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Trade liberalization in textiles: Policy effects in an import-competing industry

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Abstract

I trace the dynamic impact of removal of textile quotas in the US on output, employment and plant closure in that industry. A dynamic theoretical model of firm-level decision-making is estimated with US Census manufacturing data and with industry-level demand-side data. Simulations performed with the estimated model provide a decomposition of the historical record into parts attributable to import competition, to technological progress, and to a secular real-wage increase. Plant closure and a fall in domestic prices are largely associated with technological progress, while downsizing, layoffs and reduction in domestic market share are associated with trade liberalization. The market-clearing domestic price of textiles is identified as a crucial channel in transmitting technology or import price shocks to layoffs and plant closure.

JEL classification: F12; F13; F14

Keywords: Plant closure; Downsizing; Layoffs; Import competition; Technological progress

1. Introduction

Import penetration and its effect on US firms have become flashpoints of the globalization debate. Three phenomena have become tightly associated with this debate: lower market prices, layoffs and plant closure. As imports have become more important in US markets, and as US firms have closed plants and laid off workers, the causality from import penetration to these phenomena has become accepted wisdom. Trade restrictions have typically been introduced to counter the effects of import competition or to mitigate its effects on workers, based in part on the static reasoning of standard international trade models. While researchers posit that there will be dynamic

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effects of such policy, these effects are not typically derived formally.[1] A dynamic structural model of an import-competing industry is necessary to derive appropriate policy recommendations.

In this paper I provide a dynamic theoretical and empirical economic analysis of trade liberalization in an import-competing industry: textiles production in the US. I use plant-level information from the Annual Survey of Manufactures (ASM) and the Census of Manufactures (CM) of the US Bureau of the Census to estimate a structural model of plant-level production and input use in the US textiles industry. I then combine this information with industry-level behavioral equations for plant entry, exit and the derived demand for textiles to simulate the impacts of trade liberalization in the US textile industry and its downstream users.

Policy choices based on this type of model can decompose three competing causes of dynamic adjustment in the US textiles sector: trade liberalization, technological progress, and real wage growth. The endogenous response of the domestic price of textiles, an effect impossible to separate in a reduced-form model, proves to be key in identifying that difference. Simulation of the estimated model confirms that import competition has less impact in lowering aggregate prices and forcing plant closure than does technological innovation. The major impacts of trade liberalization are in the downsizing of domestic plants and concomitant layoffs of workers.

2. Import competition and underlying technology-wage dynamic of textiles sector

US textiles production is a natural candidate for analysis of the impact of trade liberalization on output, employment, plant closure and downstream welfare. The US has historically supplied the great majority of its needs for textiles, although in recent years imports from other countries have made substantial inroads in the market. The product can be measured in a common unit (square meters), allowing derivation of unit values (or unit value indices) for foreign products. When considering international trade in textiles and the import competition for US producers, the dominant categories are broadwoven cotton textiles and broadwoven textiles of man-made fibers (MMF). These production categories are distinguished historically by their Standard Industrial Classification (SIC) designations: SIC 2211 for broadwoven cotton textiles and SIC 2221 for broadwoven MMF textiles. In the discussion that follows I will present the results for broadwoven cotton (SIC 2211).[2]

2.1. Evidence of import competition

Table 1 indicates the scope of imports of broadwoven cotton and man-made-fiber cloth into the US in the period 1989–2005. The value of imports began in excess of $1 billion and rose throughout the period until 2000, then experienced a sharp drop in 2001. While imports increased throughout, the share of imports in consumption also rose. The percent of broadwoven cotton imports in total consumption fluctuated between 20% and 33% until 2001 and then rose to over 50% by 2004.

While imports were increasing in value, the average value per square meter followed a very different pattern. Fig. 1 illustrates this difference in evolution over time.[3] The unit value of imports

[1] Rodrik and Rodriguez (2000) summarizes the theoretical foundations and empirical evidence of a dynamic link from trade policy to economic growth. This literature is usually based on reduced-form cross-country regressions, while the present paper takes a structural, industry-specific approach.

[2] The results for MMF textiles (SIC 2221) are similar and are available on demand.

[3] The value of imports used is the landed duty-paid value of imports; it thus includes both transport costs and tariffs paid to the US.

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Table 1
Imports of broadwoven textiles into the US.

	Millions of USD		Percent of total (in quantity terms)	
	Cotton imports	Man-made fiber imports	US cotton imports/ consumption	US MMF imports/ consumption
1989	1216.057	1477.614	22.91	5.31
1990	1279.475	1473.125	23.85	5.24
1991	1452.628	1634.557	26.04	6.11
1992	1677.296	1733.949	30.41	7.94
1993	1736.998	1825.572	29.00	8.00
1994	1682.163	1873.326	31.27	8.44
1995	1814.628	1816.899	29.94	8.09
1996	1682.489	1861.179	26.22	8.86
1997	1876.957	2059.075	28.74	9.89
1998	1882.309	2026.807	29.90	10.78
1999	1805.867	1855.528	30.33	10.36
2000	1934.224	1979.893	33.70	12.14
2001	1706.977	1635.132	37.38	12.74
2002	1839.632	1314.539	45.19	15.20
2003	1647.063	1228.537	47.46	16.28
2004	1651.717	1364.501	55.00	17.94
2005[a]	700.574	854.005	51.79	na

Source: US International Trade Commission, Current Industrial Reports of various years.
[a] The Current Industrial Reports began a new categorization of textiles in 2005. It is not strictly comparable to previous years.

rises in 1990, declines through 1993, rose through 1996 and then stayed roughly constant at $1.85 per square meter thereafter. The nominal price index for domestic production first rose, and then fell, over the sample period.[4] The US consumer price index (CPI) rose by about 50% over the same period. Competition, whether from foreign or domestic sources, clearly constrained domestic producers to real reductions in output price. The year 1998 was a turning point in this evolution, with domestic prices falling sharply after that time. The comparison of domestic prices and import unit values in Fig. 1 illustrates the typical pattern of import competition: foreign prices begin below US domestic prices, with the differential shrinking over time due to competitive pressure.[5]

Import competition was restrained in this industry during this time period by the existence of bilateral quotas on imports into the US. These bilateral quotas were summarized in the Multi-Fiber Arrangement prior to 1995, and in the Agreement on Textiles and Clothing (ATC) after 1995. Not all exporters to the US were governed by these quotas—over this period only 19 countries were subject to potentially binding quotas in cotton cloth. Table 2 identifies the countries with binding quotas by year.[6] These had a significant effect on the quantity imported from countries subject to those quotas, as Dean (1990, 1995) demonstrates.

[4] The domestic price is created from an index based upon that of Bartelsman, Becker and Gray (2006) and extended using the estimates of Haltiwanger. The unit value of US exports in these two classifications in 1989 is used as the first observation for the domestic price, and the price index is then used to update the value to subsequent years.

[5] The continuing gap between prices could reflect a quality difference in domestic and foreign goods. It could also reflect the quota rents earned by US importers under the Multi-Fiber Arrangement and its successor, the Agreement on Textiles and Clothing.

[6] Quotas generally take one of two forms. There are individual quotas assigned to single quota categories, and Table 2 reports the existence of binding individual quotas by country in at least one of the quota categories. There are also group

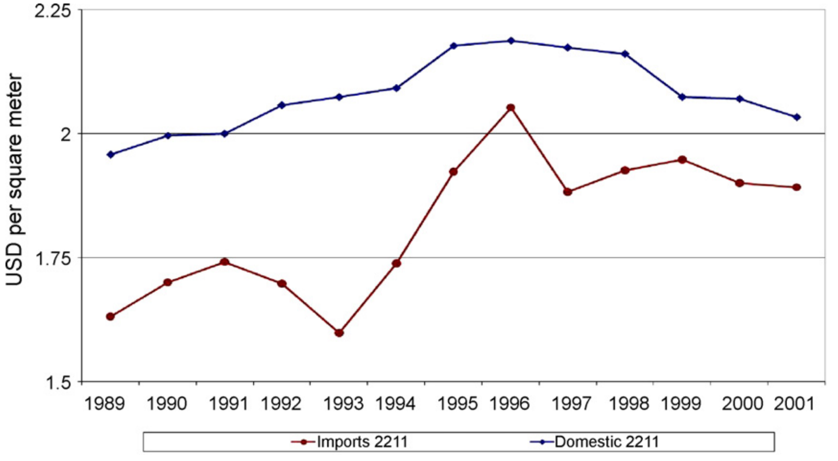

Fig. 1. Domestic price index and unit value of US imports.

Table 2
Countries with at least one binding quota in Broadwoven cloth.

	Cotton	MMF
Belarus		2001–2002, 2004
		1993–1994, 1998, 2001–2003
China	1993–1995, 1998–2004	
India	1993–1999	
Indonesia	1989–2001	1989–2002
Korea	c	1993, 1995–2000, 2002 d
Malaysia	1993 a	1995–2000 b
Pakistan	1993–1995, 1997–2003	1993–1994, 1997–2002
Sri Lanka	1993–1995, 1998	
Taiwan		1993–2003 e
Thailand	1993–1995, 1998–1999	1993–2002
Turkey		1993
United Arab Emirates	1993–1994	

Source: OTEXA, US Department of Commerce. a: 1993–1994, binding in broad category, b: 1993–1994, binding in broad category, c: 1993–2004, binding in broad category, d: 1993–2002, binding in broad category, and e: 1993–2003, binding in broad category.

When the quota is binding, importers will be unable to source additional cloth from that supplier in that quota category. Table 2 indicates that in 1993, for example, imports from China, India, Indonesia, Malaysia, Pakistan, Sri Lanka, Thailand and United Arab Emirates were all constrained in at least one of the cotton quota categories, while South Korea was constrained in a broad grouping that included these quota categories. This meant in practice that those wishing to purchase imported cotton cloth had to turn to other suppliers in that year. Binding quotas were exclusively observed on imports from developing countries during this period. The upward pressure on prices due to binding quotas generated higher unit values on aggregate developing-

quotas assigned to span a set of quota categories for each country. A group quota may be binding even if quotas are non-binding in individual quota categories. Binding group quotas are indicated in Table 2 by letters.

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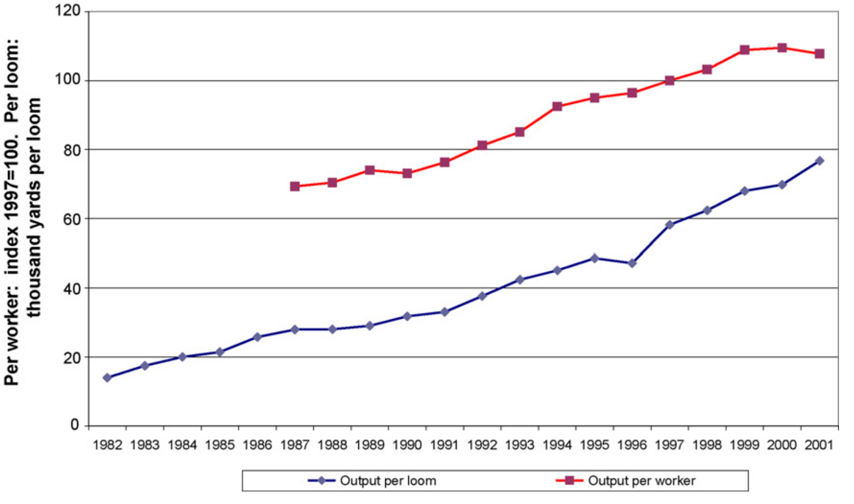

Fig. 2. Productivity in US textiles production. *Sources:* Current Industrial Reviews, various years, and Bureau of Labor Statistics.

country imports during the period 1993–1999.[7] The US quotas imposed under the ATC were removed at the beginning of 2005, although for imports from China alone a new bilateral quota was imposed in mid-2005 and will expire in 2009.

2.2. *Evidence of productivity and real-wage growth in textiles production*

As the competitive pressure from imports continued during this period, so also did the opportunities for increased productivity (and increased wages) inherent in technological progress in cotton textiles production.

Fig. 2 provides two simple indicators of technological growth in this industry.[8] There is labor-saving technological growth, as evident in the trend in output per worker. This is also capital-saving technological growth, as is evident in the rising ratio of output per loom. These increases in productivity over time could be due to exogenous technological innovation. They could also be due to the effects of Schumpeter's (1975) "creative destruction": competition from new firms weeding out less-productive firms. In the product market, that competition was largely from other domestic firms. The price of textiles output fell relative to the CPI as increasing supply kept downward pressure on the price. In the labor market, textiles manufacturers competed against other potential employers for workers. The cost of a worker in terms of textiles output rose throughout almost all the period as the wage was bid up. These two tendencies are illustrated in Fig. 3. The upper line illustrates the wage–price ratio in textiles for the period 1958–2000.[9] Aside from a slight downturn in the early 1970s, this ratio rose strongly throughout the period. This was not idiosyncratic to tex-

[7] Consideration of unit values for developing countries in the appendix supports this conclusion.

[8] The statistics on output per loom are drawn from Current Industrial Reports for broadwoven cotton cloth. The statistics on output per worker are drawn from BLS, and are for all fabric mills (NAICS 3132).

[9] The textiles wage is reported by the US Bureau of the Census. The SIC 2211 textiles price index is reported by Bartlesman, Becker and Gray for 1958–1996, and is extended to 2000 as in Haltiwanger. The manufacturing wage and the consumer price index are taken from the Economic Report of the President.

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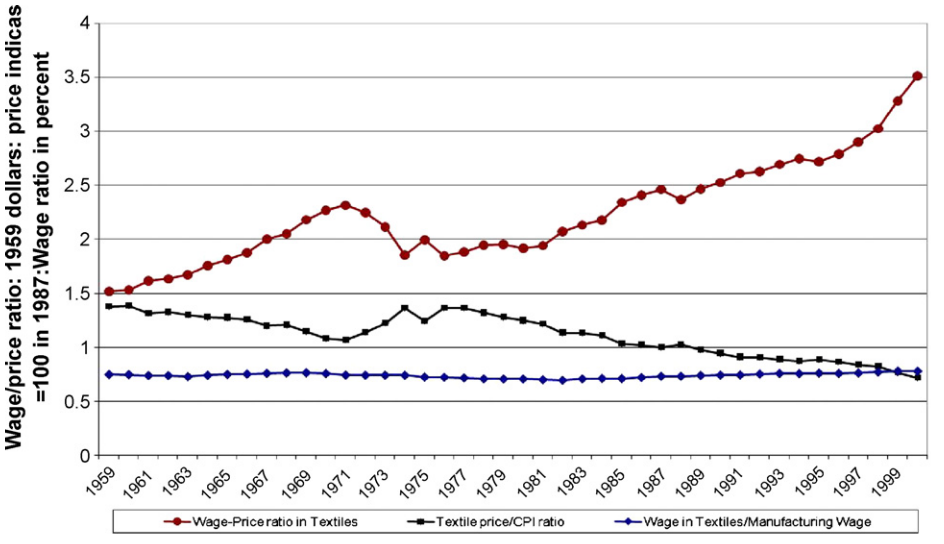

Fig. 3. Wage–price scissors in textiles.

tiles wages: the bottom line illustrates that the mean hourly wage in textiles remained roughly 75% of the mean hourly wage in manufacturing throughout the period. Over the same period, the ratio of the price of textiles to the consumer price index was reduced by about 50%. The rise in wages relative to final-good price may have been triggered by general demand conditions in the labor market, but it could not have been sustained at these levels of production without the concurrent growth in productivity.

2.3. *Two-way trade in textiles*

While the textiles sector in the US is an import-competing industry, it has also been the source of significant exports. In the 1970s the two-way trade was roughly balanced. The dollar appreciation of the early 1980s corresponded with a massive adjustment in trade patterns: imported textiles rose from 15% to 40% of output, while exported textiles fell from 11% to 4% of output. Those trade patterns remained relatively static until 1997: the dollar appreciation against Asian exporters beginning at that time, combined with the progressive dismantling of the Agreement on Clothing and Textiles, led to another jump in imported textiles that continued through 2004. In this later period the quantity exported also began to rise relative to output as Mexico and Central America became important offshore assembly markets for US textiles. This must be incorporated in industry equilibrium.

2.4. *Implications for policy choice*

Given the history of technological growth and falling product prices in this industry, a comparative-static exercise of falling import prices in a static equilibrium will misstate the impact on output and employment. Proper analysis must include a structural dynamic model of firm entry, firm exit, and endogenous domestic product price and market share.

3. Previous research

Trade policy decisions typically occur at the level of industry or the macroeconomy, but many of the policy questions of interest are observed at the microeconomic (i.e., firm) level. Researchers have two competing strategies for policy analysis.

- The computable-general-equilibrium (CGE) approach creates an economy-wide model within which industry-level decisions can be interpreted as those of representative firms.[10] This has recently been employed to examine trade and industrial policies in Philippines (Cororaton & Cockburn, 2007) and Thailand (Field & Wongwatanasin, 2007), and has also been employed in "global" analyses using the GTAP structure (e.g., Fugazza & Maur, 2008). These have merit at an aggregate level, but have insufficient institutional detail for effective analysis of firm-level responses to the policy reform. The parameters of the models are also typically based on calibration to a specific year of data, and lack the precision possible through time-series or panel estimation.
- Analysis based upon plant-level behavior has addressed either the static effects of trade liberalization or the effects on firm exit and entry—there is no unified dynamic analysis of the two.[11] This analysis is typically performed at such a level of aggregation as to be unable to model the endogenous determination of domestic price of the import-competing good: as will be evident, this is important in decomposing the effects of import competition from the effects of technological growth.

The static effect of import competition in firms in continuous operation has been called "imports as market discipline" 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, chap. 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. Empirical research has subsequently provided evidence in favor of both the downward price movements and the net entry of firms.[12]

Current theoretical models of plant-level production, entry and exit provide a new dynamic window for observation of plan closure and downsizing as an equilibrium phenomenon. In Hopenhayn (1992), for example, productivity at the plant level follows a Markov process. 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 *a priori* information about their actual productivity.[13]

In this paper, I adapt the theoretical analysis of Hopenhayn (1992) and the insights of Devarajan and Rodrik (1989) to empirical investigation of US production and import of textiles. In doing so,

[10] Dervis, deMelo and Robinson (1982) summarizes the initial trade-policy research using this technique.

[11] The analysis of Baldwin and Robert-Nicoud (2005) is a partial exception; it considers the static and steady-state effects of international competition on an exporting nation. It does not explore dynamics, and provides no empirical evidence, as is provided here.

[12] Conway (2006) provides a detailed discussion of empirical tests of this hypothesis.

[13] Melitz (2003) introduces international trade to the Hopenhayn model. His treatment of entry is identical – *a priori* 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. 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.

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I make three key extensions of the research mentioned above. First, I estimate the effects of import competition using plant-level data and a micro-founded model of behavior. In this way, I am able to distinguish plant-level differences in productivity that create the key dynamic in Hopenhayn (1992) and Melitz (2003) from the impact of import competition. Second, I use observations for a relatively homogenous textile sector in the US. By doing so, I am able to obtain the price-based estimators of import competition required by the theoretical model. Third, I extend the theory to import-competitive plants by explicitly modeling the endogeneity of the domestic price of textiles: this makes it possible to distinguish between technological progress and import competition as causes for the phenomena of closure and layoffs in the US market.

This policy modeling approach can thus be thought of as a combination of the best elements of the two approaches in the literature: the general-equilibrium, flexible-price approach of the CGE model and the careful estimation of firm-level research. Each of these will be crucial for measuring the effects of a policy reform to the system of textile quotas.

4. Estimating the model of the optimal behavior of domestic plants

I consider an industry of imperfectly competitive plants producing both domestically and overseas for the US market. Plant-level choices – including output supply, labor demand, investment and the decision to exit – are derived from maximization of the plant's discounted present value of profits. Equilibrium requires that supply equal demand for each variety of product and that the number of varieties supplied equal the number of varieties demanded. The specifics of the model and the detailed estimation results are presented in the appendix to this paper available at http://www.unc.edu/home/pconway/dload/TLT_Web_appendix.pdf.

Estimation is undertaken in three stages: estimation of the plant-level technology, estimation of the decision to enter and exit, and estimation of the industry-level parameters of aggregate demand and domestic market share.

4.1. Plant-level technology

In the first stage, I merge the Census of Manufactures with the Annual Survey of Manufactures of the US Bureau of the Census to create a panel database of plants reporting their primary product to be broadwoven cotton. A translog production technology in four factors of production – capital, labor, energy, materials – is estimated simultaneously with the constraints implied by the plant's first-order conditions and the downstream purchasers' demand for this cloth. The results are the parameters of the translog function, plant-specific measures of total factor productivity, estimated industry-level growth in technology over time, and the purchasers' elasticity of substitution among varieties. Conway (2006) reports the results of that estimation and describes the corrections made for selection bias, survival bias and heterogeneity of plants. Three features of the production technology and market characteristics are of special interest[14]:

- The estimate of the elasticity of substitution across varieties is relatively high (around 14) and is precisely estimated.
- The technological coefficients take reasonable values. The generality of the translog specification is consistent with the data in this industry. The coefficient restrictions necessary to reduce

[14] While the estimated coefficients are not reported, it is the case that multi-plant firms differ insignificantly from unit-plant firms in production technology.

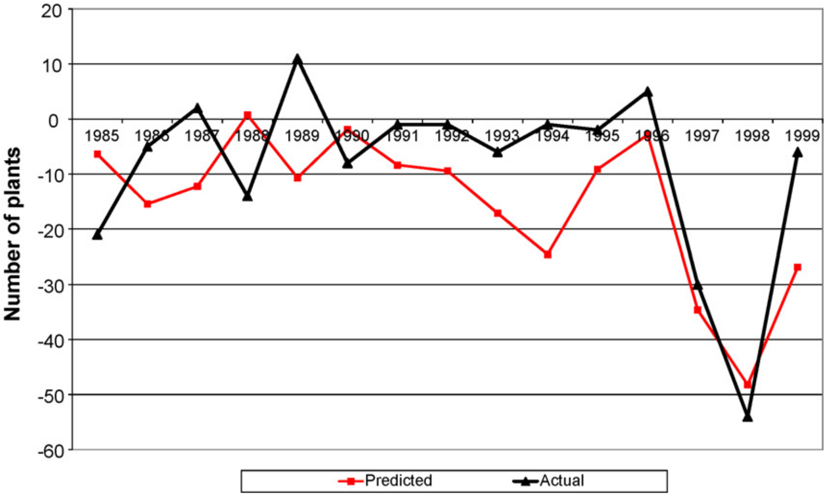

Fig. 4. Net entry of plants to the textiles market.

this to the Cobb-Douglas specification often used in policy analyses in CGE models (e.g., Field & Wongwatanasin, 2007) or in plant-level analyses (e.g., Pavcnik, 2002) are strongly rejected by the data.

- Pressures of import competition on these firms enter through the demand for varieties, while technological growth is a supply-side phenomenon. Both are statistically significant components of the model. Policy analysis can exploit this separation to derive independent effects of the two.

This estimated model serves as the base for simulations of plant-level behavior by plants in continuous operation.

4.2. Entry and exit decisions

Conway (2006) reports the results of estimating a plant-level probit model of the decision to exit using panel data from the US Census. Here I use the industry-level information on entry and exit to estimate a count model of the decisions to enter and to exit: estimation details are provided in the appendix. The historical record shows that the rate of exit has exceeded the rate of entry for 15 of the 18 years in which both are 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. Fig. 4 illustrates the actual and in-sample predicted net entry for the textiles sector of the US economy. There is a net loss of plants over the time period, with a strong downward shock in 1998: the estimated equations pick up this downward spike very well.

4.3. Total demand for textiles and domestic market share

Total demand for textiles in the US and domestically produced market share are estimated simultaneously using the specification derived from the underlying Dixit-Stiglitz utility function and the GMM estimation technique. The estimation results are reported in the appendix. As noted above, the estimated elasticity of substitution among varieties of textiles is $\sigma = 14.40$. The point estimate of foreign-price elasticity of domestic demand share is 5.04; the point estimate of the wage elasticity of domestic demand share is −4.32. Calculation of a point estimate of the elasticity of domestic share with respect to the endogenous P_{Dt} is also possible, and is equal to −0.72; note that it is smaller than the effect of the exogenous variables, because it has the offsetting effects of increasing the relative price of the final good while reducing the relative price of inputs.

5. Simulating the dynamic response to trade liberalization

I simulate the impact of trade liberalization on the economy in two steps. First, I report in-sample simulations using the plant's translog production technology: this illustrates the impact of exogenous shocks and policy changes on the decisions of plants in continuous operation. Second, I embed these results within the dynamic industry-level model to derive the general-equilibrium effects attributable to endogenous adjustment of the domestic price of textiles.

5.1. Static simulations: plants in continuous operation

I consider three simulations that illustrate the relative importance of technology and import competition in modeling plant-level employment. The first simulation gauges the impact of technological improvement on the decision to hire labor. The baseline simulation includes the observed technological growth, and the counterfactual is that there is no technological growth over the sample period (and that other exogenous variables take their historical values). The second simulation examines the price pressure on these plants that results from having import prices grow less rapidly than domestic prices: the counterfactual is that the import price P_{Ft} grew at the same rate as the US CPI during the within-sample period and other predetermined variables took their historical values. The third simulation examines the impact of the wage–price scissors on the hiring decision: the counterfactual is that the nominal wage W_t grew at the same rate as the domestic textiles price P_{Dt} during the sample period and that other predetermined variables took historical values. Fig. 5 reports the results of these simulations.

The results are striking. If there were no technology growth, ceteris paribus, there would have been a cumulative 60% decrease in the use of labor at each plant. If W_t had grown at the rate of P_{Dt}, there would have been over 100% more use of labor in each plant. The labor gains that would have resulted if P_{Ft} had grown at the rate of the US CPI are small relative to the other two sources, and for an intuitive reason—over this sample, P_{Ft} actually grew at a rate roughly equal to the US CPI.

There are two possible reasons for the reported reduction in labor use: either the per-plant level of production was reduced, reducing labor demand in turn, or the labor-output ratio was reduced. Fig. 6 reports the average per-plant labor/output ratio for each simulation. The absence of technological growth in-sample lowers per-unit labor use: the labor-output ratio is roughly 50% lower by the end of the sample than it would have been at benchmark technological growth. The growth in W_t relative to P_{Dt}, by contrast, has led to substantial labor-saving adjustments at the plant level. Change in the growth rate of P_{Ft} relative to the US CPI has no effect on the labor/output ratio since the impact of P_{Ft} on plant behavior enters from the demand side of the market. It does lead to adjustments in average plant-level output, and these output adjustments are the basis for the labor demand adjustments to changing P_{Ft}.

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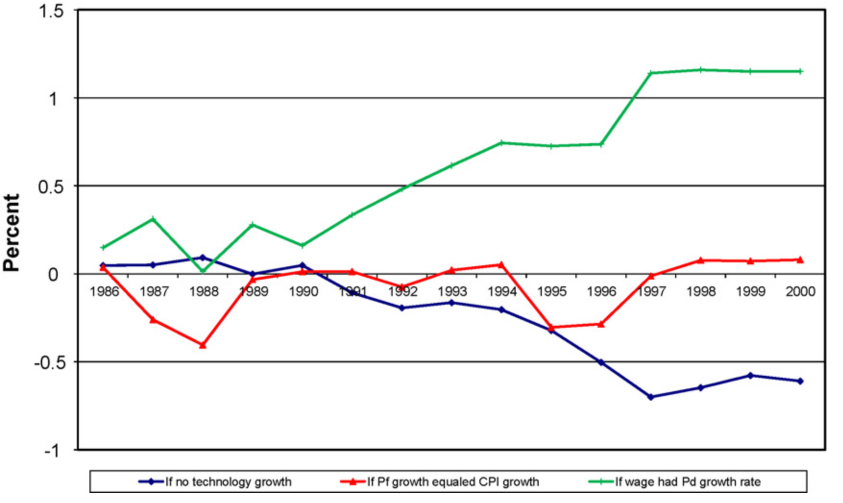

Fig. 5. Simulation of per-plant labor demand.

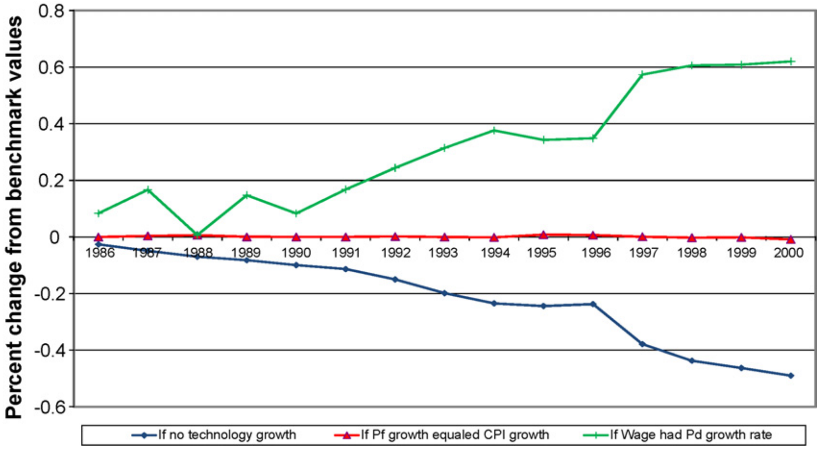

Fig. 6. Simulation of average labor/output ratio.

5.2. Dynamic simulations

Embedding this profit-maximizing plant in an industry-wide model provides a rich environment for simulating the impact of various exogenous shocks to the economy. In what follows I will use "2005" as the base year for simulation, with a downward shift in P_{Ft} assumed to begin in 2006.[15] Growth in W_{t} and technology are also varied in successive simulations. The simulations are carried through a six-year horizon to 2010. The key innovation of this set of simulations is the endogenous determination of domestic textile price P_{Dt}, the number of domestic firms N_{Dt} and the

[15] Plant-level data for 2005 were not available from the US Census at the time of this research. I use the mean values and number of plants from 1999 as the basis for the simulation, and recognize that as those data become available it will become important to redo the simulations with those more up-to-date data.

share of the market served by domestic firms χ_t: as will become evident, their joint endogeneity has very important ramifications for the effectiveness of policy.

The structural model estimated above proves to be stable. When the complete model (plant-level choices, exit, entry, and market equilibrium) is simulated with unchanging technology, wages and import prices, the industry (ceteris paribus) as observed in "2005" is adjusting only slightly: plant-level choices (price, quantity, and labor use) and industry characteristics (share produced domestically) are nearly constant over the six-year horizon.

To this dynamic equilibrium, I introduce two independent shocks. The first is the combined effect of technological progress and real wage growth at historic rates.[16] The second is the trade policy reform. The prices of competing imports will no longer be constrained to rise over time as higher-cost suppliers are identified—instead, the lower-cost producers will be able to export without restriction into the US market. I model this as a one-time, 10% reduction in P_{Ft} in 2006 followed by constant P_{Ft} thereafter.[17]

Table 3 reports the values for P_{Dt}, plant-level output q_{Dt}, plant-level labor use l_t, χ_t, N_{Dt} and P_t derived from a series of six-year dynamic simulations beginning with the "2005" equilibrium. The first panel of the table provides the values for these variables in the no-technology-growth, no-wage-increase and no-foreign-price-change case. The second panel reports the change in these values simulated when technological growth and nominal wages grew at historical rates. The third panel reports the additional simulated effect from a 10% reduction in P_{Ft} in 2006. The fourth panel indicates the aggregated simulated effect of continuing technological and wage growth and the reduction in $P_{Ft.}$

There is evidence of lower prices, plant closure, reduced per-plant labor use and production downsizing in this industry. However, these effects come from very different sources.

Plant closure is a feature of dynamic equilibrium under both sources of shocks. These closures occur gradually, rather than at once, as the plants respond to the rising real wage or rising gap between foreign and domestic price by exiting at a more rapid pace.

- Plant closure is most sizeable in the technological progress/wage-price scissors simulation, as the second panel of Table 3 indicates. The number of plants is reduced to 80% of its initial value by 2010.
- Increased import competition leads to plant closure as well, although the impact of that shock is smaller. There is an additional reduction of 10% of plants by the end of the six-year period after P_{Ft} is reduced.

The *price charged by domestic plants* (P_{Dt}) evolves quite differently in the two simulations. This difference is crucial to the understanding of the two effects.

[16] The increase in average nominal wages can realistically be taken as exogenous to plant-level decision-making. Technological growth could be modeled as a choice at the plant level; I do not introduce that complexity here, but will address it in future work.

[17] This percentage is derived from Francois and Spinager (2005, Table 16F3). They calculate that the "export tax equivalents" that correspond to the impact of the quota on the sale price of the exporting country in 2001 was at its highest 20% for China and Vietnam and less for other exporters. I chose 10% as an average of that effect – especially with China placed under quota once again in mid-2006. The actual difference in average price of imported broadwoven cotton between 2005 and 2006 was miniscule – from $0.68 and $0.69 per square meter. This may be due to exchange-rate movements over that period: from end-2005 to end-2006, for example, the US dollar depreciated 3% against the Chinese yuan, 9% against the Korean and Indonesian currencies, 8% against the Singapore dollar and 12% against the Thai baht. That exchange-rate effect should properly be separated for policy evaluation purposes.

Table 3
Simulation values for the out-of-sample period.

Base values from simulation						
	p_{Dt}	q_{Dt}	l_{t}	χ_{t}	N_{Dt}	P_{t}
2005	0.28	10.96	6.37	0.70	1.00	1.27
2006	0.28	10.96	6.36	0.70	0.99	1.27
2007	0.28	10.96	6.36	0.70	0.98	1.27
2008	0.28	10.96	6.36	0.70	0.98	1.27
2009	0.28	10.95	6.36	0.70	0.97	1.27
2010	0.27	10.95	6.35	0.70	0.96	1.27
Difference from base: technological progress and wage growth at historical rates						
2005	0.00	0.00	0.00	0.00	1.00	0.00
2006	−0.02	−0.03	−0.05	−0.02	1.00	−0.02
2007	−0.03	−0.04	−0.09	−0.03	0.98	−0.03
2008	−0.05	−0.02	−0.12	−0.05	0.94	−0.05
2009	−0.06	0.01	−0.12	−0.07	0.88	−0.06
2010	−0.08	0.08	−0.08	−0.09	0.80	−0.07
Difference from technological progress: the added effect of foreign price reduction						
2005	0.00	0.00	0.00	0.00	1.00	0.00
2006	0.04	−0.11	−0.12	−0.11	1.00	−0.03
2007	0.05	−0.10	−0.11	−0.12	0.98	−0.03
2008	0.05	−0.08	−0.09	−0.12	0.96	−0.02
2009	0.06	−0.06	−0.06	−0.12	0.93	−0.02
2010	0.08	−0.04	−0.04	−0.12	0.90	−0.02
Difference from base: the total effect of technological progress, wage growth and foreign price reduction						
2005	0.00	0.00	0.00	0.00	1.00	0.00
2006	0.03	−0.14	−0.17	−0.13	1.00	−0.05
2007	0.02	−0.14	−0.20	−0.15	0.96	−0.06
2008	0.01	−0.11	−0.21	−0.17	0.90	−0.07
2009	0.00	−0.05	−0.18	−0.19	0.82	−0.08
2010	0.00	0.04	−0.12	−0.21	0.72	−0.09

Source: author's calculations. Number of firms is measured as a ratio to initial value in 2005.
Domestic market share is listed in percentage points.

- Technological progress leads to reduction in P_{Dt} that becomes cumulatively larger over the six-year horizon, as indicated in the second panel of Table 3.
- The trade policy reform has both "downsizing" and "shrinking domestic market share" effects. In simulation the "downsizing" effect dominates and P_{Dt} rises to clear the market in the initial period. Adjustment thereafter has the pattern of falling N_{Dt} and rising P_{Dt} over time.
- There is no reduction on net in P_{Dt} when both shocks are considered together, as is indicated in the last panel of Table 3. This minimal net effect masks an 8% reduction in P_{Dt} over the simulation due to technological progress and an 8% increase in P_{Dt} over the period due to the foreign price reduction.

Downsizing (the reduction in per-plant output) also differs markedly by the source of shock. The phenomenon is more directly linked to increased import competition than to technological progress.

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- Downsizing is observed only slightly in the first years of the simulation when technological progress and wage increases are introduced. This effect is reversed over time as the impact of technological progress grows stronger.
- Downsizing is an immediate and very large effect of increased import competition. Output falls by 18% immediately as the relative cost of inputs rises. That effect is reduced over time as closure leads to larger demand for continuing plants.

Substantial *layoffs* are evident in plants in continuous operation in response to both shocks, but the timing of layoffs differs across the two.

- With technological progress and wage growth, labor use falls by just 5% in the initial year. Layoffs grow to a cumulative 12% in the third year, and then workers are called back to plants in continuous operation due to the expanding demand due to closure of other plants.
- With increased import competition there is an immediate layoff of 12% of the labor force of plants in continuous operation. Beginning in the second year the workers are called back to plants in continuous operation so that by the end of the six-year horizon the remaining layoffs at plants in operation is close to 4% of the initial employment.

Cost to the downstream producers and consumers falls in both simulations—an indication of the welfare gains ultimately possible to the consumer from trade liberalization.

- The greater cumulative reduction in P_t follows from technological progress, and is due to the drop in P_{Dt} over time. The effect leads to a 2% reduction in the first year, but a 7% cumulative reduction by the end of the six-year horizon.
- P_t falls as well with trade policy reform. The reduced P_{Ft} has a negative direct effect on P_t, but plant closure indirectly leads to an increase in P_{Dt} and a lessening of this effect. The initial impact is a 3% reduction in P_t, but this is reduced to a cumulative 2% by the end of the time horizon.

These quantitative results are contingent upon the assumptions of specific rates of wage growth and technological progress observed in past data, and also upon the magnitude of the reduction in P_{Ft}. Constructing alternative simulation scenarios will change the quantitative effect, but not the basic duality of the results: plant closure and reduction in P_{Dt} are primarily associated with technological progress in this dynamic equilibrium, while downsizing, reduced labor use and immediate loss of market share are more closely associated with trade liberalization.

One additional simulation reinforces this point. It was evident in surveys administered to textiles executives (see Conway & Connolly, 2004) that their propensity to invest in new technology was fundamentally altered in 1997 with the intensification of competition from Asian suppliers subsequent to the Asian financial crisis. This changing propensity will logically lead to a reduction, and perhaps elimination, of technological progress in the industry that did not emerge from the sample over which the model is estimated. To test the robustness of the conclusions above to an industry with less technological progress, I redo the simulations with no technological progress. I contrast an industry with continuing annual growth in P_{Ft} of 2% with an industry in which P_{Ft} falls by 10% in 2006 and then stays constant thereafter. The difference in simulations is illustrated in Fig. 7. Note the same patterns remarked earlier: the reduction in P_{Ft} leads to substantial downsizing of plants in continuous operation. P_{Dt} rises through the simulation period due to the downsizing, even though the share of the market served by domestic plants is also dropping sharply. Per-

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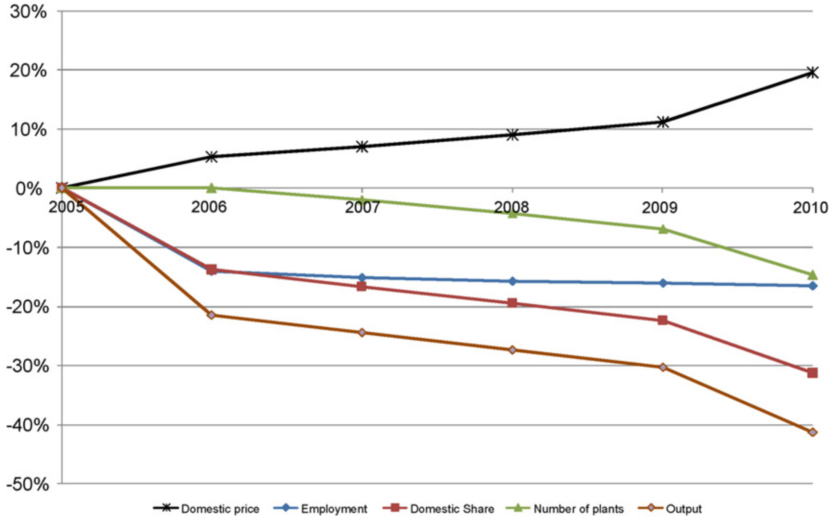

Fig. 7. Impact of reduction in P_{Ft} with no technological progress.

plant employment declines, but less precipitously—the rise in P_{Dt} combined with the 2% annual growth in W_{t} leads to a roughly constant real wage over the simulation period. The number of plants declines relative to the baseline results.

Key to these findings is a fundamental feature of the US market for textiles: it is growing slowly. The recent uptick in exports of textiles, predominantly to Mexico and Central American countries, has eased that constraint only slightly. These exports are themselves destined for re-importation into the US, and the US apparel market is a mature industry. Growth in demand slower than technological growth triggers the plant closure and reduction in P_{Dt} reminiscent of "creative destruction". Import competition has the dual effect of encouraging individual plants to downsize and of reducing the share of demand served by domestic plants. The empirical evidence suggests that downsizing is the dominant effect, thus placing less downward pressure on P_{Dt} and N_{Dt}.

6. Policy implications

The estimation and simulation reported in this paper provide a model uniquely equipped for trade policy analysis. Trade policies affect the economy through changes in relative prices, and this model derives those changes endogenously. The effects of trade policy must also be disentangled from the effects of technological progress, and this model has the structure necessary to do this.

Examination of the experiences of textiles plants in the US provides an important window on the impact of trade liberalization. There is clear evidence of the overall welfare gain in the fall in the average market price of textiles. There is also clear evidence of the disruption to domestic producers through layoffs, downsizing and plant closure.

The key dilemma for this market is the robust technological growth coupled with a low growth rate of demand. The combination has led historically to plant closure and layoffs. The simulation results here illustrate that the mechanism for this was the reduction in domestic price relative to input prices; the increase in nominal wages industry-wide accelerated the effect. The effects of competition from lower-cost imports must be seen as an overlay on this dynamic. The fall in import prices reduces the share of the market served by domestic products, but it also causes downsizing at continuing plants—and the latter dominates the former in the simulation horizon I consider.

By uncovering and separating the effects of trade reform from technological progress, this model also informs the design of policies to mitigate the effects of import competition on plants and workers. The US government has created the Trade Adjustment Assistance (TAA) and Alternative Trade Adjustment Assistance (ATAA) programs to provide resources to and speed the transition of workers finding themselves unemployed due to import competition.[18] The prerequisites for participation in those programs are presented in Conway (2009). When applied to the record of TAA petitions in North Carolina textiles, I find that TAA (and ATAA) support was available to much less than half of those losing their jobs in this sector in recent years. Redesign and retargeting of that policy will be enhanced by consideration of the results from structural dynamic models such as this one.[19]

The simulations performed here embody the assumption that plant-level behavior continues through the out-of-sample period as it was observed during the sample. Manufacturing executives I interviewed suggested that this might be violated for technological progress: I heard from them repeatedly that the domestic industry's appetite for investment and technological innovation was fundamentally reduced by the experience of the Asian crisis years of 1997–1998. In future work I will model technology more flexibly to accommodate breaks in these years.

There is a fundamental, but unavoidable, flaw in the research design of this paper: while the effects of trade liberalization will be observed in plant behavior after 2005, the plant-level estimation did not include data from that period. These data were not available from the US Census, but will be in coming years. The results from these simulations can then be reinforced by estimation over a longer time horizon.While this paper investigates the impact of policy reform in the textiles sector in the US, the modeling strategy is more general. Trade policy analysis will be better informed in general through use of such dynamic structural models. In fact, such models are crucial to separating out confounding factors such as technological progress and real wage growth in this case.

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[18] See Baicker and Rehavi (2004) for a summary of these programs.

[19] The analysis of this paper raises a separate, more fundamental, question. Why should those losing their jobs through import competition be treated differently from those losing their jobs due to technological progress? In terms of worker dislocation, the impact is identical.

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