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**Downsizing, Layoffs and Plant Closure:  
The Impacts of Import Price Pressure and Technological Growth on US Textile  
Producers**

Patrick Conway  
Department of Economics  
Gardner Hall, CB 3305  
University of North Carolina at Chapel Hill  
Patrick\_Conway@unc.edu

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Abstract

Downsizing, layoffs and plant closure are three plant-level responses to adverse economic conditions. I provide a theoretical and empirical analysis that illustrates the sources of each phenomenon and the implications for production and employment in the textiles industry.

I create a micro-founded model of plant-level decision-making and combine it with conditions for dynamic market equilibrium. Through use of detailed plant-level information available in the US Census of Manufacturers and the Annual Survey of Manufacturers for the period 1982-2001, along with price data on imports, I examine the relative contribution of technology and import competition to the decline in output, employment and number of plants in textiles production in the US in recent years. The market-clearing domestic price of textiles is identified as a crucial channel in transmitting technology or import price shocks to downsizing, layoffs and plant closure.

The model is estimated on two 4-digit sectors of textiles production (SIC 2211, broadwoven cotton and SIC 2221, broadwoven man-made fiber). The results validate modeling the production sectors as monopolistically competitive, and the elasticity of substitution between foreign and domestic varieties is found to be high. In simulations for the broadwoven cotton industry, the effects of technological progress are shown to have a much larger impact on layoffs than on plant closure, with plant size as measured by output actually increasing. Falling foreign prices lead to greater relative magnitudes of plant closure than of downsizing or layoffs.

Key words: plant closure, downsizing, layoffs, import competition, technological progress

JEL classifications: F12, F13, F14

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Import penetration (and its effect on US firms) has been a flashpoint of the globalization debate. Three phenomena have become tightly associated with this debate: downsizing, layoffs and plant closure. As imports have become more important in US markets, and as US firms have laid off workers, downsized and closed in response to falling demand for their goods, the causality from import penetration to these phenomena has become accepted wisdom.

In this paper I decompose the causes of these various effects for the US textiles industry. I use the Annual Survey of Manufactures (ASM) and the Census of Manufactures (CM) of the US Bureau of the Census to model the plant-level dynamics of entry, production, investment and exit in the textiles industry. This work is done using ASM data for the years 1983-1986, 1988-1991, 1993-1996 and 1998-2001, and CM data from 1982, 1987, 1992 and 1997. The textile industry is examined at the 4-digit SIC level. For the current paper I examine categories 2211 (broadwoven cotton cloth) and 2221 (broadwoven cloth of man-made fibers).

Downsizing is defined in this paper as the reduction in the quantity of production of the plant. Layoffs are defined as a reduction in employment by a plant in continuous operation. Plant closure is what it sounds like: the owners decide to close its doors and cease production.

In reality, competition from imports is only one of the determinants of these phenomena. Estimation and simulation indicates that increased layoffs are in equilibrium more closely associated with technological progress, while increased plant closure and downsizing are more closely associated with increased import competition. The

endogenous response of domestic prices is revealed to be a key factor in determining the relative importance of plant closure and layoffs in responding to economic shocks.

### **I. Research design.**

Economists have been concerned with the impact of international competition on the US manufacturing sector for at least a generation. Lawrence (1983) summarizes neatly the concern in his title – *Is Trade Deindustrializing America?* – and provides an empirical answer. Three conclusions stand out from his analysis of the 1970s:

- There is a great variability in industrial growth across manufacturing subsectors.
- There is no close correlation between growth in net trade and growth in production when examined at the sub-sectoral level.
- The secular trends associated with the title were less important than the US producer's response to changing real exchange rate in determining output, employment and value added at the sub-sectoral level.

His empirical research design is also indicative of early work. He used data on output for 52 manufacturing industries in the US in the years from 1970 to 1980 and matched it with net export (export-import) data in the same years. The US manufacturing input-output table was used to measure production used as intermediate inputs. He created growth rates over the period for each sub-sector. The effect of net exports on growth was associated with international competition.

While the empirical work was carefully done, there were difficulties in interpreting the results.<sup>1</sup> Most notable are two: (1) the theory underlying the analysis involves plant-level decisions while the data are aggregated to the industry level, and (2)

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<sup>1</sup> These are difficulties recognized by the author and by Cooper (1983) in his comment on the paper.

the alternatives to international competition as a source of deindustrialization are not specified.

Subsequent analyses worked with similar data, but addressed the questions of simultaneity and statistical significance through a regression framework. For example, Revenga (1992) examined the impact of import competition on US manufacturing employment and wages. Rather than take net exports as given, she defines a reduced-form model in which it depends upon various demand shifters and the relative price of imports. The import price was modeled as simultaneously determined, and a two-stage estimation procedure was used to correct for simultaneity bias. Data were collected for 38 industries over the 1977-1987 period, representing 72 percent of total imports in 1985, and a pooled cross-section time-series analysis was undertaken. After controlling for simultaneity, she concludes that, other things equal, a 10 percent reduction in the price of the import good is associated with a drop of 2.5 to 4 percent in employment. This effect was statistically significant, though it is dependent upon the maintained hypothesis that demand shifters and relative import price enter the reduced-form equation for each industry with the same parameter.

Subsequent work in this area has followed these two research designs.<sup>2</sup> On the one hand, there have been input-output analyses such as Scott, Lee and Schmitt (1997). These use industry-level data and the same basic structure as in Lawrence (1983), and their conclusions on import competition are subject to the same criticisms. On the other

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<sup>2</sup> Much empirical work recently has been in two related areas that I won't comment upon further. The first is the empirical testing of the Heckscher-Ohlin trade model; there, the papers by Leamer and Levinsohn (1995), Trefler (1995), Davis and Weinstein (2001) and Conway (2002) provide a good summary. The second is the voluminous literature on the determinants of increasing wage inequality within trading economies. Freeman (1995), Slaughter (1998) and Wood (1998) provide a good introduction to this related question.

hand there are industry-level analyses of output and employment that account carefully for the potential simultaneity between net export and output outcomes. Harrigan (1997) is an example: the author examines specific industries over time and across countries to distinguish between the comparative-advantage and technological progress explanations for the evolution of output shares in 10 OECD countries over the period 1970-1988. While these studies have been somewhat successful at identifying import-competition effects, they all suffer from the drawback that they cannot model the plant-level decision carefully.

Current theoretical models of plant-level production, entry and exit, by contrast, provide a template for consideration of closure, layoffs and downsizing. In the current literature on plant entry and exit, forward-looking plants maximize cumulative discounted expected profits: if these become negative, the plant will exit. In Hopenhayn (1992), for example, productivity at the plant level follows a Markov process.<sup>3</sup> When this productivity falls below a critical value (conditioned by expectations of future final-good and input prices) the plant exits. Plant entry, by contrast, occurs at random since potential plants have no information about their actual productivity. Plant entry is constrained by zero expected profits of new entrants. Hopenhayn's analysis is for a single sector, and there is no distinction made between domestic and foreign plants.

Melitz (2003) introduces international trade to the Hopenhayn model. His treatment of entry is identical – undifferentiated plants continue to enter until their expected discounted profits are zero. Exit is also identical in spirit: those plants with the lowest productivity draw will exit. The differences arise among continuing plants.

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<sup>3</sup> The results of this random productivity model are isomorphic to a model in which productivity is identical but quality of final product follows a Markov process.

While in the Hopenhayn model there is a bifurcation of plants into continuing and exiting based upon the realization of productivity in any period, in Melitz there is a three-way assignment. The lowest-productivity plants exit, as in Hopenhayn. The continuing plants from Hopenhayn are divided in two. The middle group (when ranked by productivity) do not exit, but they experience a loss in production and market share as they compete with foreign producers for the domestic market – they are import competitors. The highest-productivity plants find it possible not only to compete in the domestic market but also to compete in foreign markets – they are the exporters. In a model with international trade, trade liberalization leads to increased exit, increased pressure to downsize on the import competitors, and increased production among the exporters.

These theoretical papers lay out the structure for an investigation of plant closure and downsizing. They also set an agenda for empirical work.

- The productivity measure at the heart of Hopenhayn and Melitz is known to the plant, but is not observed by the econometrician. In the typical analysis (Pavcnik (2002) is a good example, and provides a useful summary of earlier work) the productivity in question is modeled as unobserved total factor productivity. To identify this measure, the empirical analysis must specify and estimate completely the productive technology.
- The productivity shocks affecting plant operating and closure decisions are drawn from a distribution. The observed outcomes of plants will provide a biased view of those shocks, as the exiting plants will be drawn from the bottom tail of the distribution.

- While the theoretical papers have focused upon random productivity, an empirical analysis of import competition must model as well the evolution of import price (or quantity) pressure on the plants' decisions.

Previous work on the impacts of import competition has not addressed this complete agenda. Earlier research put forward two differing hypotheses of the link between import competition and firm-level productivity. The first has been called the “imports as market discipline” approach by Levinsohn (1993) and the “procompetitive effect of trade liberalization” by Devarajan and Rodrik (1989). It is a straightforward application of the discussion of imperfect competition in Dixit and Norman (1980, ch. 9): with more entrants into an imperfectly competitive market, the price-cost margin will be reduced in equilibrium for all competitors and welfare will rise. Levinsohn (1993) and Harrison (1994) test this hypothesis for firm-level evidence in Turkey and Cote d'Ivoire, respectively, and find indirect evidence of price-cost margin compression in firms facing increased competition from imports.<sup>4</sup>

The second hypothesis is more primitive, and suggests that technological efficiency at the firm level will be improved through import competition. An unobserved technological parameter of the plant-level production function indexes the productivity of the plant relative to the industry as a whole. Once a plant-level proxy is derived for this unobserved variable, it can be tested in a difference-in-difference framework. Pavcnik (2002) addresses the impact of trade liberalization in Chile: she derives an average productivity indicator for three types of plants (exporter, import-competitor, non-tradable) both at the beginning of trade liberalization and for each year during the trade

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<sup>4</sup> The evidence is indirect because it is inferred from coefficients on factor use – there is no direct examination of domestic and foreign prices. Feenstra (2004, pp. 341-342) provides a nice summary of this work.

liberalization. The null hypothesis is that average growth in productivity is insignificantly different across plant type, while the alternative hypothesis is that average growth in productivity in the import-competing industries will be significantly greater than that in the non-tradable industry. Her estimation technique controls for both simultaneity and selection bias and yields proxies for productivity that allow her to reject the null in favor of her alternative hypothesis.<sup>5</sup> She recognizes the potential importance of the market-discipline argument, but does not control for such effects directly. She does devote substantial effort, however, in contrasting her results with those if the productivity changes were in fact the product of real exchange rate movements – one variant of the market-discipline hypothesis.

Bernard, Jensen and Schott (2006) examine the evidence of reduced growth in US manufacturing plants due to competition from low-wage countries between 1977 and 1997 using the plant-level data of the US Bureau of the Census. While they do not provide a plant-level model of decision-making, they posit that output growth is a function of plant-level characteristics (employment, age of plant, wage of non-productive labor, wage of productive labor, total factor productivity) the capital/labor ratio of the plant, plant-level fixed effects, and a number of measures of the degree of import competition from low-wage countries (by 4-digit SIC code). These measures of import competition are associated with significant downsizing (reductions in output) and layoffs among those firms that survive, and with a significantly greater propensity for a firm facing higher import competition to close between the two years.

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<sup>5</sup> She does not have a hypothesis for the relationship between exporters and non-tradables, but does find significant improvement in productivity on average for those plants as well.

There has been some attention to plant-level productivity effects in the literature on the textile industry. Levinsohn and Petropoulos (2001) examine the dynamic evolution of the textiles and apparel industry in the US through examination of plant-level data from the US Census Bureau. While import competition is at the heart of their argument, they do not model this competition directly. They derive a proxy for unobserved productivity using an approach similar (but not identical) to Pavcnik (2002), and then use that proxy to explain the plant-level decision to shut down. Given the lack of modeling of the impact of foreign competition in the market for these goods, the coefficient estimates and the resulting proxy for productivity are both potentially inconsistent. Nevertheless, their estimates of the impact of competition on firm exit are sensible.

This paper extends those previous in an important dimension. I use plant-level data, but examine a more homogeneous set of plants. By doing so, I will both have more confidence that the technological parameters are sensible and will be able to derive direct indicators of import competition. The result of this agenda will be a decomposition of the causes of downsizing, layoffs and plant closure among the sample of US textile plants. The following theoretical derivation is built upon the Melitz (2000) structure, but introduces explicitly the relative-price effects due to import competition. Conway (2006) provides a related analysis of productivity, with a more detailed explanation of solutions to idiosyncracies of the US Bureau of Census data.

## **II. The plant-level theory of downsizing, layoffs and closure.**

Consider an industry of imperfectly competitive firms serving a downstream industry (e.g., textiles serving the apparel sector). Demand for those imperfectly

competitive inputs in period  $t$  can be derived from a CES production function for the downstream industry; consider each firm's output  $Q_{it}$  (with quality  $\Lambda_{it}$ ) as a separate differentiated input with elasticity of substitution  $\sigma$ .<sup>6</sup> The aggregate price index of differentiated inputs is written  $P_t$ , the number of upstream firms (and inputs) given by  $N_t$  and the total revenue of all firms in the upstream industry given by  $R_t$ .<sup>7</sup> Denote the logarithm of a variable by its lower-case version. The demand for each differentiated product can then be represented as:

$$q_{it} = r_t - n_t - p_t + (\sigma-1)\lambda_{it} - \sigma(p_{it} - p_t) \quad (1)$$

It is also important to introduce explicitly the distinction between domestic and foreign production of these goods. I separate the firms producing this differentiated product into two groups: group D of domestic firms, with number  $N_{Dt}$ , and group F of foreign firms, with number  $N_{Ft}$ .<sup>8</sup> Aggregate prices and perceived qualities can be decomposed into these groups as well, with quality-adjusted price indices  $P_{Dt}$  and  $P_{Ft}$  as components of aggregate price index  $P_t$ .<sup>9</sup> For firms  $i$  and  $j$ , competition is assumed to lead to the following logarithmic relation in quality-adjusted prices:

$$p_{it} - \lambda_{it} = \tau_{jt} + p_{jt} - \lambda_{jt} \quad (2)$$

<sup>6</sup> This specification builds on Melitz (2000). The downstream production function can be written  $A = (\sum_i (\Lambda_i Q_i)^{(\sigma-1)/\sigma})^{(\sigma/(\sigma-1))}$  with summations over  $i$  from 1 through  $N$ . It is straightforward to include productivity shifts, or to recast this problem as one of differentiated final goods facing a representative consumer. Quality differences are more difficult to model, as noted below.

<sup>7</sup> The aggregate price index for this CES production function can be written (with summations over 1 through  $N$ ):  $P = [(1/N)\sum_i P_i^{\sigma-1}]^{1/(\sigma-1)} / [(1/N)\sum_i \Lambda_i^{\sigma-1}]^{1/(\sigma-1)}$

<sup>8</sup> Of course,  $N_t = N_{Dt} + N_{Ft}$ .

<sup>9</sup> These can be defined  $P_{kt} = [(1/N_{kt})\sum_i P_{it}^{\sigma-1}]^{1/(\sigma-1)} / [(1/N_{kt})\sum_i \Lambda_i^{\sigma-1}]^{1/(\sigma-1)}$  for  $k = D, F$ . The summations are over the firms  $i$  in the groups D and F, respectively. The aggregation of domestic and foreign indices into the aggregate is somewhat complex due to the assumption of different perceived qualities. If the only quality distinction (denoted  $0 < g_t < 1$ , with higher  $g_t$  indicating less quality differential) is between foreign and domestic, with  $g_{\Lambda_d} = \Lambda_f$ , and if we define  $\chi_t = N_{Dt}/(N_{Dt} + N_{Ft}g_t^{\sigma-1})$  as the domestic share of effective firms then  $P_t = [\chi_t P_{Dt}^{\sigma-1} + (1-\chi_t)P_{Ft}^{\sigma-1}]^{1/(\sigma-1)}$ . For computational ease I use the geometric mean approximation  $P_t \approx P_{Dt}^{\chi} P_{Ft}^{1-\chi}$ .

with  $\tau_{jt}$  the tariff-equivalent measure of the transportation costs and trade barriers that applies in bringing a product  $j$  from the foreign country into the domestic market. For  $i$  and  $j$  both from either group D or group F and with the simplification on quality in fn. 5, this becomes  $p_{it} = p_{jt}$ .<sup>10</sup> For  $i$  from group D and  $j$  from group F, it becomes  $(p_{it} - p_{jt}) = \tau_{jt} - \ln(g_i)$ .

Introduction of an additional low-price foreign firm  $j$  reduces the demand for the domestic differentiated product  $i$  in (1) in two ways. First, there is a relative-price effect: the aggregate price index  $p_t$  falls, reducing  $q_{it}$  for given  $p_{it}$ . Second, there is a market-sharing effect: for given real market demand  $(r_t - p_t)$  the number of firms  $n_t$  rises, reducing demand for the product of firm  $i$ . Both effects will be identified in what follows.

### **Plant-level choices.**

On the production side, the basic model for each plant  $i$  includes the production technology and associated first-order conditions. Define physical output at plant  $i$  at time  $t$  as  $Q_{it}$ . A production function will be defined for  $Q_{it}$  in value added ( $Y_{it}$ ), energy use ( $E_{it}$ ), materials use ( $M_{it}$ ), a plant-specific invariant productivity effect ( $Z_i$ ) and a plant-specific but time-varying TFP effect ( $\Pi_{it}$ ).<sup>11</sup> Value-added is the joint contribution of capital ( $K_{it}$ ) and production labor ( $L_{it}$ ) to output.<sup>12</sup>  $\varepsilon_{it}$  is a random shock to value-added. This can be written in logarithms:

$$q_{it} = z_i + \beta_y y_{it} + \beta_e e_{it} + \beta_m m_{it} + \pi_{it} \quad (3)$$

<sup>10</sup> If the two products are both foreign, but come from different countries, facing different transport costs and tariffs, then the relation is  $p_{it} = (\tau_{jt} - \tau_{it}) + p_{jt}$ .

<sup>11</sup> The presentation here is based on a Cobb-Douglas technology. In estimation, both Cobb-Douglas and translog functions will be employed.

<sup>12</sup> Capital-augmenting and labor-augmenting technology by industry at each time will also be investigated.

$$y_{it} = \alpha_k k_{it} + \alpha_l l_{it} + \varepsilon_{it} \quad (4)$$

Equating supply and demand for each good  $i$  defines its equilibrium relative price. This can be rewritten in terms of aggregate domestic price  $p_{Dt}$ .

$$(p_{it} - p_{Dt}) = [-q_{it} + (r_t - n_t - p_{Dt}) + (\sigma-1)\lambda_{it}]/\sigma + (p_t - p_{Dt})(\sigma-1)/\sigma \quad (5)$$

Increases in real net industry sales or product quality will, *ceteris paribus*, raise the relative price of good  $i$ . So also will reductions in the quantity produced, whether due to reduced value-added, reduced energy use or reduced total factor productivity. The market-sharing effect of foreign entrants serves to lower  $p_t$  and the relative price of good  $i$ , *ceteris paribus*.

In Bureau of Census plant-level data, the price of each good is not observed. Instead, the value of sales of the firm ( $R_{it}$ ) is reported.<sup>13</sup> As Melitz (2000) points out, estimation must then be based on a “revenue production function”.<sup>14</sup> The technological specification in (3) is supplemented by the effects of total demand, supply and quality on relative price in (5).

$$r_{it} - p_{Dt} = q_{it} + (p_{it} - p_{Dt}) \quad (6)$$

or, using (5) and the approximation to  $P_t$  in fn. 5:

$$r_{it} - p_{Dt} = ((\sigma-1)/\sigma)[q_{it} + \lambda_{it}] + (r_t - n_t - p_{Dt})/\sigma + ((\sigma-1)/\sigma)(1-\chi_i)(p_{Ft} - p_{Dt}) \quad (7)$$

The derivation of (7) illustrates the lessons about biased estimation with deflated sales data made by Klette and Griliches (1996), Melitz (2000) and Katayama, Lu and Tybout (2003): price variation can be confounded with output response. There is an additional implication here as well, original to this paper and critical to work with traded goods such

<sup>13</sup> The Bureau of Census data also aggregates across all products of a specific plant, further complicating estimation. See Melitz (2000) for an extension of the technique to address multi-product firms.

<sup>14</sup> Bernard, Eaton, Jensen and Kortum (2000) provide an alternative approach to modeling imperfect competition, but the Melitz (2000) formulation seemed more appropriate to this market.

as textiles: indicators of international competition should also enter the estimating equation. This is evident in the final term in (7), where the relative-price effect of trade barriers drives a wedge between foreign and domestic prices.  $\chi_t$  will in addition be falling over time with foreign entry and the exit of domestic firms.<sup>15</sup>

Profit maximization implies first-order conditions for labor, energy and materials. These include the industry-wide logarithmic price of materials ( $p_{mt}$ ) and the plant-level logarithmic wages for production workers ( $w_{it}$ ) and price of energy ( $v_{it}$ ).<sup>16</sup>  $\varepsilon_{lit}$ ,  $\varepsilon_{eit}$  and  $\varepsilon_{mit}$  are random errors.<sup>17</sup>

$$((\sigma-1)/\sigma)(p_{it}/p_{Dt})\beta_y\alpha_l = \exp(w_{it} + l_{it})/\exp(p_{Dt} + q_{it}) + \varepsilon_{lit} \quad (8)$$

$$((\sigma-1)/\sigma)(p_{it}/p_{Dt})\beta_e = \exp(e_{it} + v_{it})/\exp(p_{Dt} + q_{it}) + \varepsilon_{eit} \quad (9)$$

$$((\sigma-1)/\sigma)(p_{it}/p_{Dt})\beta_m = \exp(m_{it} + p_{mt})/\exp(p_{Dt} + q_{it}) + \varepsilon_{mit} \quad (10)$$

Total factor productivity  $\pi_{it}$  in (3) is derived as a residual. To obtain consistent estimates of technological coefficients the system (3)-(10) must be estimated, and the market-discipline effect removed. For operating plants, the decision to reduce labor use will lead to layoffs; the decision to reduce output will be interpreted as downsizing.

### **Dynamic equilibrium.**

These static plant-level choices are only the start of a characterization of equilibrium. Also necessary are explanations for plant entry and exit from the market, for

<sup>15</sup> The impact of import competition is also evident in the market-sharing effect ( $r_t - n_t - p_{Dt}$ ). The entry of relatively small foreign competitors will lower the average revenue per firm and ceteris paribus lower the deflated sales of firm  $i$ . This is the “imports as market discipline” effect, derived at the level of the market.

<sup>16</sup> Firms maximize profits, plants don't, and so the specification given here is an approximation. It will be a good approximation for intratemporal optimization, but may miss product mix-shifting motives for multi-plant exit or investment decisions. I investigate that in the research through division of the sample into single-plant and multi-plant firms and checking for significant coefficient differences in estimation results for the two subgroups.

<sup>17</sup> In all three equations, the elasticity of aggregate price with respect to increases in the single firm's factor use is excluded as second-order in size.

investment choices, and for the determination of the equilibrium domestic price level  $P_{Dt}$ .

**Plant entry.** Plant entry is a prospective choice in an industry such as textiles: the plant owner has an expectation of plant-level productivity but is not certain of the realization for this specific plant. I follow Hopenhayn (1992) in modeling this decision as a competitive process that continues until  $P_{Dt}$  is driven down to equate the present value of expected future profitability to current entry costs. Thus, the individual entry decision is increasing in  $P_{Dt}$ .

**Plant exit.** The discounted present value of future profitability  $\Lambda_{it}$  is defined

$$\Lambda_{it} = \sum_{s=t+1}^{\infty} E_t [R_{is} - W_{is}L_{is} - V_{is}E_{is} - P_{Mis}M_{is} - P_{Iis}I_{is}] / ((1+r)^s P_{Ds}) \quad (11)$$

After log-linearization and the substitution of (3), (4), and (8)-(10),  $\Lambda_{it}$  is shown to be a function of  $P_{Ds}$ , the relative prices of inputs, the plant-specific profitability factor  $z_i$  and the unobserved productivity  $\pi_{is}$  for all future periods.

The plant-level exit decision is contingent upon the plant's expectation of its future profitability: when  $\Lambda_{it} < 0$ , then the plant will choose to close. Define  $\pi_{it+1}^0(p_{Dt}, \kappa_{it})$  :  $\Lambda_{it}(p_{Dt}, \pi_{it+1}^0, \kappa_{it}) = 0$  where  $\kappa_{it}$  is the expectation of all other determinants of  $\Lambda_{it}$ . For a given  $p_{Dt}$ , the plant will choose to exit if  $E_t(\pi_{it+1}) < \pi_{it+1}^0$ .

**Plant investment.** The plant-level investment decision depends upon the maximization of  $\Lambda_{it}$  with respect to  $I_{is}$  for all  $s$ . For our purposes, it is sufficient to note that this investment will be increasing in  $\pi_{is}$ , other things equal. Investment will be ambiguously affected, depending upon the substitutability of capital with the other factors of production, with an increase in  $P_{Ds}$ .

Hopenhayn (1992), Pavcnik (2002) and Melitz (2003) have similar models of entry, exit and investment. They focus almost exclusively on the unobserved

productivity  $E_t(\pi_{it+1})$ . For the purposes of this study it is important to note as well the implications of changing  $P_{Ds}$ . As  $P_{Ds}$  rises, other things equal, the plant-level decision to exit will become less attractive. Aggregating across all potential firms, the number of entrants will rise with an increase in  $P_{Dt}$ . Aggregating across all existing firms, differing in  $z_i$ ,  $k_{it}$  and  $E_t(\pi_{it+1})$ , the expected number of plants closing will fall with an increase in  $P_{Ds}$ . The volume of net entry (i.e., entry minus exit) will thus increase as  $P_{Ds}$  rises. This relationship is illustrated in Figure 1 and is labeled NX.

**Equilibrium  $P_{Ds}$ .** Market equilibrium also requires material balance. I begin with two assumptions about the evolution of the overall market demand and the supply of foreign product:

$$(N_{Dt}Q_{Dt} + N_{Ft}Q_{Ft}) = T_o e^{gt} P_{Dt}^{-\epsilon} \quad (A-1)$$

$$N_{Ft}Q_{Ft} = (1+\mu) N_{Ft-1}Q_{Ft-1} \quad (A-2)$$

The first specifies the growth in total US demand for textiles at a rate  $g$  and with price elasticity of demand  $\epsilon$ . The second specifies the growth in import quantities into the US occurs at rate  $\mu$ . This rate is governed in part by the quota system in prior years.

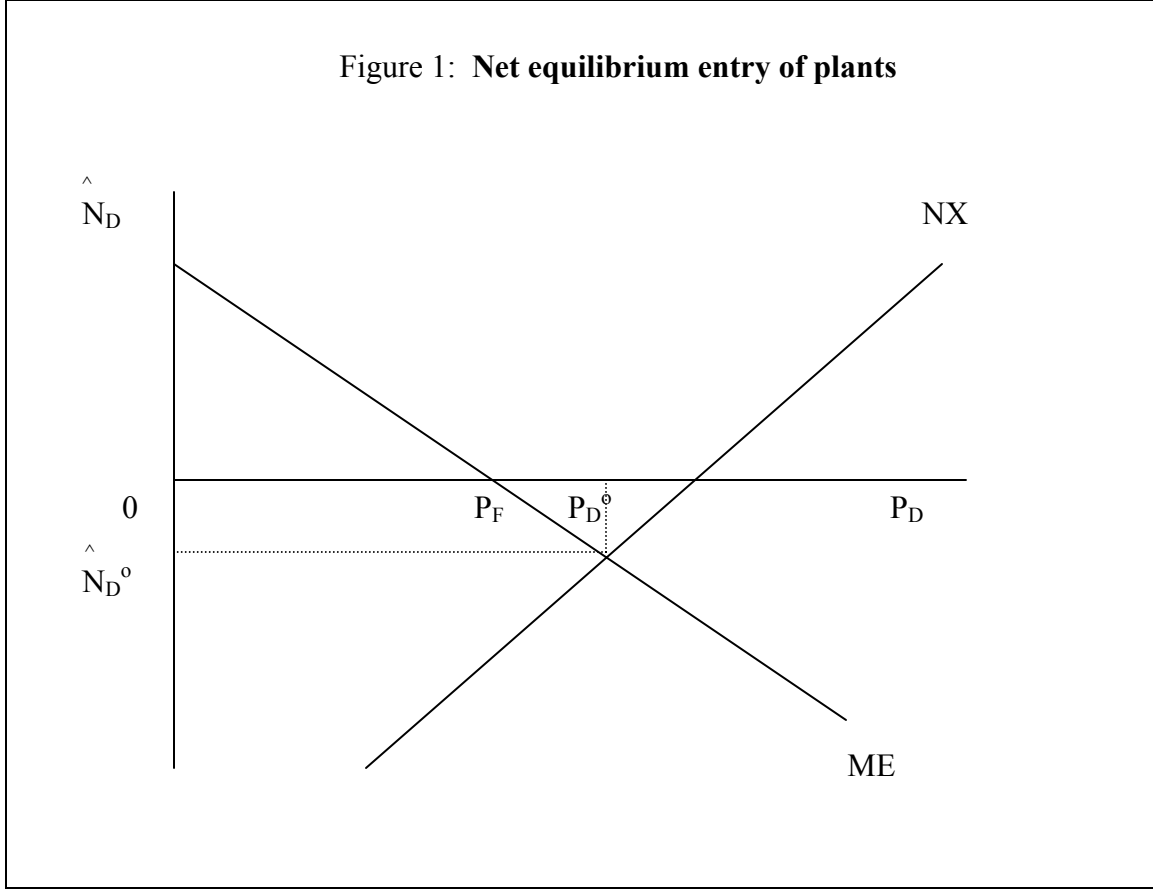
The elasticity of substitution defines a relation between the numbers and output of domestic and foreign suppliers:

$$(N_{Ft}Q_{Ft}/N_{Dt}Q_{Dt}) = d_o(P_{Dt}/P_{Ft})^\sigma \quad (12)$$

or

$$\chi_t = (N_{Dt}Q_{Dt}/(N_{Dt}Q_{Dt} + N_{Ft}Q_{Ft})) = (1/(1+d_o(P_{Dt}/P_{Ft})^\sigma)) \quad (13)$$

A fall in  $P_{Ft}$  relative to  $P_{Dt}$ , for example, will lead to a reduction in the share  $\chi_t$  of sales from domestic plants, with that reduction increasing with the size of  $\sigma$ .



Combination of (12) with (A-1) and (A-2) yields an expression in the net entry of domestic plants as a function of relative price:

$$\begin{aligned} (N_{Dt} - N_{Dt-1})/N_{Dt-1} = & \{g(1+(1/d_o)(P_{Dt-1}/P_{Ft-1})^{-\sigma}) - \mu\} (1-\chi_{t-1})/\chi_{t-1} \\ & - (Q_{Dt} - Q_{Dt-1})/Q_{Dt} \end{aligned} \quad (14)$$

The relative price enters the first expression explicitly, with increases in the relative price of the domestic product reducing net entry. The relative price will also enter through the evolution in sales of the average domestic plant in continuous operation, given by the second term on the right-hand side. An increase in the relative price of the domestic product will increase the size of the average plant through this channel, thus further

reducing the equilibrium net entry. This equilibrium relationship is illustrated in Figure 1 and labeled ME.

The general equilibrium illustrated in Figure 1 is one with continuing net exit of domestic plants. For illustration I've also provided the underlying average price of foreign imports  $P_F$ . In this case, market equilibrium consistent with no net exit will exist when  $P_D = P_F$ .<sup>18</sup> However, individual plants do not find that a profitable outcome. As the corresponding value on NX indicates, at  $P_D = P_F$  there will be more net exit of domestic firms than will be consistent with market equilibrium. As a result,  $P_D$  is bid up to  $P_D^0 > P_F$  with less net exit in this period. With no change in prices or other parameters of the decision-making process, this proportion of net exit will be observed in each period.

Three comparative-static calculations with this model lead to reasonable conclusions. An increase in the growth rate of import quotas ( $\mu$ ) will lead to more rapid inflow of foreign imported goods. This is illustrated by a downward shift in ME, leading to less net entry and a lower equilibrium  $P_D$ . By contrast, an increase in the growth rate in demand for textiles in the US ( $g$ ) is illustrated with an upward shift in ME, greater net entry and a higher  $P_D$ . An increase in input prices ( $w_t, v_t, p_{mt}$ ) will have an ambiguous effect on net entry, but will increase  $P_D$  in equilibrium. The ambiguity is due to the negative effect on net entry from raising production costs (NX shifts down) but the positive effect on net entry due to the downsizing of the typical plant (ME shifts up).

It is important to note that this (and any) dynamic equilibrium is characterized by continuing plant closure. This is a Schumpeter (1975) equilibrium of "creative destruction", with new plants entering and existing plants closing in each period. The

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<sup>18</sup> This is not a general property, but is used here to simplify the discussion.

NX curve represents net entry minus exit in each year, but even with an equilibrium characterized by positive net entry there will be plants closing each year.

### III. Difficulties in Estimation.

Use of US Bureau of Census data to estimate this model raises three critical estimating issues. First, the productivity term  $\pi_{it}$  is unobserved, and potentially correlated with  $k_{it}$ : this will introduce bias in the coefficient estimates. Second, there is no reliable series of the value of capital available in the ASM. Third, the primary product classification in the CM and ASM is not consistent throughout the sample period. Conway (2006) provides detail on the solutions to the second and third issues, while the first is addressed below.

**Unobserved heterogeneity in productivity.** As Olley and Pakes (1996) and Pavcnik (2002) illustrate, correlation between  $\pi_{it}$  and  $k_{it}$  will introduce bias in the coefficient estimates. In the current model, the sources of bias are concentrated in the term  $\psi_{it}$ .

$$q_{it} = z_i + \psi_{it} + \beta_e e_{it} + \beta_m m_{it} + \beta_y \alpha_l l_{it} \quad (15)$$

$$\psi_{it} = \beta_y \alpha_k k_{it} + \pi_{it} + \beta_y \varepsilon_{it}$$

Following Pavcnik (2002), I assume that the investment decision derived from (11) is monotonically increasing in unobserved productivity and invert the investment function.

This provides an expression for  $\pi_{it}$  that can be substituted into  $\psi_{it}$ . To estimate, I use a series expansion  $\Omega(k_{it}, i_{it-1})$  in place of  $\psi_{it}$  in defining  $q_{it}$ .<sup>19</sup>

$$q_{it} = z_i + \Omega(k_{it}, i_{it-1}) + \beta_e e_{it} + \beta_m m_{it} + \beta_y \alpha_l l_{it} + \beta_y \varepsilon_{it} \quad (16)$$

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<sup>19</sup> I will use the notation  $\Omega(x_a, x_b)$  to represent a third-order series expansion in the arguments  $x_a$  and  $x_b$ . Separate coefficients are estimated on each component of the expansion. Since these are not interpretable from theory, I do not report these coefficients. They are available on demand. Expansion of other orders yielded similar results, and are not reported here.

There is as well potentially a survival bias in the data due to the exit of firms. This causes a non-zero mean of the unobserved  $\varepsilon_{it}$ , and this effect is corrected through inclusion of the inverse Mills ratio  $\xi_{it}$  from the probit estimation of the exit decision.<sup>20</sup> Incorporation of  $\xi_{it}$  into (7) permits consistent estimation of  $\beta_e$ ,  $\beta_m$  and  $\beta_y\alpha_l$  through the system (8), (9), (10), (16) and (17).

$$\begin{aligned} r_{it} - p_{Dt} = & ((\sigma-1)/\sigma)[q_{it} + \lambda_{it}] + (r_t - n_t - p_{Dt})/\sigma \\ & + ((\sigma-1)/\sigma)(1-\chi_t)(p_{Ft} - p_{Dt}) + \mu\xi_{it} \end{aligned} \quad (17)$$

Define the consistent estimates of  $\beta_e$ ,  $\beta_m$  and  $\beta_y\alpha_l$  as  $b_e$ ,  $b_m$ , and  $b_y a_l$  respectively. An estimate of  $\psi_{it+1}$ , defined  $f_{it+1}$ , is then

$$f_{it+1} = q_{it+1} - b_e e_{it+1} - b_m m_{it+1} - b_y a_l l_{it+1} \quad (18)$$

Using (15), we can rewrite this in terms of next-period productivity:

$$\beta_y \pi_{it+1} = f_{it+1} - z_i - \beta_y \alpha_k k_{it+1} - \beta_y \varepsilon_{it+1}$$

The productivity  $\pi_{it+1}$  is unobserved. Since unobserved productivity is assumed to follow a random walk for each firm, then<sup>21</sup>

$$\pi_{it+1} = \pi_{it} + \zeta_{it} \quad (19)$$

If unobserved productivity is positively correlated with continuation, then those plants exiting the sample will have disproportionately negative shocks  $\zeta_{it}$ . To control for this upward bias in continuing firms I model next-period productivity as a series expansion in unobserved productivity  $\pi_{it}$  and the probability of continuation  $ps_{it}$ . The

<sup>20</sup> If the variable  $X_{it}$  takes a value of one for a firm exiting in  $t+1$ , the exit decision could be written:

$$\begin{aligned} X_{it} &= 1 \text{ for } g(E_t(\pi_{it+1}), k_{it+1}, z_i) > 0 \\ &= 0 \text{ otherwise} \end{aligned}$$

The resulting survival propensity links expected productivity with investment.

$$ps_{it} = \theta(E_t(\pi_{it+1}), k_{it+1}, z_i) \quad \theta_1 > 0, \theta_2 > 0, \theta_3 > 0$$

The inverse Mills ratio  $\xi_{it}$  is also derived from this estimation.

<sup>21</sup> In estimation, I allow for a time-invariant fixed effect as well as a component following this random walk.

estimation equation for the capital coefficients becomes as in (20), while the investment decision of the plant (21) is estimated simultaneously. In addition to capital, lagged investment and the unobserved productivity term, I include the aggregate capacity utilization in apparel ( $cu\_a_t$ ) and aggregate capacity utilization in textiles ( $cu\_t_t$ ) in the US as variables to measure potential market-pressure effects on the investment decision.

$$\beta_y \Omega(up_{it}, ps_{it}) = i_{it+1} - z_i - \beta_y \alpha_k k_{it+1} - \beta_y (\varepsilon_{it+1} + \varepsilon_{\pi it}) \quad (20)$$

with

$$i_{it} = \eta_0 + \eta_1 k_{it} + \eta_2 i_{it-1} + \eta_3 up_{it} + \eta_4 cu\_a_t + \eta_5 cu\_t_t + v_{it} \quad (21)$$

$$up_{it} = \Omega(k_{it}, i_{it-1}) - \beta_y \alpha_k k_{it}$$

The coefficients  $\beta_y \alpha_k$  and  $\eta_0$  through  $\eta_5$  are estimated consistently with this joint estimation procedure. The standard errors of coefficients are estimated consistently through use of a bootstrap method, and those are reported in the tables that follow.

**Missing capital stock.** Reliable estimates of  $k_{it}$  are only available each five years when the CM is conducted. I create an estimate of the capital stock using the perpetual inventory method with capital values reported in the CM, investment values reported in the ASM, and a depreciation rate that minimizes the sum of squared deviations from perpetual inventory: see Conway (2006) for details.

**Defining a consistent sector classification of plants by primary product.** The change in classification system from the Standard Industrial Classification (SIC) to the North American Industrial Classification System (NAICS) in 1997 in US Census data created problems of non-comparability in the textiles sector. The conversion to NAICS has grouped both cotton and manmade-fiber products in the same aggregate classification, while in the SIC the cotton and manmade fibers had separate

classifications. Given the difference in raw materials, it is important for industrial analysis to be able to separate the two groups. However, in the ASM and CM under the NAICS classification it is not immediately possible.

I used information in the product trailer records to create a consistent series of cotton and of MMF textiles producers for the most recent years in the sample. The data for the years 2000 and 2001 (when only NAICS is used) are brought into consistency with those of prior years (when the SIC distinction between cotton and MMF textiles was used). Further, the methodology was checked by calculating this breakdown in the period 1997-1999 and comparing with the plants' own reported SIC code. The method shows a near-identical assignment of the plants to cotton and MMF categories.

#### **IV. Estimation of the downsizing/closure model.**

I estimate the model represented by equations (8) through (21) using data for large US textile plants drawn from the ASM and CM. Plants with "administrative record" responses are excluded. Plants are matched across years by permanent plant number (PPN) to create a panel of data.

The data are separated into two groups by the dominant SIC code reported by each plant. SIC 2211 is the category for cotton broadwoven fabrics. SIC 2221 is the category for broadwoven MMF fabrics. The number of plants with cotton products is somewhat less than that with MMF products, but there are sufficient numbers of each to allow panel estimation. I use data from the years 1983-2001 for a total of 19 years of data. I retain the demand specification used in the theoretical derivation above, and use the Cobb-Douglas model of productive technology.<sup>22</sup> Four inputs are considered in

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<sup>22</sup> Estimation results for SIC 2211 using the translog specification are reported in Table A1 and are presented in detail in Conway (2006).

production: capital, labor, electricity and materials. Parameter restrictions to impose constant returns to scale are imposed in all versions of the model, as are first-order conditions for labor, electricity and materials. The foreign price  $P_{ft}$  is represented by the average unit value of imports in that SIC classification.<sup>23</sup>

Table 1 reports the results for the plants producing broadwoven cotton fabric (SIC 2211). The first two columns report estimation of the equation system (7)-(10) under the simple assumption that capital is exogenous to the decision – in other words, ignoring the bias due to unobserved productivity. The first column conducts that estimation with no fixed effect terms  $z_i$ , while the second column includes  $z_i$  as components of the production technology. In both cases, the corresponding first-order conditions are imposed. The third column reports the coefficient estimates when unobserved productivity is accounted for as in equations (8)-(10) and (15)-(21). The standard errors of the two-step estimation procedure reported in the last column are derived through bootstrapping using 100 draws on the errors.<sup>24</sup>

There are three important features of the production technology and market characteristics of SIC 2211.

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<sup>23</sup> The unit value of imports is calculated inclusive of tariff and transport costs. This is the appropriate indicator of foreign-good price, despite the complex system of quotas put in place during this period by the Multi-Fiber Arrangement (until 1995) and the Agreement on Clothing and Textiles (from 1995 on). This was a system of bilateral quotas, and was never binding in aggregate – there were always potential supplier countries with unexhausted quota (or exporting countries with no quota at all). For equal quality, then, theory would suggest that the importer would purchase first from the lowest-cost (quality adjusted) exporter, and when the quota became binding on that country to purchase from the next lowest. As this continues ad seriatum the rising unit value of imports will reflect the diversion of trade to higher- and higher-cost countries. The average unit value will be an average, rather than marginal, measure. However, it will rise as quotas become binding and purchasers buy from higher-cost unconstrained suppliers.

<sup>24</sup> The bootstrapping procedure is as follows. First, the two-step estimation procedure is completed, and the parameter estimates derived. These estimates are then employed with actual explanatory variables to obtain predicted values for each observation. Actual minus predicted yields the errors. A bootstrapping sample is created by drawing at random (with replacement) from the pool of errors and then adding that random error to the predicted values. The resulting series of the dependent variable is used to re-estimate the two-step procedure. After 100 samples are drawn and re-estimated, the estimated distribution of the coefficients is used to derive the standard errors in the table.

- There are jointly significant plant-specific effects evident in the data. The likelihood-ratio test of joint significance is reported at the bottom of Table 1, and its coefficient (1123.36) indicates rejection of the null of an insignificant contribution to explanation of differences in real revenue across firms.
- When plant-specific effects are included, the estimate of the elasticity of substitution across suppliers is relatively high (from 7.34 to 10.68) and is significantly different from zero. This indicator of an elastic market implies that small reductions in the relative price of foreign goods to domestic goods will cause large shifts in market share toward the foreign producers.
- The technological coefficients take reasonable values for the most part. The share coefficient for intermediate inputs is just over half in all formulations. The coefficients for labor and energy are stable across specifications and take on reasonable values. The coefficient on capital varies slightly from first to second specification, but is quite different (and smaller) when estimated using the Pavcnik two-step approach. This differs from the evidence in Pavcnik (2002), where the coefficient on capital was larger once the correction was undertaken.

Table 2 reports comparable estimation results for plants producing in SIC 2221. The three features noted in estimation of SIC 2211 are evident here as well. Once again, the coefficient estimates (with the exception of capital) are quite stable across specifications. The results of the likelihood-ratio test indicate that the existence of plant-specific differences in productivity cannot be rejected. Once again, the capital coefficient is less when estimated through the two-step approach. And, most importantly, the

elasticity of substitution between domestic and foreign goods in consumption is both large and precisely estimated (with coefficients of 8.98 and 9.15 in the two specifications with plant-specific effects).

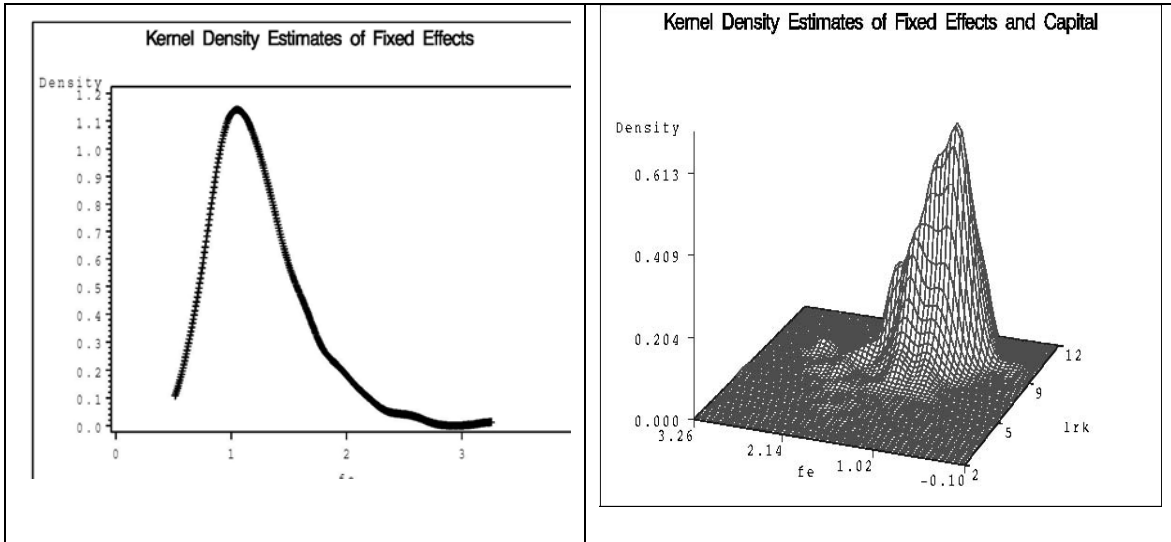


Figure 2a: Kernel-density estimate of distribution of plant effects in SIC 2211

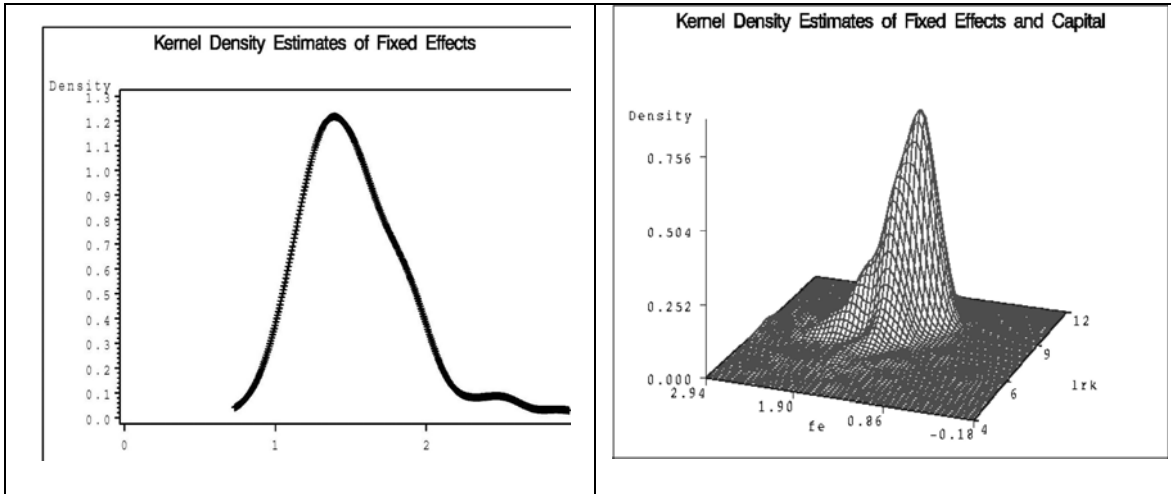


Figure 2b: Kernel-density estimate of distribution of plant effects in SIC 2221

**Features of plant-specific effects.**

There are two components of plant-specific productivity. The first is the time-varying  $\pi_{it}$ , and that will be discussed in detail below. The second is the plant-specific

but time-invariant effect  $z_i$ . The estimated distribution of  $z_i$  in production of SIC 2211 is illustrated in two ways in Figure 2a. In the left panel the univariate distribution takes a unimodal form. There is somewhat more variation in observations above the mode, with a fat tail of plants with specific effects well above the mode. In the right panel the bivariate distribution of fixed effects and plant-level capital stock is plotted. The univariate distribution is evident, but there is also a skewing of the distribution toward larger specific effects when installed capital is lower. Figure 2b illustrates the distribution of specific effects in SIC 2221 in univariate and bivariate form as well, and is characterized by the same unimodal form and skewing of larger plant-specific effects toward the plants with smaller installed capital stocks. The plants under consideration are thus characterized by similar, though not identical, time-invariant productivity (or possibly quality), with a small number of smaller plants indicating higher-productivity outcomes.

### **The investment decision.**

The investment decision is a function of unobserved plant-specific productivity, and as such should be estimated simultaneously with that measure. When (8)-(10) and (15)-(21) are estimated, the capital-related coefficients of the third columns of Tables 1 and 2 are the outcome. So also is a behavioral equation for investment. The results of this estimation are reported in Table 3 for the two product categories. Investment is rising with the capital stock of the plant, and also with the lagged investment decision: both of these effects are significant. Unobserved productivity has the expected positive and significant correlation with investment, as the more productive a plant the higher the return on investment. The capacity utilization rates in the apparel and textiles industries

enter significantly, although for textiles it enters with the opposite sign to that expected, in SIC 2211. For SIC 2221, increased capacity utilization leads to increased investment as predicted, but the measured effect is small and insignificantly different from zero.

**Estimation of entry and exit decisions.**

The preceding estimation results were based on self-reported sampling: if the plant reported that its primary product was from SIC 2211 in that year, it was used in estimation for the SIC 2211 model in that year. However, it is not difficult for the typical plant to shift from SIC 2211 to SIC 2221 products and back again. Determining the appropriate measures of exit and entry into this market is as a result complicated by the possibility of switching production to the other product category. I investigate this as a two-stage decision. The first stage of the decision has to do with entry and exit from the textiles sector generally. The second stage has to do with the choice of product category from among those in the textiles sector. For the purposes of this analysis the textiles sector is divided into three categories: SIC 2211, SIC 2221, and other. There is some evidence of switching among sectors, but little systematic effect: these data are described and analyzed in Appendix B.

Table 4 reports the observed entry and exit in the resulting sample of textiles-sector plants. If this were a complete panel, the evolution of plant/year observations over time would coincide with the exit and entry of plants from the sample. For example, the number of plant/year observations in 1983 would be 415 (the number in 1982) minus 16 (the exits observed in 1982). In fact, the number at 374 is substantially less due to missing records for some PPN. By the end of the sample, however, the figures balance

out: the difference between the original number of plants and the 2001 number of plants is equal to total exits minus total entries.

The historical record shows that the rate of exit has exceeded the rate of entry for 15 of the 18 years observed. In seven of these years the number of exiting plants was at least double the rate of entering plants. Rates of exit and entry increased in the last half of the 1990s; while more plants were leaving the market there were also more plants entering the market.

Systematic reasons for exit are derived from estimation of the propensity to exit, with results reported in Table 5. The exit propensity is modeled as a function of year-specific and US state-specific dummy variables to capture unobserved time or place-specific influences. Of the remaining variation in propensity to exit, the increases in the deviation between foreign and domestic final-good prices in SIC 2221 enters significantly and with the expected sign, while the deviation between foreign and domestic final-good prices in SIC 2211 enters significantly, but with the wrong sign. The “real” wage enters with the expected positive sign, but insignificantly. The real materials and energy prices have negative coefficients, with the materials coefficient significantly different from zero. Also insignificant are the effects of the size of capital and investment, both in logarithms and logarithms squared.<sup>25</sup>

It is impossible to identify a similar propensity to enter, as the universe of potential entrants is not observed. Instead, treating all potential entrants as identical, I estimate Poisson count regressions to explain the number of entering plants observed in each year. The results from this estimation are reported in Table 6. A higher relative

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<sup>25</sup> The predicted propensity to exit from this estimation is used in the inverse Mills ratio correction in Tables 3 and 4.

price of either category of foreign goods encourages entry, although neither coefficient is significantly different from zero. The larger average size of plants (as measured by average real revenues) increases the number of entrants, though also insignificantly. Surprisingly, the real prices of labor and energy also enter with positive coefficient; this is inconsistent with the “ceteris paribus” predictions of profit-maximization, but could be due to the churning effect (high exit leading to high entry) of these relative prices. The increase in the relative price of intermediate inputs has the expected negative effect on entry, and is the sole significant coefficient in the regression.

## **V. Simulation results.**

The model estimated above allows simulations of downsizing, layoff and closure behavior as a response to import-competition and technological shocks. For each production simulation, I use the estimates of Table 1, column 3, to represent the technology. For the elasticity of substitution between imports and domestic goods I use the value of 7.34 reported in Table 1.

The first simulation illustrates the cause of one fascinating feature of the historical textile market: in the period before 1997, the US price of textiles was rising more slowly than the price of imported textiles. (It was also rising significantly more slowly than the US producer price index.) Technological improvements were significant in textiles production prior to 1997, and estimates indicate an 11 percent annual increase in total factor productivity on average even after controlling for survival bias.<sup>26</sup> Technological improvements were a spur to plant entry. As total factor productivity of entering plants rose, there was increased net entry at each  $P_D$ . However, technological improvement also worked through competition to reduce market-equilibrium  $P_D$  (or equivalently, to induce

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<sup>26</sup> This result is derived in Conway (2006) and reported in Table A1 using the same data sample.

net exit at any  $P_D$ ). Figure 3 illustrates the net impact of technology growth: while the impact on net entry is ambiguous, there is an unambiguous reduction in  $P_D$  relative to  $P_F$ . While the system of quotas restrained the competitive impact of foreign producers, nothing stood in the way of competition among US producers.

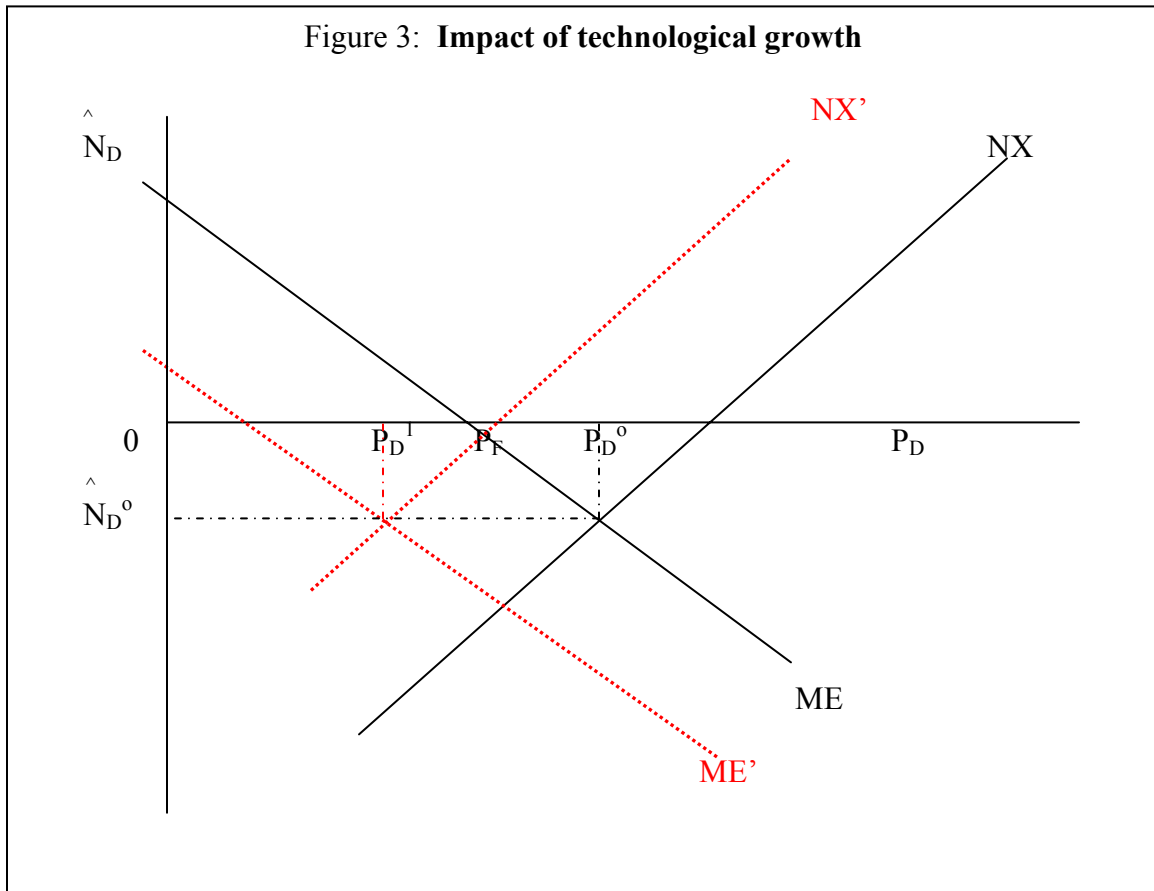


Table 7 reports the results of simulations to measure the impact of technological progress. Introduction of technological progress at a positive rate induces both net entry for given  $P_D$  and a reduction in domestic price  $P_D$  through the general-equilibrium impact of increased supply. The top panel of Table 7 illustrates the impact on  $P_D$  in the absence of a shift in net entry, and thus illustrates the rightward shift in ME for given  $N_D$ . For example, an annual rate of technological growth of 12 percent triggers an annual

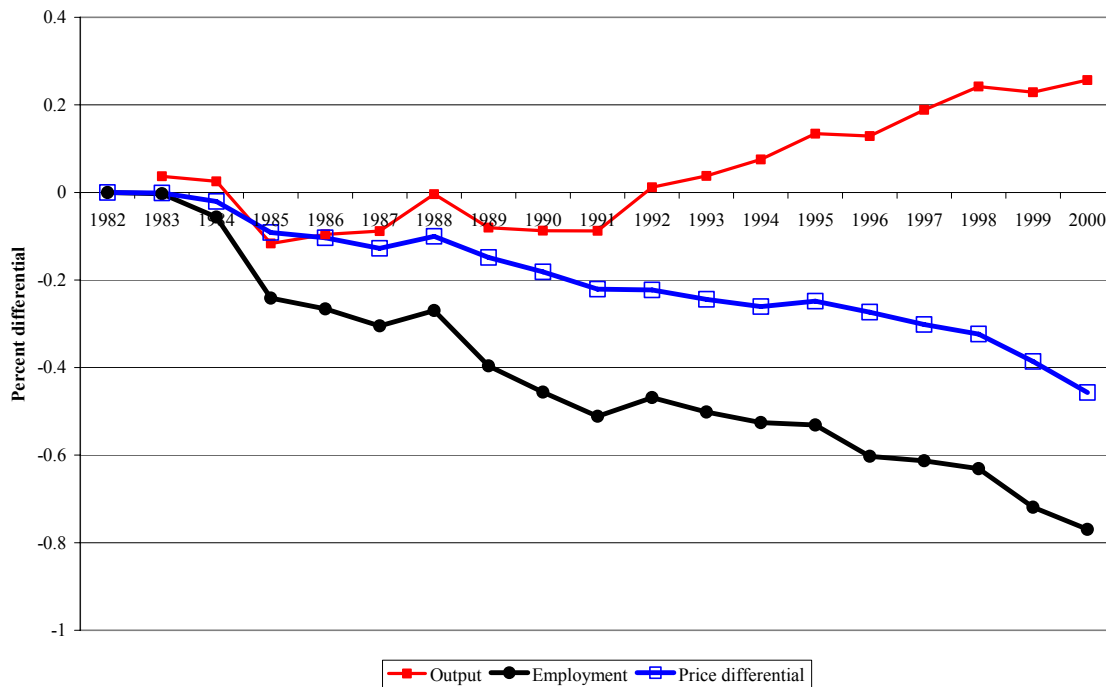
reduction in  $P_D$  of 3.17 percent, output growth of 6.6 percent per annum and layoffs of 6.4 percent of the labor force per annum. The complete effect of this technological progress, though, must incorporate the impact on net entry. Technological progress also triggers net entry of plants into the market. With technological progress of 12 percent, the estimated model predicts an annual net entry rate of 9.8 percent (i.e., an upward shift of  $NX$ ) and this depresses further the equilibrium  $P_D$  to a reduction of 5.62 percent annually. There is less rapid output growth of 2.16 percent per annum, but a reinforced rate of layoffs of 11.6 percent annually. (The fall in  $P_D$  leads, for given wage, to an increase in the real wage and a substitution away from labor in production.)

The simulation suggests, in sum, that technological progress will not lead to downsizing: the measure of output per plant is actually increasing. Net closure is ambiguously affected: while productivity increases led to increased net entry, falling  $P_D$  led to increased exit. Layoffs will be increased. The increased productivity implies that fewer workers are needed to meet the same demand, and this translates into an equilibrium fall in  $P_D$  and rising real wage to induce layoffs. This illustration of market dynamics is similar to the Schumpeter (1975) concept of “creative destruction”, with the destructive effect working through exit induced by the fall in domestic prices and the creative effect through entry induced by higher expected productivity.

This effect is quite evident in the record of prices, output and employment since 1982. Figure 4 illustrates the differential between two simulations: the model using the actual  $P_{Dt}$ , and the model using  $P_{Dt}$  tracking the consumer price index over the same period. The price differential indicates the percent difference between the domestic price index for SIC 2211 and the consumer price index, with the negative percent differential

indicating the degree to which the SIC 2211 price rises less rapidly than the CPI. The output differential indicates the relatively more rapid growth with technological progress. The employment differential tracks the percent reduction in employment attributed to observing the textile price index  $P_{Dt}$  rather than a higher price consistent with the consumer price index. These simulations do not incorporate any shocks due to import competition. The lower  $P_{Dt}$  in this case is due solely to the increased competition due to technological progress at a rate greater than the growth rate in demand for the product, and layoffs are an implied outcome at plants continuously in operation.

Figure 4: Impact of textile price compression



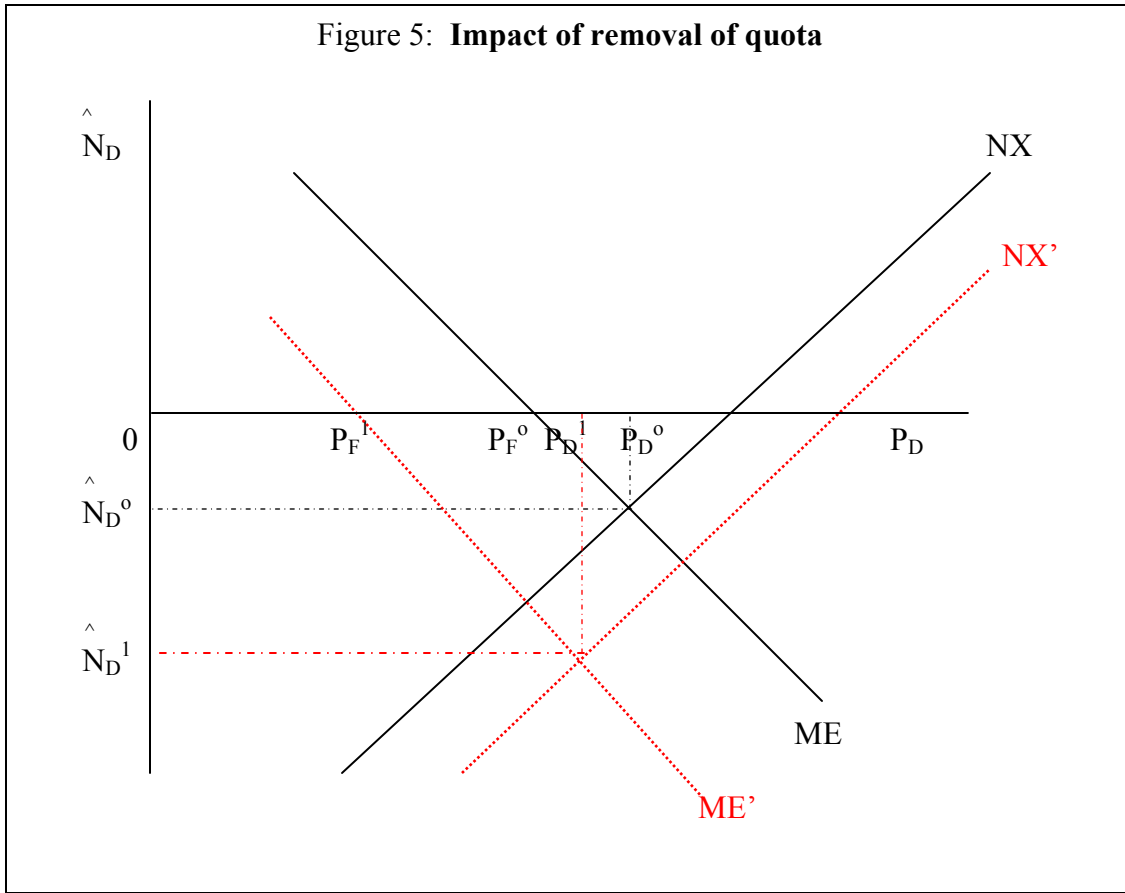
The second set of simulations combines the plant-level model with equilibrium in the textiles market to derive the impact of a reduction in foreign import prices by 20 percent. Figure 5 illustrates the impact of this foreign import price reduction on the ME and NX

curves: both will shift downward in this instance. The 20-percent reduction is taken from the literature as the maximum reduction to be expected in the aftermath of removal of textile quotas.<sup>27</sup> For less extreme cases, I also consider the impact of 5-percent, 10-percent and 15-percent reductions. Table 8 reports the results of these simulations.

The first panel of Table 8 reports the results of simulations with net entry held constant at zero. These are thus the results consistent with the shift in ME curve in Figure 5. Consider the results with a 20 percent reduction in  $P_F$ : this will induce a reduction of 7 percent in  $P_D$ , as well as reductions in plant output (downsizing) and plant real sales revenue of 27 percent and reductions in employment (layoffs) of 31.7 percent. The second panel of the table reports the results when net entry is held constant at its historical average of -5.2 percent per annum. With plants exiting on net there is less pressure for US plants to lower their prices in response to the fall in  $P_F$ . With the 20-percent reduction, for example,  $P_D$  falls by only 5.6 percent while the share of US goods in the market falls to 50 percent (as opposed to 53.2 percent in the first simulation). Output and employment fall by comparable magnitudes to those in the first simulation.

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<sup>27</sup> Francois and Spinager (2005, Table 16F3) derive “export tax equivalents” that correspond to the impact of the quota on the sale price of the exporting country. They estimate that the increases in import prices into the US from China and Vietnam in 2001 due to the quota were 20.8 and 20.6 percent respectively; these were the largest export tax equivalents derived. For the 20-percent simulation to be relevant, China and Vietnam would have to be able to expand exports to the US at the same sales price to meet all demand. If demand remains for other countries’ products, as is likely, the impact of quota removal on import price will likely be less than 20 percent.



The bottom panel of Table 8 provides an illustration of the equilibrium in Figure 5 with endogenous net entry. The NX curve of Figure 5 is derived from the estimated values reported in Tables 5 and 6, and the system of equations defining plant-level equilibrium and net entry are solved simultaneously to find the equilibrium change in  $P_D$  and net entry of US plants. With a 20-percent reduction in  $P_F$  the reduction in  $P_D$  (to  $P_D^1$ ) is 3.6 percent, less than in the previous simulations. The reason is evident in the third column: the percent of US plants exiting after the reduction in  $P_F$  rises to 12.1 percent per annum.

Those plants remaining in operation choose downsizing of 28.2 percent and layoffs of 32.6 percent. This is a flow equilibrium of downsizing, layoffs and closure,

implying that 12 percent of plants will exit in each year.<sup>28</sup> In sum, this approach yields the same results as found in Bernard, Jensen and Schott (2006) for each of these phenomena, while being based upon the microfoundations of an intertemporal profit-maximization model.

The preceding simulations are based upon aggregate conditions of market equilibrium. The entry, exit and investment decisions of the individual plants can also be simulated simultaneously through use of the estimated investment, entry and exit equations of Tables 3, 5 and 6 in conjunction with the estimated distribution of the unobserved productivity variable  $\pi_{it}$ .

The first three columns of Table 9 illustrate the evolution of average investment, capital and unobserved productivity under the quota regime.<sup>29</sup> In the baseline simulation, the average productivity  $\pi_t$  for plants in operation only 1 year aggregates all those entering in the first year of the simulation and not yet making the exit decision. It is thus markedly lower than in subsequent years, when poor-performing plants choose to exit. The number in “plants surviving” should be compared to the number (nine) entering in each year. The quantity of capital and the average investment rise with the number of years in operation, as predicted by Hopenhayn (1992), Melitz (2003) and others, due to

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<sup>28</sup> It is also possible to hypothesize that the reduction in  $P_F$  will have its own impact on the net entry behavior of the firm. This downward shift in the net entry curve will support an equilibrium with smaller reductions in  $P_D$  and more rapid net exit by US plants from the market. This can be derived from Tables 7 and 8, with implied net exit of 18 percent per year and a reduction in  $P_D$  of 1.7 percent. These results are available on demand, but they appear to imply too strong an exit response; in future research I will investigate the sensitivity of this response to other specifications of the exit and entry estimation equation.

<sup>29</sup> This simulation is based upon the investment equation for SIC 2211 of Table 5, on the exit equation of Table 7 and the entry equation of Table 8. Unobserved productivity is modeled as in (15), with  $\zeta_{it}$  distributed  $N(0, 0.5)$ . The unobserved productivity to trigger exit is  $\pi_{it}^0 = .15$ . The  $\zeta_{it}$  is drawn randomly from the distribution and is used to update  $\pi_{it}$ . This  $\pi_{it}$  is used in the investment equation, and is compared to  $\pi_{it}^0$  to determine whether the plant chooses to exit or not. The entry condition is independent of  $\pi_{it}$  since the plant does not observe its productivity before deciding to enter. The expected values of productivity, capital and investment for entering plants were 0.8, 37000 and 4000, respectively. Plants cannot exit until their second year.

the upward ongoing selection bias – although, given the small number of plants in total, the rise is not monotonic. At the end of a 10-year simulation, the number of plants falls from the initial 101 plants to a total of 85. Of these, 56 plants continued from the beginning through the entire 10-year period, while 29 of the 90 who entered during the 10-year period managed to stay in operation.

The last three columns of Table 9 illustrate a similar situation with the removal of the quota system.<sup>30</sup> The number of plants surviving the 10-year period falls to 35, with only 17 of the initial 101 plants remaining in continuous operation. Of the nine entering in each period, at most one or two survive to the end of the simulation. Those that survive are more productive, as is evident in the average productivity, investment and capital, but they are few in number.

## **VI. Conclusions and extensions.**

Examination of the experiences of textiles plants in the US provides an important window on the phenomena of downsizing, layoffs and closure. Two determinants of these phenomena are advanced – technological progress and import competition – and the differing implications of the two are laid out through estimation and simulation.

Downsizing, defined as the reduction in production at an operating plant, is most strongly observed in response to foreign import price increases. Layoffs are most strongly associated with domestic technological progress. Increases in total factor productivity lead to reductions in employment through the channel of falling domestic prices of textiles. While layoffs are also observed in response to increased import

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<sup>30</sup> This simulation takes the values of the previous simulation, but due to the falling equilibrium price  $P_{Dt}$  the  $\pi_{it}^0$  that triggers exit rises from 0.15 to 1.10.

competition (as for example the removal of quotas), that effect is muted by the relatively smaller impact on domestic final-good prices of import competition.

Closure, the cessation of production activity at a plant, is a phenomenon more closely associated with import competition. Increased import competition discourages plant operators; they examine their future profit prospects, and conclude that it is time to quit. Technological progress does not have that same effect; the increased productivity taken alone discourages exit and encourages entry.

The textiles industry has been an excellent laboratory for the measurement of these two effects. Estimation of the micro-founded plant-level production model indicates the importance of both technological progress and falling import prices to the production decision. Estimation of plant-level exit, entry and investment decision rules reinforces the importance of these two factors in considering market dynamics as well. The simulations reported highlight the differing effects in the US economy of technological progress and import competition on the downsizing and closure phenomena.

There are two important contributions of this research. The first is the detailed and precise description of plant-level behavior in this industry in the face of international competition. The second is market equilibrium analysis that endogenizes the domestic price. Conway and Connolly (2004) reports price reduction as a pervasive response from textiles executives surveyed on their strategies for dealing with import competition during the quota years. This also provides a testable hypothesis for evaluating the model as data become available in the post-quota years.

I have chosen to focus almost exclusively on producer decisions in this analysis, and the impacts of import competition on downsizing and closure are portrayed (at least in connotation) in negative terms. These effects should not obscure the overarching fact that consumers at home and abroad are benefiting from these lower prices. The negative effect on domestic output and employment should be evaluated in that context.

**Table 1: Estimation of Production Technology and Market Parameters for SIC 2211 under the Cobb-Douglas restriction**

SIC category	2211		2211		2211	
	1983-2001		1983-2001		1983-2001	
	$r_{it} - p_{Dt}$		$r_{it} - p_{Dt}$		$r_{it} - p_{Dt}$	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
$a_o$	<b>1.51</b>	0.025				
$a_k$	<b>0.22</b>	0.003	<b>0.19</b>	0.007	0.07	0.036
$a_l$	<b>0.22</b>	0.036	<b>0.23</b>	0.003	<b>0.24</b>	0.077
$a_e$	<b>0.04</b>	0.001	<b>0.04</b>	0.001	<b>0.04</b>	0.013
$a_m$	<b>0.52</b>		<b>0.52</b>		<b>0.56</b>	0.182
$\mu$	336.69	162.2	<b>502.44</b>	145.9	161.35	380.0
$\sigma$	<b>36.09</b>	8.380	<b>10.68</b>	0.760	<b>7.34</b>	0.420
N	1402		1402		1259	
$\chi^2$ test of plant-effect terms			<b>1123.36</b>			
critical $\chi^2(185) = 217.73$						
Number of plants: 186						

Coefficients significantly different from zero at the 95 percent level of confidence are presented in boldface. The first column is without fixed-effect terms while the second and third columns include plant-specific effects; those coefficients are not included in the table. The third column uses the Pavcnik two-stage estimation technique and does not impose constant-returns-to-scale conditions. The standard errors of the third column are obtained by bootstrapping.

**Table 2: Estimation of Production Technology and Market Parameters for SIC 2221 under the Cobb-Douglas restriction**

SIC category	2221		2221		2221	
	1983-2001		1983-2001		1983-2001	
	$\Gamma_{it} - p_{Dt}$		$\Gamma_{it} - p_{Dt}$		$\Gamma_{it} - p_{Dt}$	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
$a_o$	<b>1.20</b>	0.021				
$a_k$	<b>0.32</b>	0.004	<b>0.30</b>	0.005	0.09	0.114
$a_l$	<b>0.18</b>	0.002	<b>0.19</b>	0.002	<b>0.19</b>	0.085
$a_e$	<b>0.03</b>	0.0004	<b>0.03</b>	0.0004	<b>0.03</b>	0.013
$a_m$	<b>0.47</b>		<b>0.48</b>		<b>0.47</b>	0.212
$\mu$	<b>250.81</b>	135.1	<b>448.9</b>	115.4	712.9	458.1
$\sigma$	<b>21.05</b>	2.35	<b>8.98</b>	0.453	<b>9.15</b>	0.594
N	2866		2866		2591	
$\chi^2$ test of plant- effect terms			<b>3127.1</b>			
critical $\chi^2(291) = 331.79$						
Number of plants: 292						

Coefficients significantly different from zero at the 95 percent level of confidence are presented in boldface. The first column is without fixed-effect terms while the second and third columns include plant-specific effects; those coefficients are not included in the table. The third column uses the Pavcnik two-stage estimation technique and does not impose constant-returns-to-scale conditions. The standard errors of the third column are obtained by bootstrapping.

Table 3: Investment in the Textiles Sector, 1983-2001

	SIC 2211	SIC 2221
Intercept	-1.77	0.30
	(0.42)	(0.32)
$k_{t-1}$	<b>0.38</b>	<b>0.24</b>
	(0.01)	(0.02)
$\dot{i}_{t-1}$	<b>0.38</b>	<b>0.48</b>
	(0.03)	(0.007)
$up_{it}$	<b>0.42</b>	<b>0.14</b>
	(0.06)	(0.04)
$cu_{a_t}$	<b>0.04</b>	0.001
	(0.005)	(0.003)
$cu_{t_t}$	<b>-0.04</b>	0.004
	(0.005)	(0.003)
N	1238	2546

Bootstrapped standard errors in parentheses. These coefficients were estimated jointly with those of the second step of the two-step estimation process used in the third columns of Tables 3 and 4:  $up_{it}$  is the same unobserved variable in both equations.

**Table 4: Dynamics of Textiles Plant Sample**

<b>Year</b>	<b>Plant observations</b>	<b>Exit</b>	<b>Entry</b>
1982	415	16	
1983	374	20	7
1984	345	11	3
1985	347	27	6
1986	342	17	12
1987	356	5	7
1988	334	17	3
1989	319	2	13
1990	328	19	11
1991	323	13	12
1992	346	9	8
1993	321	13	7
1994	290	3	2
1995	297	9	7
1996	308	15	20
1997	341	37	7
1998	305	74	20
1999	265	21	15
2000	249	132	2
2001	117		
Total Exits		460	
Total Entries			162

Source: LRD, US Census, and author's calculations

Table 5: **Plant propensity to exit**

	Coefficient	Standard Error
Intercept	-0.54	1.65
$(p_{ft} - p_{dt})_{11}$	<b>2.39</b>	0.84
$(p_{ft} - p_{dt})_{21}$	<b>-1.62</b>	0.40
$(p_{mt} - p_{dt})$	<b>-5.79</b>	2.94
$(v_{it} - p_{dt})$	-0.14	0.18
$(w_{it} - p_{dt})$	0.15	0.21
$k_{it}$	0.21	0.33
$i_{it}$	-0.16	0.14
$k_{it}^2$	-0.03	0.02
$i_{it}^2$	0.01	0.01
n	4268	

Probit estimation. Coefficients in bold are significantly different from zero at the 95 percent level of confidence. Each probit regression also included a complete set of time and state-of-origin dummy variables.

Table 6: **Poisson regression of propensity to enter.**

	Coefficient	Standard Error
Intercept	-6.74	24.22
$(p_{ft} - p_{dt})_{11}$	1.88	3.57
$(p_{ft} - p_{dt})_{21}$	3.52	1.94
$(p_{mt} - p_{dt})$	<b>-14.26</b>	6.56
$(v_{it} - p_{dt})$	6.57	3.64
$(w_{it} - p_{dt})$	2.69	3.19
$(r_{it} - p_{dt})$	1.78	1.80
n	19	

Poisson count regression. Coefficients in bold are significantly different from zero at the 95 percent level of confidence.

Table 7: **Impact of technological progress**

			Annual growth in		
	$\tau$	Net entry	$P_D$	output	labor
First case: no net entry					
	0.04	0	-1.09	2.18	-2.16
	0.08	0	-2.12	4.43	-4.24
	0.12	0	-3.17	6.59	-6.41
	0.16	0	-4.22	8.70	-8.62
Second case: endogenous net entry					
	0.04	3.3	-1.94	0.73	-3.88
	0.08	6.7	-3.83	1.40	-7.80
	0.12	9.8	-5.62	2.16	-11.6
	0.16	12.9	-7.39	2.90	-15.39

Source: author's calculation

In the second case, the endogenous net entry rate refers to the increase observed in aggregated plant behavior (i.e., in the upward shift of the NX curve) rather than in general equilibrium.

Table 8: Simulation results – plants continuously in operation

<b>Short run: No closure of plants</b>						
	Percent	Post-shock	Growth rates in			
	change	$\chi$	Q	(R/P <sub>D</sub> )	(P <sub>i</sub> /P <sub>D</sub> )	L
P <sub>D</sub>	-1.5	0.726	-5.5	-5.3	-0.5	-6.6
P <sub>F</sub>	-5.0					
P <sub>D</sub>	-3.6	0.668	-12.0	-11.7	-1.3	-14.1
P <sub>F</sub>	-10.0					
P <sub>D</sub>	-5.0	0.602	-19.4	-19.0	-2.4	-22.6
P <sub>F</sub>	-15.0					
P <sub>D</sub>	-7.0	0.532	-27.4	-27.1	-3.8	-31.7
P <sub>F</sub>	-20.0					
<b>Short run: with net exit of plants at historical average (5.21 percent net exit)</b>						
P <sub>D</sub>	-0.9	0.70	-3.9	-4.2	-0.9	-4.6
P <sub>F</sub>	-5.0					
P <sub>D</sub>	-1.7	0.64	-11.0	-11.2	-1.8	-13.0
P <sub>F</sub>	-10.0					
P <sub>D</sub>	-3.6	0.58	-19.0	-19.2	-3.1	-22.2
P <sub>F</sub>	-15.0					
P <sub>D</sub>	-5.6	0.50	-27.6	-27.8	-4.6	-32.0
P <sub>F</sub>	-20.0					
<b>Intermediate run: endogenous net exit of plants</b>						
	Percent	Net exit	Growth rates per surviving plant			
	change	percent p.a.	Q	(R/P <sub>D</sub> )	(P <sub>i</sub> /P <sub>D</sub> )	L
P <sub>D</sub>	-0.035	5.4	-3.8	-4.2	-0.9	-4.5
P <sub>F</sub>	-5.0					
P <sub>D</sub>	-1.2	7.3	-10.6	-11.1	-2.1	-12.5
P <sub>F</sub>	-10.0					
P <sub>D</sub>	-2.7	9.6	-18.9	-19.6	-3.7	-22.0
P <sub>F</sub>	-15.0					
P <sub>D</sub>	-3.6	12.1	-28.2	-29.2	-5.9	-32.6
P <sub>F</sub>	-20.0					

Source: author's calculations

Table 9: Simulating investment and net entry

Years in operation	Baseline simulation				Impact of quota removal			
	$\pi_t$	$I_t$	$K_t$	Plants surviving	$\pi_t$	$I_t$	$K_t$	Plants surviving
1	0.12	4402	37000	9	0.12	4402	37000	9
2	1.10	4152	37723	5	1.59	4845	37723	2
3	1.08	4155	38260	2	1.64	5326	38731	1
4	1.62	6074	39589	3	2.15	7794	40697	2
5	0.79	3142	38231	3				
6	2.07	8598	47081	1	2.07	8598	47081	1
7	2.00	8577	46297	2	2.00	8577	46297	2
8	0.78	2798	37673	2				
9	1.67	6849	45673	2	2.04	9854	53473	1
10+	1.63	8487	55832	56	2.19	15184	76900	17
Total				85				35
Initial number of plants				101				

Source: author's calculations

The initial number of plants in the simulation was chosen to match the actual data in SIC 2211.

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**Appendix A: Estimating equations for the translog production technology.****I. Excluding time trend**

$$\begin{aligned}
\ln(Q_{it}) = & a_0 + a_k \ln K_{it} + a_l \ln L_{it} + a_e \ln E_{it} + a_m \ln M_{it} \\
& + a_5 \ln K_{it} \ln K_{it} + a_6 \ln L_{it} \ln L_{it} + a_7 \ln E_{it} \ln E_{it} + a_8 \ln M_{it} \ln M_{it} \\
& + b_1 \ln K_{it} \ln L_{it} + b_2 \ln K_{it} \ln E_{it} + b_3 \ln K_{it} \ln M_{it} + b_4 \ln L_{it} \ln E_{it} \\
& + b_5 \ln L_{it} \ln M_{it} + b_6 \ln E_{it} \ln M_{it} \tag{A1}
\end{aligned}$$

Sufficient conditions for constant-returns-to-scale:

$$\begin{aligned}
1 &= a_k + a_l + a_e + a_m \\
-2 a_6 &= b_1 + b_4 + b_5 \\
-2 a_5 &= b_1 + b_2 + b_3 \\
-2 a_7 &= b_2 + b_4 + b_6 \\
-2 a_8 &= b_3 + b_5 + b_6
\end{aligned}$$

First-order conditions:

$$a_l + 2a_6 \ln L_{it} + b_1 \ln K_{it} + b_4 \ln E_{it} + b_5 \ln M_{it} = W_{it}L_{it}/P_{it}Q_{it} \tag{A2}$$

$$a_e + 2a_7 \ln E_{it} + b_2 \ln K_{it} + b_4 \ln L_{it} + b_6 \ln M_{it} = V_{it}E_{it}/P_{it}Q_{it} \tag{A3}$$

$$a_m + 2a_8 \ln M_{it} + b_3 \ln K_{it} + b_5 \ln L_{it} + b_6 \ln E_{it} = P_{mit}M_{it}/P_{it}Q_{it} \tag{A4}$$

**II. Inclusion of time trend:**

$$\begin{aligned}
\ln(Q_{it}) = & a_0 + a_k \ln K_{it} + a_l \ln L_{it} + a_e \ln E_{it} + a_m \ln M_{it} + a_9 t + a_{10} t^2 \\
& + a_5 \ln K_{it} \ln K_{it} + a_6 \ln L_{it} \ln L_{it} + a_7 \ln E_{it} \ln E_{it} + a_8 \ln M_{it} \ln M_{it} \\
& + a_{10} t^2 + b_1 \ln K_{it} \ln L_{it} + b_2 \ln K_{it} \ln E_{it} + b_3 \ln K_{it} \ln M_{it} \\
& + b_4 \ln L_{it} \ln E_{it} + b_5 \ln L_{it} \ln M_{it} + b_6 \ln E_{it} \ln M_{it} \\
& + b_7 \ln K_{it} t + b_8 \ln L_{it} t + b_9 \ln E_{it} t + b_{10} \ln M_{it} t \tag{A1'}
\end{aligned}$$

Same constant-returns-to-scale restrictions:

First-order conditions:

$$a_l + 2a_6 \ln L_{it} + b_1 \ln K_{it} + b_4 \ln E_{it} + b_5 \ln M_{it} + b_8 t = W_{it}L_{it}/P_{it}Q_{it} \tag{A2'}$$

$$a_e + 2a_7 \ln E_{it} + b_2 \ln K_{it} + b_4 \ln L_{it} + b_6 \ln M_{it} + b_9 t = V_{it}E_{it}/P_{it}Q_{it} \tag{A3'}$$

$$a_m + 2a_8 \ln M_{it} + b_3 \ln K_{it} + b_5 \ln L_{it} + b_6 \ln E_{it} + b_{10} t = P_{mit}M_{it}/P_{it}Q_{it} \tag{A4'}$$

Table A1: Estimation of Production Technology and Market Parameters using the Translog Specification

	2211		2211	
	1983-2001		1983-2001	
	$\Gamma_{it} - p_{Dt}$		$\Gamma_{it} - p_{Dt}$	
	Coeff	S.E.	Coeff	S.E.
$a_0$	<b>1.57</b>	0.090		
$a_k$	<b>0.24</b>	0.036	<b>0.20</b>	0.012
$a_l$	<b>0.24</b>	0.051	<b>0.58</b>	0.008
$a_e$	<b>0.03</b>	0.010	<b>0.01</b>	0.002
$a_m$	<b>0.49</b>		<b>0.21</b>	
$a_5$				
$a_6$				
$a_7$				
$a_8$				
$a_9$	<b>0.10</b>	0.03	<b>0.13</b>	0.030
$a_{10}$	0.001	0.001	<b>0.001</b>	0.0005
$b_1$	-0.005	0.012	0.001	0.001
$b_2$	0.002	0.002	<b>-0.002</b>	0.0001
$b_3$	0.033	0.024	<b>-0.041</b>	0.004
$b_4$	-0.003	0.003	<b>-0.006</b>	0.0004
$b_5$	0.017	0.021	<b>-0.090</b>	0.001
$b_6$	-0.007	0.004	<b>-0.007</b>	0.0002
$b_7$	<b>-0.015</b>	0.003	<b>-0.014</b>	0.004
$b_8$	<b>-0.006</b>	0.001	<b>0.002</b>	0.0003
$b_9$	<b>-0.0009</b>	0.0002	<b>-0.001</b>	0.0001
$b_{10}$	<b>0.008</b>	0.002	<b>-0.002</b>	0.001
$\mu$	<b>0.323</b>	0.090	<b>0.367</b>	0.076
$\sigma$	144.13	898.0	<b>14.40</b>	1.07
N	1402		1402	
Number of plants in sample: 186				

Coefficients significantly different from zero at the 95 percent level of confidence are presented in boldface. Coefficients  $a_5$  through  $a_8$  have been replaced through constant-returns-to-scale restrictions in the first two columns; see the estimating system in Appendix A for details. The first column is without fixed-effect terms while the second column includes plant-specific effects; those coefficients are not included in the table.

## Appendix B: Data use.

The data used in this study are drawn from the Annual Survey of Manufacturers (ASM) and from the Census of Manufactures (CM). Both are conducted by the US Bureau of the Census, with the CM collected in years ending in “2” and “7”, and the ASM collected in all other years. The years used are 1982-2000 inclusive.

Two datasets are created from these files. For all years, the establishments reporting only administrative records are excluded. For the CM years, only those firms with  $xx=1$  are included to ensure comparability with the ASM years. The first subset is for all firms with  $IND=2211$  (cotton textiles) and the second is for all firms with  $IND=2221$  (man-made-fiber textiles). These correspond to the subsets by SIC codes.

In 2000, the US Bureau of the Census stopped classifying plants by SIC 2211 or SIC 2221. The new NAICS classification combines cotton and man-made broadwovens into a single category (with a few other components as well). In estimation, only those firms continuing from 1999 are used, and they are classified by their 1999 SIC code

Three industry-level price indices were imported from the Bartlesmann/Becker/Gray database:

$$\begin{aligned} p_{mt} &= \text{PIMAT} - \text{materials price index} \\ p_{dt} &= \text{PISHIP} - \text{price index of final goods} \\ p_{It} &= \text{PINV} - \text{price index for investment goods} \end{aligned}$$

There is one of these for each SIC code in each year through 1996. In the subsequent years, the price indices are extended by reference to the series created by Haltiwanger and published to his website.

Variables are derived from the Census data to correspond to the theoretical specification for Appendix A. The theoretical variable is given first in the table below, while the corresponding Census variables are given on the right side of the equality.

$$\begin{aligned} L_{it} &= TE \\ M_{it} &= CM/p_{mt} \\ E_{it} &= PE \\ W_{it} &= SW/TE \\ V_{it} &= EE/PE \\ I_{it} &= TCE/p_{It} \\ Q_{it} &= TVS/p_{dt} \end{aligned}$$

There is one of these for each plant in each year. Time (t) is measured as well:

$$t = \text{Year} - 1980.$$

The variable  $p_{ft}$  is created as an industry-specific unit value of imports in that 4-digit SIC code. It is calculated from the data maintained by Feenstra and Schott on US import value and quantity. There is one of these for each SIC code in each year.

Each establishment is assigned a unique plant number, referred to as “count”. This “count” is used to create a fixed-effect array used in estimation. Also created are variables “contin”, “exit” and “enter”, binary variables indicating whether the plant continues operation, exits in the next period, or enters this period.

The technology specifications use four inputs ( $L_{it}$ ,  $K_{it}$ ,  $E_{it}$ ,  $M_{it}$ ), plant-specific productivity effects and  $t$  as a proxy for the common trend in technology. The associated first-order conditions introduce relative prices  $w_{it}$ ,  $p_{eit}$ ,  $p_{mt}$ . . The impact of foreign price competition in the imperfectly competitive market is modeled by  $(p_{ft} - p_{dt})$ .

### **Defining participating plants, entry and exit.**

There is no simple way to sort the US Census databases to provide a consistent panel of data on textiles firms across time.<sup>31</sup> To create such a panel, I used the following two-step procedure with the data drawn from the ASM and CM for the period 1982-2001.

- In a first step, all plant/year observations not identifying their primary product as either SIC 2211 or SIC 2221 (or its counterpart for 2000 and 2001) in the ASM were excluded. These data were then sorted by PPN, and a list of all PPN observed in the aggregated data was compiled.
- In the second step, I returned to the complete ASM and CM for 1982-2001. I culled the subset of data for plants with these PPN, whether or not they listed SIC 2211 or SIC 2221 as primary product in that year.

This two-step process provided 6322 plant/year observations. The initial search over the ASM alone was designed to exclude smaller manufacturing plants that would be observed only in CM years. The plants retained were expected to respond on an annual basis to the Census, thus creating a panel data set. In practice, there was substantial evidence of non-response.

Entry and exit are then defined as the first appearance and final appearance of the PPN in the sample. In cases in which there are multi-year gaps between observations of the same

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<sup>31</sup> In principle, there is a simple sort possible. The CM/LRD is a large-scale survey of manufacturers occurring every 5 years. The ASM/LRD is a smaller-scale survey of a subset of large manufacturers. The US Census categorizes each plant by a weight: if the weight is one, the plant is certain to be invited to complete the survey each ASM/LRD year. If the weight is less than one, then the weight represents the probability that the plant will be invited to complete the survey in any ASM/LRD year. All manufacturers are invited to complete the survey in CM/LRD years, but for the smallest the survey is abridged. These “administrative record” responses are also excluded from the sample used here by the sorting used here. It is unfortunately the case that many plants in this category nevertheless do not have responses tabulated at the US Census for all years. There are two potential reasons: either the Census reclassified the plant at some point in the period from certain response to probabilistic response, or the plant simply refused to (or forgot to) submit the information in a given year.

PPN, the beginning of the gap is not treated as an exit. Further, entry and exit refer here to entering or leaving the joint textiles category including all plants with at least one year of primary production in SIC 2211 or SIC 2221.

Within the sample of 6322 plant/year observations, there were 5745 instances of observations from the same PPN in consecutive years. These observations were combined in a pseudo-Markov panel to identify the switching by plants among products, and the results are reported in Table A2. Entering and Exiting refer to the same plants summarized in Table 4, although here they are categorized by the primary product reported in their first and last years in the sample, respectively. As is evident in comparing the two tables, plants typically entered the sample producing one of these categories of goods. Exit is less straightforward – while in the 1980s the plants generally exited from these categories of production, in the 1990s exit was more likely to occur from the “other” category (not illustrated here).<sup>32</sup> The percentages of exit and entry in broadwoven cotton cloth are appreciably higher than those for cloth of man-made fiber throughout the sample.

The Switching Out and Switching In categories refer to changes in primary product classification by a given plant from year to year. In the first instance, this switching will be due to the plant’s reporting a change in primary product. However, it is also the case that the US Census discourages year-by-year shifts in these classifications. In cases where the plant has nearly equal production value in its top two product classifications the Census will lock in the primary product classification for a five-year period. The relatively larger switching numbers in the CM years (1987, 1992, 1997) are most likely indications of that periodic reclassification at work.

For both classifications of goods, however, there is evidence of switching at work. The totals for “Switching out” exceed those for “Switching in” for both categories of goods (151 vs. 125, and 232 vs. 137), with the balance for these absorbed by the “other” category.

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<sup>32</sup> A common “other” activity is dyeing and finishing of cloth, and many plants in the sample had this capability. While for most it remained a secondary product, for those facing intense competition in the core business of textile weaving it was attractive to switch the mix of production towards a specialization in dyeing and finishing. Then, if that proved to be unprofitable, the plant exited the sample from that “other” category.

**Table B1: Dynamics of Adjustment in Production of Textiles in the US**

	SIC 2211					SIC 2221					Switching within these categories	
	Continuing in same	Switching out	Switching in	Entering	Exiting	Continuing in same	Switching out	Switching in	Entering	Exiting	From 2211 to 2221	From 2221 to 2211
1982	102				5	251				11		
1983	91	6	1	1	4	241	3	9	6	15	6	1
1984	79	5	7	0	5	222	14	4	2	6	0	7
1985	77	4	5	3	5	221	6	10	3	21	4	5
1986	74	8	6	6	6	211	10	6	5	11	4	5
1987	71	14	30	1	1	171	54	12	4	2	6	26
1988	90	8	8	0	7	169	11	8	2	7	6	6
1989	88	4	0	5	0	162	3	3	6	2	1	0
1990	83	10	5	3	7	168	1	11	5	11	7	1
1991	80	4	9	6	6	163	11	4	5	3	3	5
1992	73	20	17	4	2	159	20	20	3	1	13	12
1993	84	2	2	2	4	172	2	3	2	5	2	2
1994	78	4	5	1	2	152	8	5	1	1	3	4
1995	77	5	2	2	0	157	1	4	4	6	3	1
1996	77	3	6	11	4	153	7	4	3	9	1	5
1997	75	24	13	3	9	151	17	24	4	15	14	8
1998	79	0	2	9	24	152	3	0	11	43	0	1
1999	68	0	0	11	12	129	0	1	4	7	0	0
2000	40	28	6	0	1	68	61	4	2	6	3	5
2001	43	2	1	0	0	68	0	5	0	0	2	0

Source: LRD, US Census, and author's calculations. The omitted category is "all other textiles".