically, without loss of generality we set the mean utility from imports to zero ($\bar{u}_{0t} = 0$) and we measure the quality of domestic good *j* relative to the quality of imports as:

$$a_{jt} \equiv \xi_{jt} - \xi_{0t} = \alpha p_{jt} - \gamma r_t - \sigma \ln(s_{j|g,t}) + \ln\left({s_{jt}}/{s_{0,t}} \right) \quad j = 1,\ldots,N \quad t = 1,\ldots T \qquad (6)$$

Note that equation (6) does *not* explain how a_{jt} is determined; rather it provides a way to solve for an unobserved matrix in terms of observed matrices and parameters that can be estimated.

Estimation

Of course, equation (6) cannot be used to impute quality unless α, γ and σ are known. We identify these parameters by substituting the right-hand side of equation (6) into a linearized version of equation (1) wherever a_{jt} appears:

9 More precisely, we calculate M_t using a constant real exchange rate to convert real dollar imports to pesos in all years. Thus we are assuming that the real dollar cost of imports corresponds to the volume of intermediate goods used to produce them. Our approach to measuring imports also implies that foreign producers do not adjust their dollar price in response to exchange rate fluctuations—that is, we assume complete pass-through. This implication is consistent with our expressions for equilibrium market shares and prices, which are based on the premise that the price of the outside good does not respond to adjustments in the prices of the domestically produced varieties. While the empirical literature suggests that the dollar prices of imported goods are likely to respond some to exchange rate fluctuations (Knetter and Goldberg, 1999), our assumption does not seem too far from reality.

$$a_{jt} = a_0 + \sum_{q=1}^{Q} \lambda_q a_{j,t-q} + \sum_{q=Q+1}^{2Q} \lambda_q c_{jt-q} + \lambda^x \boldsymbol{x}_{jt} + \lambda^b \boldsymbol{b}_{jt-1} + \varepsilon^a_{jt}, \tag{1a}$$

$$c_{jt} = a_0 + \sum_{q=1}^{Q} \phi_q c_{j,t-q} + \sum_{q=Q+1}^{2Q} \phi_q a_{j,t-q} + \phi^x \boldsymbol{x}_{jt} + \phi^b \boldsymbol{b}_{jt-1} + \varepsilon^c_{jt}, \tag{1b}$$

$$j = 1, \cdots, N \quad , \quad t = Q+1, \cdots, T \; .$$

Then we estimate these equations jointly with the equilibrium price relationship that obtains when firms compete Betrand-Nash in the product market (Berry, 1994): [10]

$$\ln(p_{j,t}) = \ln\left\{ c_{j,t} + \frac{(1-\sigma)/\alpha}{1-\sigma \cdot s_{j|g,t} - (1-\sigma)\cdot s_{j|g,t} \cdot s_{g,t}} \right\} + \varepsilon^P_{jt} \tag{7}$$

That is, we estimate the demand parameters at the same time that we estimate the parameters describing the effects of international activities on each dimension of performance (λ^b and ϕ^b).

It remains to discuss the properties of the error terms in the system (1a), (1b) and (7). First, if ε^P_{it} reflects measurement error in costs or intermediate inputs, it will be correlated with the right-hand side variables in equation (7). Unlike Berry (1994), we assume this problem away by positing that the noise in equation (7) comes from exclusively from measurement error in revenues (and thus in prices).[11]

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[10] This condition presumes that the (common knowledge) performance vector ($\boldsymbol{\omega}_{1t}, \boldsymbol{\omega}_{2t}$, $\boldsymbol{\omega}_{jt}$, . . . $\boldsymbol{\omega}_{Nt}$) is realized at the beginning of each period and that future states of the industry do not depend upon current price and quantity choices, given $\boldsymbol{\Omega}_{t-1}$ and $\mathbf{B}_{t-1}$. Also, mixed strategies in the product market competition are disallowed. (See Ericson and Pakes (1995) for a formal discussion of the relation between product market competition and industry dynamics.)

[11] Lu and Tybout (2000) discuss some alternative ways to allow for noise in (2'); they complicate the estimation procedure but can be feasibly implemented. We plan to explore their properties in future work.

Second, if the disturbance terms ε_{jt}^{a} and ε_{jt}^{c} are serially correlated, they will not be orthogonal to lagged endogenous variables $(\boldsymbol{b}_{jt-1}, a_{jt-q}, c_{jt-q})$ and spurious correlation patterns may result. There are two standard ways to deal with this problem. One is to choose a sufficiently long lag length (*Q*) that all persistence in the endogenous variables is absorbed by the explanatory variables, leaving ε_{jt}^{a} and ε_{jt}^{c} serially uncorrelated. This solution is simple and appealing, but in short panels like ours it means sacrificing most of the time series information in the data. Since time series variation is key for Granger causality tests, we choose the other standard approach. That is, we assume that the error terms are characterized by a standard error component specification and we correct for the associated initial conditions problem (Heckman, 1981).

Specifically, we write the disturbances as $\varepsilon_{jt}^{a} = \mu_{j}^{a} + \upsilon_{jt}^{a}$ and $\varepsilon_{jt}^{c} = \mu_{j}^{c} + \upsilon_{jt}^{c}$, where: $\text{var}(\upsilon_{jt}^{k}) = \sigma_{\upsilon,k}^{2}$, $\text{var}(\mu_{j}^{k}) = \sigma_{\mu,k}^{2}$, $\text{cov}(\upsilon_{jt}^{k}, \upsilon_{jt-s}^{k}) = 0 \quad \forall s \neq 0$, $\text{cov}(\upsilon_{jt}^{a}, \upsilon_{jt}^{c}) = \sigma_{\upsilon,ac}$, $\text{cov}(\mu_{j}^{a}, \mu_{j}^{c}) = \sigma_{\mu ac}$ and $\text{cov}(\mu_{j}^{a}, \mu_{m}^{c}) = \text{cov}(\mu_{j}^{k}, \mu_{m}^{k}) = 0 \quad \forall j \neq m$ and $\forall k = a, c$. Then we use Wooldridge's (2000) conditional likelihood function to dealing with initial conditions problem. That is, we write the joint density for *T* realizations on the vector ω_{jt} and the unobserved effects, $\mu_{j} = (\mu_{j}^{a}, \mu_{j}^{c})$, *conditioned* on ω_{j1} and x_{j}, as:

$$f(\omega_{j2}, \cdots, \omega_{jT}, \mu_{j} \mid \omega_{j1}, x_{j}, b_{j}) =$$

$$f(\omega_{jT} \mid \omega_{jT-1}, \omega_{j1}, x_{jt}, \mu_{j}, b_{jT-1}) \cdot f(\omega_{jT-1} \mid \omega_{jT-2}, \omega_{j1}, x_{jt}, b_{jT-2}, \mu_{j}) \cdots f(\omega_{j2} \mid \omega_{j1}, x_{j1}, b_{j1}, \mu_{j}) g(\mu_{j} \mid \omega_{1j}, x_{j})$$

Then we express μ_{j} as a linear projection on ω_{j1} and the temporal mean of x_{j}, plus a residual plant effect:

$$\mu_{j} = \rho_{0} + \rho_{1}\omega_{1j} + \rho_{2}\bar{x}_{j} + \mu_{j}^{*}. \tag{8}$$

Finally we substitute this expression for μ_j in the density function above conditioned on ω_{j1} and x_j and integrate out the unobserved plant effects, $\mu_j^* = (\mu_j^{a*}, \mu_j^{c*})$. Since μ_j^* is orthogonal to ω_{j1} by construction, this approach eliminates the initial conditions problem and the compound disturbance vector, $(\upsilon_{jt}^a, \upsilon_{jt}^c) + \mu_j^*$, has standard error components properties.[12] We use a full information maximum likelihood estimator for the system (1a), (1b), (6), (7), and (8) presuming that all disturbances are normally distributed.

Activity determinants

Our final methodological task is to develop a version of equation (2) that can be estimated. Structural estimation of the deep parameters is out of the question, given the complexity of the optimization problem and the number of parameters involved. Instead, we assume that the probability of choosing the *k*th activity bundle can be written as a reduced-form linear expression in the observable arguments of $g_b(\cdot)$. Also we drop all lags of more than one year and we summarize the performance of competing firms with a cross-firm average of $\boldsymbol{\omega}$, excluding the *j*th firm, hereafter $\overline{\boldsymbol{\omega}}^{-j}$:[13]

$$b_{jkt} = \delta_k' \mathbf{b}_{ji,t-1} + \alpha_k' \omega_{jt-1} + \eta_k' \overline{\omega}_{t-1}^{-j} + \varepsilon_{jkt}^b \qquad k=1,\ 2^K \qquad (2')$$

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12 Note that we are assuming μ^* is independent of $b_{j\cdot}$, although μ may not be.

13 In principle, a multinomial probit verion of the decision rule could be estimated using the simulated method of moments (Geweke, Keane and Runkle, 1997). However, this approach is difficult to apply in our datasets because we do not have any firm-specific information on variables that affect the utility of different choices (Keane, 1992). Extension experimentation with this estimator thus proved fruitless.

(Unlike in equation (2), firms' choices of activity bundles are not deterministic here because we do not have access to the entire information that they base their decision upon.)

As with equations (1a) and (1b), we adopt an error components specification for ε^{b}_{jkt}, and we address the associated initial conditions problem using Wooldridge (2000)'s technique. In principle there are some efficiency gains to be reaped by estimating these equations jointly with those in the system (1a), (1b) and (7) above. However, so long as the residual plant effects in equation (2') are not correlated with μ^{*} in equations (1a) and (1b), this is not necessary for consistency. We therefore opt keep the model manageable and estimate the activity determinant equations separately.

III. Empirical Results

To implement our estimator, we shall exploit annual industrial survey data from three semi-industrialized countries: Colombia, Mexico and Morocco. (See Roberts and Tybout, 1996, for detailed descriptions of the data.) Ideally we would like to study *all* of the activities identified in table 1, but unfortunately, each data set provides information on only a subset. The Colombian data reveal whether firms are exporting and whether they are importing intermediate goods; the Moroccan data identify exporters and firms with foreign owners (FDI), and the Mexican data identify exporters, importers of intermediate goods, and importers of capital goods. Thus, although no single country spans the entire set of activities, between them we observe a fairly large collection of conduits for international technology transfer.

For several reasons, we shall focus our empirical analysis on manufactured chemicals. First, to treat all of the establishments in our data sets would be an overwhelming task. Second, among the sectors with sufficient observations to support inference, the chemicals industries are relatively prone to engage in international activities. Third, these industries also rely relatively heavily on scientists, technicians and engineers, so when technology diffusion takes place, we are likely to find it among them. Fourth, in most chemicals industries, imported final goods are sufficiently important to play the role of an outside good in our demand system. Finally, the chemicals industries are well represented in each of the countries. Thus cross-country comparisons allow us to examine whether particular types of production are prone to particular patterns of technology absorption.

We also limit our analysis to plants that are present during all years of the analysis. (For Colombia, the sample period is 1981 through 1991, for Mexico it is 1986 through 1990 and for Morocco it is 1986 through 1993.) Exclusion of entering and exiting plants obviously opens the door to selection bias in our findings, but it substantially simplifies the econometric modeling. We feel this is a price worth paying because the omitted firms supply a very small fraction of the market. More importantly, we are less concerned with precise parameter estimation than with simply asking whether significant patterns of association are present. It is highly unlikely that they would be manifest *only* among the new and dying plants that we leave out of our panels.

A. Performance determinants

Our results for each 4-digit chemicals industry in Colombia, Morocco and Mexico are presented in tables A2.1 through A2.3 of appendix 2, respectively. (Industries with fewer than 10 plants continually present are not treated.) Parameters of the covariance matrices for the compound disturbances are not reported to conserve space, but we do report the coefficients from equation (8) that relate the unobserved plant effects, μ^a and μ^b, to initial realizations on the performance variables, a_1 and c_1.

Under each industry heading the left-hand column reports parameter estimates and the right-hand column reports the associated standard errors. Wald test statistics for the null hypotheses that product quality is unrelated to international activities and marginal costs are unrelated to international activities are reported near the bottom of each table. All coefficient estimates that are at least twice their standard error are reported in bold, as are χ^2 statistics with *p*-values less than 0.05. The degrees of freedom for the Wald statistics depend upon the number of activity bundles that are considered, which in turn vary across countries and industries. (The latter occurs within a country because some industries do not exhibit all possible activities.) Parameters, standard errors and test statistics that describe the relationship between activities and performance are reported in shaded panels.

Demand parameters

Parameter estimates for the demand system appear in the top panel of each table. Note that α, the parameter that measures the sensitivity of indirect utility to price, is always quite significant and positive, as hoped. This gives us some confidence that the price measure implied by our normalization rule contains information relevant to consumers. It is generally higher in Morocco than in the other countries because the French accounting system there led to a price measure there that was somewhat lower than the measure we calculated for Mexico and Colombia; hence the model assigned that country higher demand elasticities.

Estimates of σ are also quite accurate. They imply that for most industries, the standard error of $\varsigma + \nu$ is roughly twice the standard error of ν alone. Or, for a given consumer, indirect utilities vary substantially across regions, as well as between foreign and domestic varieties. (It would be straightforward to use these figures to calculate measures of own-region or home market bias, but we have not yet done so.)

Finally, γ measures the effect of increase in the price of imported goods on the relative utility attained from home goods. This parameter is not estimated as accurately as the other demand parameters because it is identified solely by temporal variation, and the number of years we observe is limited. Nonetheless, it is positive in eight of the nine cases where it is statistically significant at the α=.05 level. (The exception is the detergent industry in Colombia.) Overall, then, our estimates of the demand system conform very nicely to priors.

Product quality determinants

The next panel in tables A1.1 through A1.3 reports estimates of the parameters that appear in equation (1a). Before considering the parameters of primary interest, let us recap our results on the control variables. First, conditioning on lagged performance and international activities, most industries we analyzed in Colombia and Morocco showed no significant trend in relative quality. The exceptions were Colombian detergents and Moroccan detergents and paints, each of which exhibited a tendency to improve relative to imports over the sample period. Mexico, in contrast, hosts a number of industries that fell increasing behind imported substitutes during the sample years. Rubber products and pharmaceuticals tended to improve but five of the six remaining industries showed significant negative trends.

One might expect that plants beginning the sample period with large capital stocks would exhibit relatively high quality, since initial capital stocks should reflect pre-sample demand for their products. Indeed, in all of the industries where initial capital stocks proved statistically significant, they were positively correlated with relative product quality. This relationship might seem spurious, since product quality is related to market share by the identity (6), and firms with large market shares surely have large capital stocks. However, consumers care only about prices and product appeal, not productive capacity. So, if our model is correctly specified and prices are properly measured, any relation between relative quality and initial capital stocks is indeed a consequence of interaction between quality and size.

The next control variables are lagged quality and lagged marginal cost. The former is significant in almost all cases, implying that our quality measure follows an autoregressive process. Given that product characteristics and reputation evolve slowly over time, this is what one would expect to find. In most cases the AR(1) coefficient is significantly less than unity, but Colombian pharmaceuticals and Mexican fertilizers/pesticides yield roots close to one. (We have not attempted unit root tests for our system.) Coefficients on lagged marginal cost are usually unimportant, so for most industries marginal cost shocks have little effect on the subsequent evolution of product quality. In the four industry/country cases when lagged marginal cost is significant, firms adjust to cost shocks partly by reducing the future quality of their product.

Finally, the coefficients on initial quality realizations indicate that unobserved heterogeneity is often important, and that Wooldridge's correction matters. On the other hand, coefficients on initial marginal cost realizations are usually insignificant, so our representation of unobserved heterogeneity (8) is probably more general that it needs to be for most industries. Nonetheless, the covariance matrices for our compound disturbances imply that in many cases, persistent unobserved heterogeneity remains after conditioning on these variables.

Consider now the variables of primary interest—dummies for the various activity bundles.[14] Wald statistics reported at the bottom of each table test the joint null hypothesis that last period's activity bundles have nothing to do with current quality. Tellingly, all but three of these χ^2 statistics have a *p*-value greater than 0.05, so in 16 of the 19 country/industry cases, one cannot reject the null hypothesis that previous activities have no effect on current product quality. Experiments with additional lags on activity bundles (not reported) left this basic message intact.

Further, in the three instances where activities are significantly related to quality, the dominant relationship is negative. In Moroccan plastics and Colombian fertilizers/pesticides, *any* combination of international activities leads to *worse* product quality than no international activities. In the other significant case, Moroccan paints and varnishes, firms that export and firms with foreign ownership also do worse than firms without international activities, but firms that have both types of international relationship do better. (In this case none of the coefficients for these activity bundles is individually significant, so colinearity problems prevent us from drawing strong conclusions.)

Overall, then, our methodology yields virtually no evidence that international activities Granger cause product quality improvements. (We shall return to the issue of whether we are missing significant linkages shortly.)

Marginal cost determinants

The weak and occasionally negative association between product quality and international activities need not imply that firms pursuing these activities are misguided. It may be that international activities mainly help to reduce costs rather than improve quality. Are such linkages picked up by our model?

Parameter estimates for our marginal cost equation are reported by industry and country in the lower panels of tables A1.1 through A1.3. Again we begin our discussion of the results with the control variables. First, note that most industries show no significant trend in marginal costs, once initial capital stocks, lagged costs, and activities are controlled for. The exceptions are plastics and soaps in both Mexico and Morocco, which trend significantly upward, and both fertilizers in Mexico and pharmaceuticals in Colombia, which trend downward.

More interestingly, productive capacity (measured by initial capital stocks) seems to have little to do with our measure of marginal production costs. Except among Mexican rubber producers, where marginal costs rise with capacity, and Mexican pharmaceutical producers, where the opposite occurs, initial capacity is not a significant predictor of our cost measure. This suggests that scale economies are not dramatic and

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[14] We use the following abbreviations: X (exporter), MI (importer of intermediate goods), MK (importer of capital goods), and FDI (firm with at least five percent foreign ownership).

that production technologies are reasonably homothetic over the size range we observe in our panels.

As for the role of lagged marginal costs, all of the industries show clear evidence of serial dependence. Not surprisingly, the coefficients are universally greater than zero, and most are at least two standard deviations below unity. In half of the Mexican industries, lagged quality is also associated with current costs, usually positively, but no such relationship emerges in the other countries. Finally, initial realizations on marginal costs are significant in most sectors, implying that unobserved heterogeneity is important. The (unreported) variance in residual plant effects is also often significant, and correlated with the residual plant effect in the quality equation. However, the sign of this correlation varies from industry to industry.

Now consider the relation between international activities and marginal costs. Except in Morocco, our Wald tests fail to reject the null hypothesis that the two are unrelated. There, FDI is associated with significant cost reductions among paint/varnish producers, but exports and FDI together lead to cost increases. Interestingly, the plants that both export and have FDI are also the ones predicted (weakly) to have the highest quality product, so the combined effect of these activities may well be to enhance profits.[15] Exporting and FDI tend to increase costs among detergent/perfume producers too, but here there is no evidence of offsetting quality gains. Finally, among Moroccan pharmaceutical producers, exporting and FDI significantly reduce future costs, alone or together. They also tend to reduce quality, however, so as with Moroccan paint/varnish, the net effect of these activities on profits is not immediately apparent.

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[15] It is straightforward to calculate the predicted effect of these marginal cost and quality changes on profits, firm by firm, but we have not yet done so.

Although none of the other country/industry panels shows a significant joint relationship between international activities and future marginal costs, there are instances where particular activity bundles yield statistically significant effects. These occur exclusively among bundles that involve importing intermediate inputs. In Colombia, fertilizer/pesticide producers reduce their future costs by importing intermediates, but they reduce the quality of their product too. In Mexico, intermediate imports increase marginal costs but also increase quality among rubber producers. The same is true among Mexican fertilizer/pesticide producers, although the quality effect is not statistically significant. Further, among Mexican pharmaceutical producers, imported intermediates—in combination with exports or imported capital goods—reduce marginal costs and, if anything, tend to increase product quality. Only in the "other chemicals" sector do imported imported intermediates (in combination with imported capital and exports) significantly increase future costs without also tending to improve product quality.

Overall, then, most country/industry panels show no significant association between international activities and future marginal costs. However, a minority of industries exhibits this type of causal link. Further, whether the activities increase or reduce costs, there is often an offsetting change in product quality, so the net effect of the international activities on profits is ambiguous.

A robustness check

We mentioned earlier that Granger causality tests may miss important linkages if the transmission of knowledge does not actually coincide with the observed international activity. For example, when a foreign buyer places an order with a domestic firm, it may transmit blueprints and technical assistance years before the actual exports occur. To check whether this problem has undermined our inferences, we now abandon or dynamic specification in favor of a model that simply tests for static correlation between international activities and performance. That is, we drop all $\boldsymbol{a}_{jt-q}$ and $\boldsymbol{c}_{jt-q}$ variables and we replace $\boldsymbol{b}_{jt-1}$ with $\boldsymbol{b}_{jt}$ on the right-hand side of equations (1a) and (2b), If *this* model reveals no association, we have stronger evidence against the claim that international activities transmit knowledge. On the other hand, statistical significance need not imply causal relationships from activities to performance. It may reflect causation from performance to activities (which we shall explore shortly), or it may reflect transitory effects that do not involve knowledge transmission. For example, as Ethier (1982) suggested, access to imported intermediates may enrich the menu of inputs for firms and allow them to produce better products or reduce their costs.

Tables A1.4 through A1.6 report the static version of our model for each industry/country panel. (We still use an error component specification, but we drop Wooldridge's correction for initial conditions because lagged performance measures no longer appear on the right-hand side.) Notice first that, when lagged quality is dropped and international activities are no longer lagged, many sectors show a significant association between product quality and international activity. Further, the association is now *positive* in Colombia for firms that import their intermediate inputs. This result has several interpretations. It might mean that importing intermediates allows a firm to learn something about technology and to permanently increase the quality of its product, as

Grossman and Helpman (1991) suggest.[16] *Or* it might imply static benefits from importing like Ethier (1982) described. The latter interpretation strikes us as more plausible, since we picked up no evidence of Granger causation from imported intermediates to subsequent product quality gains, and this is a type of activity that is unlikely to be preceeded with substantial knowledge transfers.

Morocco and Mexico also exhibit more significant associations in the static model. However, in contrast to Colombia, international activities still seem to hurt quality, if anything. Thus, in determining the effects of international activities on performance, country conditions may be more important than technological features of industries that are common across borders.

Finally, in the marginal cost equation, coefficients differ from those in the dynamic model but the evidence that international activities are associated with lower costs is, if anything, weaker. In sum, with the exception of the Colombian results on product quality, the timing issue does not appear to be the main reason that firms' product quality and marginal costs are unrelated to their international activities.

B. Activity determinants

Our final empirical exercise addresses the issues of how activities are chosen, and whether performance *causes* international activities. We begin with a descriptive review of the activity patterns found in our data sets. Without controlling for anything, tables A2.1 and A2.2 report probabilities of different activity bundles and transitions between

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16 " . . . [I]mports may embody differentiated intermediates that are not available in the local economy. The greater the quantity of such imports, the greater perhaps will be the number of insights that local researchers gain from inspecting and using these goods." (Grossman and Helpman, 1991, p. 166)

bundles based on simple cell counts. Clearly, regardless of which activity combinations we consider, the pursuit of one activity increases the likelihood that others will be pursued as well. Similar statements hold for transitions. If one of the international activities has been initiated, the probability that others will follow increases. Accordingly, empirical models that focus on a single activity as the key to international technology diffusion probably suffer from significant omitted variable bias. Further, policies designed to encourage or discourage certain types of international activities are likely to have unintended side effects on others.

Of course, patterns of association may not reflect complementarities among the activities. It is possible that certain firm characteristics—e.g., location in a port city or ethnic ties to foreign countries— may make them engage in multiple international activities even when complementarities are absent. To get at this possibility, and to better understand firms' activity choices, we use the system of linear probability equations (2'), allowing for unobserved heterogeneity and using Wooldridge's (2000) correction for the initial conditions problem.

Table A2.3 presents estimates of the system of equations (2') for Colombia. We report results for three of the activity choices—firms that neither export nor import intermediates are the omitted category. (Parameter estimates for this activity bundle can be derived from the adding-up constraint that the probability of choose one bundle must always be unity.) The first column reports results for all firms, but does not include performance measures. Two points merit mention. First, activities are highly persistent, even after controlling for unobserved heterogeneity. This suggests that the start-up costs associated with the initiation of new international activities are non-trivial, and thus transitory policy or macro shocks may have lasting effects on activity patterns (Roberts and Tybout, 1997). Second, we continue to find that the probability that a firm becomes an exporter is higher if was already importing intermediates in the previous year, and the probability of becoming an importer is higher for exporters than for non-exporters. However, tests reported at the bottom of Table A3.1 fail to reject the null that these differences in conditional probabilities are zero. Thus, although imported intermediates and exporting tend to go together, the dynamic interactions between them are not strong in this fuller specification.

Our second set of estimates (columns 3 and 4) adds performance measures to investigate whether firms with high quality and/or low costs are more likely to engage in activities. Since our quality variable is normalized to have the same mean in each of the four-digit industries, we cannot simply pool all sectors. Instead, we restrict attention to the largest four-digit industry in terms of the number of firms, which is pharmaceuticals. Within this four-digit industry, the two patterns noted above continue to appear. Activities are highly persistent, and the presence of one activity increases the probability that the other will be initiated. However, these dynamic interactions are not statistically significant.

Regarding the effects of quality and cost on the choice of activities, the signs of the coefficients are intuitive for the "both export and import" bundle. Firms with higher quality and lower costs are more likely to pursue this bundle of activities. However, neither coefficient is significant, nor are the coefficients for the other bundles, so the case for causation from previous performance to activity choices is weak. Given our earlier findings of strong cross-sectional correlation between international activities and performance (Table A1.1) and no Granger causality from activities to performance (Table A1.4), we can only conclude that there is insufficient temporal variation in activity choices to sort out the dynamic interactions for this industry.

Table A2.4 reports analogous results for Morocco, where we observe data on exporting and foreign equity participation. The results are broadly similar to those in Colombia. Activities are persistent, however, the degree of persistence as measured by the magnitude of the coefficients on own lagged activities is generally smaller. This is especially true for FDI, where past FDI activities raises the probability of current FDI activity by only 10 percent in the first set of regressions, and not at all in the second set including performance variables (which are reported only for plastics).

One puzzling exception to the pattern of insignificant effects of performance on the choice of activities is in the equation for the choice of both activities. Other things equal, firms with higher quality and lower costs are *less* likely to choose both activities. This mirrors the negative correlation between product quality and joint pursuit of exports and FDI found in tables A1.2 and A1.5. Taken at face value, it suggests that foreign investors are attracted to plants that have been performing relatively poorly.

IV Summary

This paper has several basic messages. First, by imposing enough structure on the production function and the demand system, it is possible to measure product quality and marginal costs at the plant level and to relate the evolution of these variables to firms' activity histories. Doing so, we find strong firm-level persistence in both quality and marginal costs, as expected. However, in most industry/country panels we studied, past international activities do not help much to predict current performance, once past realizations on quality and marginal cost are controlled for. That is, activities do not typically Granger cause performance. Interestingly, in the minority of cases where significant associations emerge, international activities appear to move costs and product quality in the same direction. Thus, the net effect on profits in these cases is not immediately apparent.

Concerning the determinants of international activities, several basic patterns emerge. Most fundamentally, they tend to go together. Thus, studies that relate firms' performance to one international activity and ignore the others may generate very misleading conclusions. Similarly, policies that encourage or discourage certain activities are likely to have unintended repercussions on other activities and these may affect firms' performances in unexpected ways.

Activities are also highly persistent, even after one controls for unobserved heterogeneity. So temporary policy or macro shocks may have long run effects on the patterns of activities observed in a particular country or industry.

Finally, there weak evidence from Colombia that firms that are already strong performers seek out foreign markets as a way to enhance their profits. But these results do not generalize to Morocco, where plastics firms that have been performing poorly are relatively likely to become exporters and receive foreign direct investment. Both sets of results are preliminary and based on a small fraction of the relevant industries, so they provide little basis for generalization.

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Appendix 1: Demand Parameters and Performance Equations

TABLE A1.1: COLOMBIAN CHEMICAL INDUSTRIES: DYNAMIC MODEL

	Basic Indus. Chemicals		*Fertilizers, Pesticides*		*Plastics*		*Paints, Varnishes*		*Pharmaceuticals*		*Detergents, Perfumes*	
Demand Parameters												
α	**2.151**	0.1	**5.363**	0.403	**16.16**	1.367	**3.388**	0.161	**2.236**	0.074	**4.174**	0.219
σ	**0.627**	0.017	**0.714**	0.018	**0.482**	0.004	**0.458**	0.018	**0.671**	0.009	**0.662**	0.008
γ	0.074	0.153	**1.69**	0.465	6.355	3.724	-1.675	0.927	0.096	0.084	**-3.133**	0.348
Product Quality Equation (1a)												
intercept	**-0.449**	0.191	1.978	1.282	0.128	2.617	0.538	0.619	0.135	0.154	**1.665**	0.659
trend	-0.018	0.012	-0.046	0.033	-0.818	0.325	-0.05	0.057	0.001	0.012	**0.189**	0.037
ln(initial capital)	0.051	0.027	-0.197	0.158	0.690	0.600	**0.166**	0.072	-0.012	0.02	-0.039	0.066
X only	0.041	0.087	.	.	.	.	.	.	-0.103	0.161	.	.
MI only	0.112	0.071	**-0.904**	0.302	0.564	1.510	-0.101	0.362	-0.04	0.071	0.05	0.152
X and MI	0.064	0.09	**-0.811**	0.258	1.482	1.707	-0.41	0.407	-0.04	0.103	0.096	0.214
a(t-1)	**0.819**	0.067	**0.648**	0.077	0.183	0.17	**0.378**	0.05	**1.016**	0.038	**0.356**	0.069
a(1)	**0.124**	0.054	**0.329**	0.100	**0.358**	0.098	**0.752**	0.068	-0.019	0.040	**0.694**	0.093
c(t-1)	-0.386	0.319	-0.056	0.462	-0.829	11.46	-2.199	2.05	**-1.572**	0.194	0.802	0.607
c(1)	0.624	0.336	**-3.481**	0.873	2.071	7.392	0.3	2.148	**0.799**	0.199	**-2.456**	0.996
Marginal Cost Equation (1b)												
intercept	-0.031	0.032	**0.175**	0.040	-0.002	0.013	0.031	0.019	**0.135**	0.039	-0.001	0.042
trend	0.001	0.002	0.001	0.003	0.000	0.002	0.001	0.001	**-0.008**	0.003	-0.005	0.003
ln(initial capital)	0.003	0.005	-0.017		0.005	0.004	-0.003	0.002	-0.003	0.005	0.002	0.004
X only	0.001	0.015	.	.	.	.	.	.	-0.028	0.041	.	.
MI only	0.009	0.012	**-0.069**	0.031	0.011	0.011	-0.011	0.012	-0.009	0.018	0.007	0.014
X and MI	0.004	0.016	**-0.063**	0.027	0.000	0.012	0.008	0.014	-0.026	0.025	0.015	0.020
c(t-1)	**0.705**	0.067	**0.915**	0.063	**0.717**	0.074	**0.788**	0.066	**0.526**	0.057	**0.632**	0.074
c(1)	**0.33**	0.072	-0.134	0.093	0.058	0.05	0.022	0.067	**0.235**	0.059	**0.156**	0.079
a(t-1)	-0.004	0.01	-0.01	0.008	0.001	0.001	-0.002	0.002	-0.012	0.01	0.001	0.007
a(1)	0.002	0.008	0.012	0.007	-0.001	0.001	0.002	0.002	0.011	0.011	-0.008	0.008
Quality effects?	.	2.658		**10.634**	.	0.756	.	1.495	.	0.62	.	0.212
MC effects?	.	0.676	.	5.936	.	1.293	.	4.323	.	1.306	.	0.612
-ln(L)		-572.82		-301.98		-72.99		-47.97		-1103.15		-543.54
Observations		324		117		108		120		639		351

TABLE A1.2: MOROCCAN CHEMICAL INDUSTRIES: DYNAMIC MODEL

	Paints, Varnishes		*Pharmaceuticals*		*Detergents, Perfumes*		*Chemicals, n.e.c.*		*Plastics*	
Demand Parameters										
α	**21.058**	2.614	**11.06**	0.996	**1.479**	0.132	**10.204**	0.789	**7.065**	0.393
σ	**0.867**	0.014	**0.761**	0.020	**0.256**	0.030	**0.703**	0.025	**0.676**	0.028
γ	**20.700**	8.110	7.844	4.069	**7.977**	3.031	4.482	3.236	**4.601**	1.329
Product Quality Equation (1a)										
intercept	4.33	4.831	-1.738	2.298	-0.609	0.823	1.833	1.212	0.623	0.58
trend	**0.634**	0.215	-0.008	0.071	**0.275**	0.056	-0.025	0.082	0.041	0.031
ln(initial capital)	0.273	0.311	**0.533**	0.185	-0.063	0.06	0.106	0.096	-0.007	0.076
X only	-1.217	1.164	**-1.219**	0.524	-0.409	0.334	0.334	0.992	-0.328	0.224
FDI only	-0.673	0.81	-0.809	0.463	0.098	0.308	0.357	0.477	-0.122	0.181
X and FDI	2.088	1.447	-0.691	0.516	-0.103	0.277	1.534	0.862	**-3.105**	0.653
a(t-1)	**-0.558**	0.169	0.069	0.154	**0.466**	0.114	**0.532**	0.106	**0.475**	0.103
a(1)	**1.129**	0.141	**0.654**	0.127	**0.608**	0.140	**0.234**	0.084	**0.478**	0.096
c(t-1)	**19.86**	7.190	2.515	2.016	-1.069	0.987	-3.202	1.909	**-3.655**	1.022
c(1)	-7.708	9.734	1.23	4.536	1.768	1.061	0.741	1.848	**2.341**	0.981
Marginal Cost Equation (1b)										
Intercept	0.099	0.086	-0.088	0.159	0.032	0.073	0.036	0.055	0.095	0.058
Trend	0.003	0.007	-0.002	0.006	**0.015**	0.006	-0.002	0.005	**0.007**	0.002
ln(K)	-0.005	0.009	0.02	0.014	-0.01	0.007	0.002	0.007	-0.009	0.008
X only	0.01	0.039	**-0.094**	0.038	0.069	0.04	-0.008	0.061	-0.015	0.021
FDI only	**-0.007**	0.024	**-0.067**	0.033	0.041	0.037	0.002	0.032	-0.023	0.017
X and FDI	**0.117**	0.044	**-0.095**	0.035	**0.099**	0.033	0.047	0.056	-0.013	0.057
c(t-1)	**0.633**	0.178	**0.534**	0.148	**0.672**	0.118	**0.314**	0.140	**0.208**	0.075
c(1)	**0.601**	0.266	0.15	0.342	0.006	0.112	**0.327**	0.139	**0.491**	0.094
a(t-1)	-0.009	0.006	-0.008	0.011	0.021	0.014	0.002	0.007	-0.01	0.007
a(1)	0.005	0.005	0.01	0.01	-0.023	0.017	0.001	0.006	0.015	0.008
Quality effects?	.	**7.834**		5.753		2.115		3.354		**.23.849**
MC effects?	.	**9.573**		**8.554**		**9.715**		0.837		2.192
-ln(L)		-111.051		-216.877		35.459		-317.777		-918.04
Observations		84		76		60		186		492

TABLE A1.3: MEXICAN CHEMICALS: DYNAMIC MODEL

	Basic Indus. Chemicals		*Synthetic Resins*		*Plastics*		*Other Chemicals*		*Rubber Products*		*Fertilizers, Pesticides*		*Pharmaceuticals*		*Soaps, Perfumes*	
Demand Parameters																
α	**1.368**	0.110	**1.828**	0.166	**2.283**	0.101	**2.261**	0.131	**2.966**	0.224	**1.975**	0.238	**1.197**	0.070	**1.725**	0.121
σ	**0.586**	0.047	**0.532**	0.049	**0.763**	0.036	**0.729**	0.074	**0.734**	0.090	**0.740**	0.084	**0.709**	0.083	**0.589**	0.034
γ	-0.488	1.264	**1.927**	0.590	1.562	1.474	**1.691**	0.580	-0.565	0.457	**3.713**	0.625	-0.363	0.447	**9.878**	1.782
Product Quality Equation (1a)																
intercept	-2.752	1.861	**1.730**	0.437	**3.450**	0.737	**1.344**	0.488	0.019	0.305	**4.795**	0.732	-0.860	0.562	**7.670**	1.141
trend	-0.010	0.255	**-0.356**	0.095	**-0.707**	0.212	**-0.322**	0.103	**0.170**	0.082	**-1.345**	0.202	**0.206**	0.102	**-0.933**	0.269
ln(initial capital)	**0.234**	0.055	0.010	0.019	-0.049	0.030	0.026	0.015	**0.062**	0.028	-0.044	0.023	0.000	0.019	-0.048	0.032
X only	0.270	0.387	-0.052	0.137	0.120	0.199	-0.133	0.236	0.101	0.381			0.191	0.271		
MI only	**-0.401**	0.157	0.026	0.077	-0.065	0.152	0.077	0.054	**0.261**	0.122			0.032	0.091	-0.060	0.118
MK only	-0.218	0.185	**-0.291**	0.141	0.032	0.268	-0.074	0.129	0.247	0.284	**-0.586**	0.277	-0.107	0.193	0.137	0.517
MI and X	-0.288	0.151	0.135	0.078	-0.035	0.192	0.059	0.066	0.141	0.110	0.178	0.159	0.058	0.062		
MK and X	-0.347	0.190	0.088	0.166	0.253	0.540										
MI and MK	-0.221	0.238			-0.121	0.151	0.040	0.082	-0.118	0.194	0.026	0.156	0.056	0.093	-0.038	0.159
MI, MK, and X	-0.255	0.139	0.029	0.057	0.086	0.156	-0.135	0.086	-0.163	0.149			0.071	0.063	0.158	0.144
a(t-1)	-0.012	0.094	**0.854**	0.052	**0.755**	0.043	**0.887**	0.044	**0.935**	0.068	**1.096**	0.124	**0.809**	0.061	**0.652**	0.049
a(1)	**0.679**	0.090	**0.146**	0.048	**0.353**	0.047	**0.092**	0.043	0.050	0.072	-0.046	0.128	**0.168**	0.058	**0.426**	0.051
c(t-1)	1.304	0.784	0.475	0.374	0.014	n.a.	-0.154	0.245	-0.555	0.481	-0.070	0.632	0.041	0.146	-0.121	0.324
c(1)	-0.739	0.752	-0.192	0.341	**-0.429**	0.154	0.317	0.222	0.542	0.483	0.617	0.378	-0.086	0.128	0.151	0.318
Marginal Cost Equation (1b)																
intercept	-0.028	0.115	**0.089**	0.035	**-0.105**	0.038	0.028	0.029	-0.062	0.039	**0.358**	0.096	**0.277**	0.092	**-0.345**	0.143
trend	-0.002	0.018	-0.027	0.014	**0.045**	0.010	-0.003	0.010	0.025	0.010	**-0.069**	0.027	0.007	0.020	**0.125**	0.049
ln(initial capital)	0.002	0.012	-0.003	0.004	0.001	0.003	-0.003	0.003	**0.018**	0.005	0.006	0.004	**-0.024**	0.010	-0.008	0.006
X only	0.024	0.035	-0.025	0.031	0.023	0.023	-0.030	0.055	0.012	0.066			-0.027	0.148		
MI only	0.002	0.027	-0.005	0.018	0.000	0.018	0.016	0.013	**0.054**	0.022			-0.092	0.049	-0.023	0.023
MK only	-0.020	0.023	-0.003	0.032	0.022	0.034	-0.011	0.030	0.028	0.049	-0.043	0.051	-0.035	0.106	-0.040	0.103
MI and X	-0.011	0.022	0.019	0.018	-0.005	0.024	0.028	0.015	-0.008	0.020	**0.075**	0.028	**-0.073**	0.033		
MK and X	-0.004	0.029	-0.037	0.038	0.103	0.062										
MI and MK	0.063	0.040			0.000	0.018	-0.018	0.019	-0.006	0.035	-0.019	0.029	**-0.107**	0.050	-0.013	0.032
MI, MK, and X	0.019	0.023	0.017	0.013	0.029	0.018	**0.044**	0.020	-0.049	0.027			-0.054	0.034	0.000	0.029
c(t-1)	**0.975**	0.071	**0.838**	0.085	**0.755**	0.043	**0.693**	0.057	**0.610**	0.103	**0.589**	0.097	**0.606**	0.081	**0.695**	0.066
c(1)	0.091	0.062	**0.184**	0.078	**0.173**	0.039	**0.238**	0.052	**0.374**	0.100	-0.074	0.068	0.096	0.071	**0.249**	0.064
a(t-1)	-0.009	0.052	**0.027**	0.011	0.001	0.005	0.013	0.010	0.017	0.013	**0.053**	0.019	**0.064**	0.031	**-0.016**	0.008
a(1)	0.003	0.036	**-0.026**	0.010	0.001	0.005	-0.009	0.010	-0.022	0.014	-0.066	0.019	-0.055	0.030	**0.020**	0.009
Quality effects?	11.311		8.451		2.099		8.379		9.503		7.029		2.367		2.091	
MC effects?	8.508		5.126		6.504		11.606		12.389		9.844		7.186		1.218	
-ln(L)		-212.78		-431.26		-345.26		-618.66		-329.45		-149.38		-372.34		-189.00
Observations		236		156		580		356		168		76		244		188

TABLE A1.4: COLOMBIAN CHEMICAL INDUSTRIES: STATIC MODEL

	Basic Indus. Chemicals		*Fertilizers, Pesticides*		*Plastics*		*Paints, Varnishes*		*Pharmaceuticals*		*Detergents, Perfumes*	
Demand Parameters												
α	**2.151**	0.100	**15.969**	1.760	**18.317**	1.777	**2.557**	0.215	**2.196**	0.075	**4.169**	0.216
σ	**0.627**	0.017	**0.500**	0.000	**0.491**	0.003	**0.294**	0.020	**0.700**	0.009	**0.664**	0.008
γ	0.074	0.153	2.083	26.857	3.540	5.221	-0.258	1.328	**-0.748**	0.116	**-3.120**	0.312
Restricted Product Quality Equation												
intercept	**-0.449**	0.191	26.713	56.287	1.052	7.206	**3.827**	0.410	**-10.451**	0.789	**-12.029**	0.897
trend	-0.018	0.012	-3.853	3.103	-0.723	0.475	**-6.152**	0.446	**-0.087**	0.019	**0.361**	0.037
ln(initial capital)	**0.051**	0.027	3.154	6.285	**3.062**	0.476	-0.111	0.371	**1.149**	0.200	**0.757**	0.186
X only	0.041	0.087	.	.	.	.	.	.	**-0.931**	0.230	.	.
MI only	0.112	0.071	-21.496	38.73	**5.531**	1.610	-2.212	4.174	**0.274**	0.096	**0.294**	0.097
X and MI	0.064	0.09	-11.446	35.52	-1.402	2.165	-0.027	0.115	**0.652**	0.141	-0.001	.
Restricted Marginal Cost Equation												
intercept	**0.819**	0.067	**0.433**	0.106	-0.004	0.019	-0.684	1.35	**0.507**	0.032	**0.332**	0.029
trend	**0.124**	0.054	-0.001	0.002	**-0.007**	0.002	0.325	0.575	-0.01	0.001	**-0.007**	0.001
ln(initial capital)	-0.386	0.319	**-0.046**	0.022	**0.038**	0.004	-1.314	0.716	0	0.01	-0.01	0.009
X only	0.624	0.336	.	.	.	.	.	.	-0.069	0.045	.	.
MI only	-0.031	0.032	-0.008	0.069	**0.06**	0.015	**0.124**	0.031	0.014	0.018	-0.007	0.015
X and MI	0.001	0.002	0.003	0.064	0.008	0.02	-0.003	0.001	**-0.056**	0.027	-0.028	0.016
Quality effects?	.	2.658	.	0.405	.	**22.322**	.	0.284	.	**50.673**	.	5.086
MC effects?	.	4.338	.	0.112	.	**22.562**	.	**17.529**	.	**11.91**	.	3.262
-log(L)		-458.158		613.069		22.083		41.823		-837.104		-512.619
Observations		396		143		132		132		781		429

TABLE A1.5: MOROCCAN CHEMICAL INDUSTRIES: STATIC MODEL

	Paints, Varnishes		*Pharmaceuticals*		*Detergents, Perfumes*		*Chemicals, n.e.c.*		*Plastics*	
Demand Parameters										
α	**22.29**	2.789	**11.712**	1.057	**1.478**	0.13	**10.869**	0.402	**8.718**	0.441
σ	**0.83**	0.016	**0.73**	0.017	**0.255**	0.027	**0.262**	0.004	**0.547**	0.019
γ	10.807	7.052	3.978	2.747	-0.048	2.062	5.285	6.8	**4.639**	1.04
Restricted Product Quality Equation										
intercept	5.817	11.856	3.84	5.261	-4.077	4.199	13.286	9.291	2.286	1.943
trend	**0.572**	0.169	-0.076	0.065	**0.278**	0.049	0.093	0.132	**0.097**	0.024
Ln(initial capital)	1.026	0.902	**0.812**	0.354	-0.31	0.356	**0.491**	0.178	**0.67**	0.14
X only	-0.347	1.491	-0.668	0.643	**-1.166**	0.545	-0.07	1.782	-0.156	0.244
FDI only	1.023	1.439	**-0.934**	0.459	0.13	0.521	0.028	1.008	-0.101	0.243
X and FDI	2.909	1.742	-0.156	0.494	-1.095	0.559	-1.747	1.496	**-1.333**	0.542
Restricted Marginal Cost Equation										
intercept	0.013	0.147	**0.312**	0.121	**0.257**	0.08	0.087	0.068	**0.242**	0.067
trend	**0.011**	0.004	-0.004	0.004	0.013	0.004	0.002	0.003	**0.006**	0.002
Ln(initial capital)	0.009	0.018	-0.007	0.013	**-0.024**	0.011	0.013	0.009	-0.013	0.008
X only	-0.025	0.042	-0.042	0.042	-0.012	0.056	**-0.106**	0.051	-0.014	0.018
FDI only	0.023	0.039	-0.048	0.031	0.081	0.05	-0.005	0.033	0.013	0.018
X and FDI	**0.100**	0.047	0.022	0.034	**0.121**	0.052	-0.047	0.049	0.047	0.04
Quality effects?		4.333		6.394		**8.737**		1.534		6.54
MC effects?		**9.193**		**9.144**		**11.281**		4.977		2.221
-ln(L)		-93.598		-223.352		49.601		221.778		-1021.81
Observations		112		104		80		248		656

TABLE A1.6: MEXICAN CHEMICALS: STATIC MODEL

	Basic Indus. Chemicals		*Synthetic Resins*		*Plastics*		*Other Chemicals*		*Rubber Products*		*Fertilizers, Pesticides*		*Pharmaceuticals*		*Soaps, Perfumes*	
Demand Parameters																
α	**1.475**	0.1	**1.987**	0.229	**7.707**	0.824	**10.77**	1.021	**1.921**	0.12	**3.524**	0.23	**4.712**	0.359	**2.643**	0.093
σ	**0.517**	0.02	**0.665**	0.028	**0.167**	0.008	**0.111**	0.006	**0.513**	0.016	**0.428**	0.022	**0.486**	0.022	**0.555**	0.008
γ	0.142	0.113	**-0.652**	0.19	-1.275	0.885	1.244	2.583	**-1.254**	0.236	-0.067	0.093	**-1.742**	0.254	**-3.073**	0.134
Restricted Product Quality Equation																
Intercept	**-4.386**	0.498	**-8.92**	1.304	**6.68**	2.656	**23.366**	8.731	**-14.229**	1.115	-0.116	0.591	**-2.419**	1.049	**-10.119**	0.456
Trend	**0.106**	0.034	**-0.592**	0.074	0.143	0.184	1.186	0.804	**0.493**	0.078	**0.017**	0.02	**-0.156**	0.057	**-0.679**	0.032
ln(K)	**0.55**	0.054	**0.739**	0.125	0.682	0.671	-0.131	.	**0.965**	0.162	**0.698**	0.051	**0.752**	0.134	**0.444**	0.060
X only	0.058	0.264	.	.	-0.41	7.907	-3.432	9.913	.	.	0.013	0.143	0.322	0.523	0.12	0.142
MI only	0.195	0.157	.	.	**-1.995**	0.903	-2.39	4.414	0.06	0.319	0.07	0.112	**-1.181**	0.372	0.142	0.144
MK only	**-0.366**	0.148	-0.307	1.016	**-3.36**	1.327	-2.477	7.056	-0.043	0.674	0.01	0.155	0.557	0.448	-0.157	0.270
MI and X	**-0.437**	0.125	-0.519	0.978	**-2.569**	0.918	-3.76	3.527	.	.	**-0.29**	0.131	0.259	0.373	0.09	0.202
MK and X	-0.212	0.157	.	.	-1.852	1.905	-2.788	6.024	.	.	.	.	.	.	-0.147	0.260
MI and MK	0.144	0.203	-0.169	0.359	-0.393	1.06	-1.956	4.316	-0.14	0.398	0.236	0.134	-0.221	0.53	**0.396**	0.145
MI, MK, and X	-0.256	0.132	.	.	-0.507	0.814	-4.341	3.659	0.042	0.355	0.005	0.109	0.429	0.446	0.285	0.162
Restricted Marginal Cost Equation																
Intercept	0.274	0.04	0.356	0.027	0.167	0.022	0.426	0.044	0.404	0.07	0.261	0.027	**0.375**	0.054	0.309	0.032
Trend	0.029	0.004	-0.025	0.005	0.021	0.003	0.008	0.006	0.016	0.005	0.009	0.002	-0.006	0.004	-0.006	0.003
ln(K)	-0.013	0.019	**-0.02**	0.009	0.005	0.008	-0.037	0.014	0.002	0.025	0.01	0.008	0	0.015	-0.017	0.010
X only	-0.069	0.062	.	.	0.036	0.109	-0.046	0.149	.	.	-0.013	0.036	0.03	0.054	0.006	0.023
MI only	-0.037	0.035	.	.	-0.003	0.026	-0.085	0.061	0.044	0.04	**-0.061**	0.023	-0.047	0.038	0.008	0.023
MK only	-0.051	0.033	**0.307**	0.088	-0.079	0.039	-0.053	0.114	0.003	0.087	-0.009	0.037	0.049	0.046	0.043	0.044
MI and X	-0.041	0.028	0.108	0.072	0	0.026	-0.067	0.047	.	.	**-0.078**	0.028	0.073	0.038	0.053	0.033
MK and X	0.006	0.035	.	.	-0.106	0.058	-0.066	0.086	.	.	.	.	.	.	-0.022	0.042
MI and MK	-0.036	0.045	-0.068	0.053	0.004	0.032	-0.011	0.066	0.018	0.051	**-0.075**	0.028	-0.017	0.055	0.041	0.023
MI, MK, and X	-0.032	0.03	.	.	0	0.023	-0.04	0.049	-0.023	0.046	-0.026	0.028	0.057	0.046	**0.063**	0.026
Quality effects?		**24.524**	.	0.833		**15.586**	.	1.685	.	0.382		**14.883**		**17.184**		10.458
MC effects?	.	6.268	.	**15.62**	.	7.351	.	4.301	.	2.455		**13.005**	.	9.796	.	9.071
-Log(L)		-308.656		154.594		18.271		746.139		-93.021		-957.527		-312.373		-810.053
Obs.		295		95		195		305		235		445		210		725

Appendix 2: Activity Patterns and Determinants

Table A2.1 – Activity Dynamics in Colombia: Descriptive Evidence

COLOMBIA CHEMICALS

		Year t+1				
		None	Import	Export	Both	**Total**
	None	509	70	9	3	**591**
Year t	Import	58	522	1	31	**612**
	Export	7	2	45	7	**61**
	Both	4	47	7	508	**566**
	Total	**578**	**641**	**62**	**549**	**1830**

P[Export]	0.343
P[Import]	0.644
P[Export|Import]	0.480
P[Import|Export]	0.903
P[Export at t+k | Not Export at t]	0.037
P[Export at t+k | Not Export at t, Not Import at t]	0.020
P[Export at t+k | Not Export at t, Import at t]	0.052
P[Ho: Export at t+1 Independent of Import at t]	**0.003**
P[Import at t+k | Not Import at t]	0.126
P[Import at t+k | Not Import at t, Not Export at t]	0.124
P[Import at t+k | Not Import at t, Export at t]	0.148
P[Ho: Import at t+1 Independent of Export at t]	**0.590**

Table A2.2 – Activity Dynamics in Morocco: Descriptive Evidence

MOROCCO CHEMICALS

		Year t+1				
		None	FDI	Export	Both	**Total**
Year t	None	660	38	15	2	**715**
	FDI	33	122	2	8	**165**
	Export	24	4	49	7	**84**
	Both	4	16	11	55	**86**
	Total	**721**	**180**	**77**	**72**	**1050**

P[Export]	0.162
P[FDI	0.239
P[Export|FDI]	0.343
P[FDI|Export]	0.506
P[Export at t+k | Not Export at t]	0.031
P[Export at t+k | Not Export at t, Not FDI at t]	0.024
P[Export at t+k | Not Export at t, FDI at t]	0.061
P[Ho: Export at t+1 Independent of FDI at t]	**0.013**
P[FDI at t+k | Not FDI at t]	0.064
P[FDI at t+k | Not FDI at t, Not Export at t]	0.056
P[FDI at t+k | Not FDI at t, Export at t]	0.131
P[Ho: FDI at t+1 Independent of Export at t]	**0.008**

Table A2.3 – Activity Dynamics in Colombia: Econometric Results

Dependent Variable	Regressors	All Firms Coef.	All Firms Std.Err.	ISIC 3522 Only Coef.	ISIC 3522 Only Std.Err.
Both Export and Import	Lagged Both	0.604	0.034	0.778	0.079
	Lagged Export	0.113	0.045	0.234	0.092
	Lagged Import	0.011	0.014	0.107	0.076
	Lagged Neither	0.015	0.014	0.110	0.071
	Quality			0.007	0.009
	Marginal Cost			-0.043	0.037
	Initial Both	0.332	1.468	0.240	0.048
	Initial Export	0.029	0.661	0.276	0.088
	Initial Import	0.058	1.093	0.046	0.031
	Average Quality			0.002	0.009
	Average Marginal Cost			0.045	0.054
Export Only	Lagged Both	0.063	0.017	0.113	0.063
	Lagged Export	0.507	0.027	0.466	0.070
	Lagged Import	0.033	0.013	0.077	0.061
	Lagged Neither	0.017	0.009	0.061	0.060
	Quality			-0.006	0.005
	Marginal Cost			0.002	0.021
	Initial Both	-0.048	0.018	-0.069	0.029
	Initial Export	0.160	0.032	-0.051	0.071
	Initial Import	-0.031	0.014	-0.037	0.022
	Average Quality			0.005	0.005
	Average Marginal Cost			-0.031	0.041
Import Only	Lagged Both	-0.032	0.043	-0.115	0.104
	Lagged Export	0.019	0.069	-0.088	0.131
	Lagged Import	0.546	0.028	0.574	0.104
	Lagged Neither	0.093	0.019	0.102	0.095
	Quality			0.005	0.013
	Marginal Cost			0.089	0.054
	Initial Both	0.072	0.044	0.170	0.065
	Initial Export	0.013	0.065	0.123	0.126
	Initial Import	0.287	0.031	0.311	0.047
	Average Quality			-0.002	0.013
	Average Marginal Cost			-0.090	0.072
P[Export at t+k | Not Export at t, Import at t] - P[Export at t+k | Not Export at t, Not Import at t]		0.012	0.016	0.013	0.032
P[Import at t+k | Not Import at t, Export at t] - P[Import at t+k | Not Import at t, Not Export at t]		0.025	0.055	-0.065	0.092

Table A2.4 – Activity Dynamics in Colombia: Econometric Results

Dependent Variable	Regressors	All Firms Coef.	All Firms Std.Err.	ISIC 3560 Only Coef.	ISIC 3560 Only Std.Err.
Both Export and FDI	Lagged Both	0.427	0.039	0.594	0.077
	Lagged Export	0.081	0.028	0.018	0.047
	Lagged FDI	-0.067	0.027	0.026	0.052
	Lagged Neither	-0.003	0.007	0.021	0.050
	Quality			-0.010	0.005
	Marginal Cost			0.081	0.041
	Initial Both	0.442	2.030	0.000	0.000
	Initial Export	0.007	1.815	0.002	0.018
	Initial FDI	0.147	1.697	0.058	0.020
	Average Quality			0.012	0.006
	Average Marginal Cost			-0.107	0.066
Export Only	Lagged Both	0.097	0.038	0.136	0.155
	Lagged Export	0.404	0.038	0.579	0.100
	Lagged FDI	0.085	0.031	0.168	0.100
	Lagged Neither	0.037	0.010	0.135	0.090
	Quality			-0.005	0.013
	Marginal Cost			0.060	0.092
	Initial Both	-0.016	0.042	0.000	0.000
	Initial Export	0.366	0.044	0.323	0.048
	Initial FDI	-0.064	0.030	-0.036	0.044
	Average Quality			0.020	0.015
	Average Marginal Cost			-0.192	0.122
FDI Only	Lagged Both	-0.262	0.050	-0.395	0.139
	Lagged Export	-0.073	0.040	-0.004	0.047
	Lagged FDI	0.101	0.040	-0.004	0.056
	Lagged Neither	0.010	0.010	-0.030	0.044
	Quality			0.003	0.011
	Marginal Cost			-0.048	0.074
	Initial Both	0.296	0.053	0.000	0.000
	Initial Export	0.063	0.046	-0.025	0.046
	Initial FDI	0.597	0.036	0.649	0.046
	Average Quality			-0.005	0.013
	Average Marginal Cost			0.090	0.071
P[Export at t+k | Not Export at t, FDI at t] - P[Export at t+k | Not Export at t, Not FDI at t]		-0.016	0.036	0.037	0.050
P[FDI at t+k | Not FDI at t, Export at t] - P[FDI at t+k | Not FDI at t, Not Export at t]		0.002	0.035	0.022	0.042