Survival of the Best Fit: Competition from Low Wage Countries and the (Uneven) Growth of US Manufacturing Plants*

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Abstract

We examine the relationship between import competition from low wage countries and the growth of US manufacturing plants from 1977 to 1997. Both employment and output growth are slower for plants that face higher levels of low wage import competition in their industry. As a result, US manufacturing is reallocated over time towards industries that are more skill and capital intensive. Differential growth is driven by a combination of increased plant failure rates and slower growth of surviving plants. Within industries, low wage import competition has the strongest effects on the least capital and skill intensive plants. Surviving plants that switch industries move into more capital and skill intensive sectors when they face low wage competition.

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1. Introduction

Two trends have dominated the US manufacturing sector over the past 30 years. First, both the level of employment and the real value of production have fallen sharply as a share of national activity. Second, the composition of industries within manufacturing has tilted towards the production of skill and capital intensive sectors: t-shirts and televisions are out, peripherals and pharmaceuticals are in. International trade is a prime suspect in these trends. Indeed, as the US has dropped its trade barriers, low wage countries like China and India have begun exporting to the US many of the more labor-intensive products it formerly produced at home. This sort of product cycling – where the US moves out of televisions as developing countries gain the know-how and market access needed to move in – is a key feature of standard trade models. Given their cost disadvantages, it is virtually impossible for US firms in the most labor intensive industries to survive head-to-head competition with firms from the world's most labor abundant economies.

In this paper we address three simple questions. First, is employment and output growth disproportionately lower for US manufacturing plants that face increasing import competition from low wage countries? Second, in the face of such competition, do plants grow more quickly if they are more skill and capital intensive? Finally, is there evidence that US firms change their product mix in response to low wage competition? Thus, rather than focusing on the issue of whether imports result in job loss or an overall decline in manufacturing, we seek evidence of a reallocation of manufacturing driven by a decline of plants and industries which are theoretically most at risk.

Our analysis of a comprehensive set of US manufacturing plants from 1977 to 1997 yields results that are both strong and intuitive. First, we find that employment and output grow more slowly for plants in industries facing higher levels of low wage competition. Second, we find that higher plant skill and capital intensity mitigate the effect of low wage competition. These findings are a combination of two trends. The first is differential growth across surviving plants. The second is a positive correlation between plant death and the level of competition in its associated industry.

We also examine the extent to which plants alter their product mix in response to low wage competition by looking at plants that switch industries. Consistent with the hypothesis of product cycling, we find that the average capital and skill intensity of the destination industry exceeds the capital and skill intensity of the industry lef behind. In addition, plants leaving industries facing low wage import competition are more likely to move to sectors with higher capital and skill intensities. Both results are consistent with the idea that plants attempt to upgrade their product mix as low wage competition intensifies.

Our investigation into the reallocation of manufacturing industries is unique in two respects. First, as in Schott (2002), we gauge the degree of *low wage* competition in an industry via the share of total import value and the share of industry products originating in countries with less than 5% of US per capita GDP. These measures have several advantages over traditional measures of import competition. Most important, they focus on *where* imports originate rather than their magnitude, thereby identifying competition from a set of countries most apt to be disruptive. In addition, they measure competition in terms of both product value and within-industry product diversity, an important consideration given coarseness of industry aggregates. Finally, they avoid well-known endogeneity problems associated with both import penetration and import price indexes, two of the more popular measures of import competition (Kletzer 1998).

Our analysis is also unique in that it focuses on plants rather than industries, an important advantage given the significant heterogeneity of plants within the same industry. This variation can affect a plant's susceptibility to industry-level competition. Variation in factor input intensity, for example, can signal variation in product mix: if the most capital and skill intensive plants in Optical Instruments (SIC3827) produce microscopes rather than magnifying glasses, they may compete less directly with Optical Instrument firms from labor abundant countries. By considering both plant and industry characteristics, we provide a more complete analysis of the link between employment, output and international trade.

This paper is most obviously related to research in international trade and labor economics that studies the effects of imports on employment. The earliest of these efforts, which are generally restricted to just one or a few industries over a relatively short period of time, find little or no association between international competition and employment growth (e.g. Krueger 1980; Grossman 1987; Mann 1988). More recent efforts, examining larger sets of industries, however, have found relatively strong links between employment growth and either import penetration or changes in import price indexes. Freeman and Katz (1991), for example, find that a 10% increase in import penetration coincides with a 5% decline in employment in their study of 428 four-digit SIC during 1958 to 1984. Revenga (1992), on the other hand, uses an instrumental variables approach to mitigate endogeneity concerns and reports employment declines of roughly 3% in response to a 10% drop in import prices. Research by Sachs and Shatz (1994) is perhaps the most closely related to our approach: their analysis of the factor content of 131 out of 140 three digit SIC manufacturing industries suggests that roughly 6% of the decline in manufacturing employment between 1978 and 1990 is due to imports from a large set of developing countries.

Our research also relates to various studies of the attributes and post-employment experience of workers who lose their jobs in mass layoffs and plant closures (Kletzer 1998). Consistent with our findings, these workers tend to be less skilled than the average worker, and disproportionately drawn from manufacturing industries.

The remainder of the paper is organized as follows. The next section summarizes the theoretical framework guiding our analysis and outlines testable hypotheses. Sections 3 and 4 describe how we construct our low wage import competition measures and summarize our dataset. Sections 5 and 6 presents the main results on manufacturing reallocation and industry switching. Section 7 concludes.

2. Theory

A key implication of standard trade models is that a country's product mix is a function of its level of development. In the factor proportions framework, development is measured via relative endowments: relatively skill and capital abundant countries like the US are expected to produce a more skill and capital intensive mix of goods than relatively labor abundant countries like China. The standard diagram for depicting this equilibrium is displayed in the left panel of Figure 1, which illustrates the relative development level of two countries – the US and China – in a world of two factors and multiple goods. Each good is represented by a Leontieftechnology unit value isoquant; goods prices identify relative wages, which anchor negatively sloped isocost lines.

In the figure, the US offers high wages relative to capital costs (w_{US}/r_{US}) due to its capital abundance. As a result, US production of labor intensive Apparel and Textiles is unprofitable. The negative profits that would be earned by firms in those sectors can be seen by comparing the amount of capital and labor that can be bought for one dollar in the US versus the amount of capital and labor needed to produce one dollar's worth of Apparel or Textile output. Relatively high capital costs in China, on the other hand, render production of capital intensive Chemicals and Machinery unprofitable in China. Though Figure 1 builds intuition for these relationships using just two factors, results are easily generalized to a world of many factors and goods (Leamer 1987).

Development in product cycle theory is a function of technology accumulation. In that framework, the world is divided between Leaders, who invent goods, and Followers, who figure out how to copy them. Leaders dominate goods markets until Followers enter, at which time the latter's (exogenous) cost advantages drive Leaders permanently from the market. A "quality ladder" variant of this model has Leaders and Followers trading dominance of a particular good over time, as Leaders improve upon existing "goods" by upgrading their quality or features (Grossman and Helpman 1991).

Both models allow for a reallocation of industry output over time. In the factor proportions framework, this cycling can occur as countries accumulate capital relative to labor. In Figure 1, for example, China would move out of Apparel and into Machinery once its capital to labor ratio exceeded k_1, and then out of Textiles and into Chemicals as its capital to labor ratio exceeded k_2. Reallocation under product cycle theory, on the other hand, depends upon the time it takes to copy new inventions. The faster developing countries are able to reverse engineer existing products, the more quickly developed country industry shares evolve. A key difference between the models is that new product introduction is an explicit component of the product cycle theory but generally ignored by the factor proportions framework. This distinction is most important for the advanced countries because, in both models, less advanced countries inherit existing goods. Nevertheless, given the high correlation between relative endowments and measures of technological accumulation, empirically distinguishing product cycle specialization from factor proportions specialization is quite difficult.

Industry reallocation can also be driven by the removal of trade barriers. As developed countries like the US open their markets to imports from developing countries, the output of developed countries in formerly protected industries is expected to decline and eventually disappear. In the factor proportions framework, the logic of this reallocation can be seen by comparing the right and left panels of Figure 1. In the right panel, trade barriers result in higher US prices for Apparel and Textiles, represented by unit value isoquants that are closer to the origin (where less capital and labor are required to produce a dollar's worth of output). As trade barriers fall, the US moves toward the equilibrium depicted in the left panel, where as noted above, production of Apparel and Textiles are not viable. It is of course possible for firms in formerly protected industries to survive by improving productivity. On the other hand, the magnitude of productivity gains required to overcome competition from the world's *lowest* wage countries is considerable and is likely to be confined to industries of medium skill and capital intensity rather than extreme labor intensity.

Consideration of standard trade models leads to several testable hypotheses linking plant performance and plant and industry characteristics.

Hypothesis 1 *Plant growth is increasing in plant skill intensity and plant capital intensity.*

Employment and output growth is expected to be lower in labor intensive plants and higher in skill and capital intensive plants. One interpretation of this hypothesis relies upon the assumption that plant input techniques reliably signal underlying product variation: labor intensive plants produce the sort of labor intensive goods most likely to be in direct competition with firms from low wage countries. This view of plant input intensities to some extent controls for the arbitrary coarseness of four digit SIC industry aggregates.

Hypothesis 2 *Plant growth is increasing in plant productivity.*

Plants can survive head-to-head competition with low wage country firms via productivity improvements. It is also possible that more skill and capital intensive plants have experienced relative productivity gains over labor intensive plants, providing an alternate interpretation of Hypothesis 1.

Hypothesis 3 *Plant growth is decreasing in competition from low wage countries.*

Though the openness of the world trading system increased substantially over our sample period, this openness has not been uniform across industries. Indeed, Apparel and Textile products are protected both by quotas and by relatively high tariffs. As a result, the growth of labor intensive plants in a liberalized industry may be lower than it is for plants with identical labor intensity in a protected sector. Our measures of low wage country competition by industry, described in the next section, control for these differences.

Hypothesis 4 *Plant growth is increasing in the interaction of foreign competition with plant skill and capital intensity and plant productivity.*

Under the assumption that input intensities signal within-industry product differentiation, we expect higher skill and capital intensity to offset the effect of industry competition. Capital intensive Gore-Tex manufacturing plants, for example, are more likely to grow relative to more labor intensive textile plants.

3. Measuring Low Wage Import Competition

We construct three measures of competition from low wage countries developed by Schott (2002) from product level import data collected by the Bureau of the Census. Industry level low-wage country competition in value terms is computed by aggregating product level data up to SIC4 industries:

$$VSH_i^L = \frac{\sum\limits_{c \in L} M_{ic}}{\sum\limits_{c \in C} M_{ic}} \tag{1}$$

where M_{ic} is US import value of industry i from country c in year t and L is the set of low wage countries in year t. This measure gives us the share of imports in an industry that come from low wage countries. It does not measure the level of imports in the industry from those countries.[1] Competition measures are available for 385 of 459 industries.[2] To avoid problems with annual fluctuations of the measure, we use the average of VSH_i^L over the five years prior to the Census year (τ) as our measure of value competition from low wage countries for industry i in year τ.

As an additional measure of low wage country competition, we consider the range of products in an industry that are imported from low wage countries. This *number share* is calculated as the fraction of total imported products that originate in low wage countries

$$NSH_i^L = \frac{N_i^L}{N_i} \tag{2}$$

where N_i is the total number of products imported in industry i in year t and N_i^L is the number of products imported from at least one low wage country in industry i in year t. US imports are recorded at the ten digit Harmonized System (HS) level of aggregation, which is our definition of a product. Again we use the average of the number share over the previous five years in our empirical work. The average number of products across manufacturing industries ranges from 21 in 1972 to 33 in 1992.

Finally, we construct an interaction of our two share measures to capture the overall level of import competition from low wage countries,

$$NVSH_i^L = NSH_i^L \times VSH_i^L. \tag{3}$$

All three measures emphasize where imports originate rather than the overall level of import activity. We classify countries as low wage if they have less than 5% of US per capita GDP.[3] A list of countries fitting this criteria is reported in the Appendix. We choose a 5% cutoff for two reasons.

[1] We recognize that the total volume of imports may be of interest but our focus is on the importance of increasing trade with low income countries.

[2] As noted in the Schott (2002), mapping products to four digit industries is a complicated process involving several imperfect concordances. The imperfections reduce the number of industries for which VSH_i^L and NSH_i^L can be calculated.

[3] We use current real exchange rates to perform the conversion to US$ rather than a PPP exchange rate. For such low levels of income the use of current rates does not change the list of countries below the cutoff, while using PPP exchange rates sharply limits the available number of countries and years due to the lack of available data.

First, it provides a relatively stable set of countries over the 1972 to 1992 period we consider. Second, this cohort of countries is responsible for a significant share of US import growth among less developed countries.[4] In our empirical specifications below, competition in year t is the average competition over the previous five years (i.e. from $t-5$ to $t-1$).

VSH_i and NSH_i have significant advantages and some disadvantages over existing measures of import competition. An important advantage is that they are largely robust to shocks affecting both domestic production and imports. An additional benefit is that we capture both the value and range of products where competition occurs. An obvious disadvantage is that the measures focus exclusively on the activity of a subgroup of countries. However, given strong interest in recent years on the impact of competition from low income countries like China and India, this focus provides us with a unique ability to focus on developing versus developed country competition.

Existing measures of international competition have a variety of potential problems. One of the more popular indexes of import competition is import penetration,

$$\text{Import Penetration}_i = \frac{\text{Import Value}_i}{\text{Domestic Production Value}_i + \text{Import Value}_i}.$$

A major problem with this index is its inclusion of domestic production value in the denominator, a feature that can induce negative correlation with plant output and employment growth.

Import price indexes are equally problematic. First, cost shocks can affect both import prices and the demand for labor and output in an industry, and this correlation can introduce the usual bias. Second, because the US is such a large market, domestic demand shocks can simultaneously affect import prices and shocks to industry labor demand. Perhaps most importantly, import price indexes are unavailable for a wide range of industries and time periods.

Table 2 summarizes the distribution of VSH_i and NSH_i from 1972 to 1992. Each column of the table reports the mean and standard deviation of

[4] Among countries with less than 30% of US per capita GDP, the cohort of countries with less than 5% experienced the largest increase in import share, by far, between 1972 and 1992.

each competition measure across industries over the prior five year period. The first cell, for example, indicates that the average industry imported 38.7% of its products from at least one low wage country between 1972 and 1976. This number share is significantly higher than the accompanying value share in both this and subsequent time periods, but both shares have roughly doubled over time.

Between 1972 and 1992, the average VSH_i grew from 3.4% to 7.5% while the average NSH_i increased to 62.1% from 38.7%. Most of the increase in product penetration occurred in the latter part of the sample with over half coming during 1982 to 1986. Similarly, over two thirds of the increase in value penetration occurred in the final sample period, 1987 to 1991. In general, high levels of product penetration across industries are positively correlated with subsequent increases in the share of low wage country import value.[5]

Table 2 also reports the evolution of import penetration and annualized three digit SIC industry real import price changes.[6] Between 1972 and 1992 import penetration in the average industry roughly doubled, from 8.8% to 15.5%. Real import price indexes, unavailable for the 1972 to 1976 period, declined in all subsequent periods. Interestingly, real import prices declined most sharply between 1977 and 1981, one or two periods earlier than the increases in VSH_i, NSH_i and import penetration.

Finally, Table 3 reports the correlation between VSH_i, NSH_i, import penetration and real import price changes over the entire 1972 to 1992 sample. Because import price changes are computed for three digit SIC industries, the final row of the table is based upon three digit SIC versions of all the competition measures. In general, though VSH_i and NSH_i covary, the correlation of these measures with import penetration and real import price changes is quite low, increasing our confidence in their ability to pick up aspects of import competition heretofore unexamined.

[5] A more complete sense of the distribution of VSH_i and NSH_i over time is provided in Figure 2.

[6] Nominal import price indexes are deflated at by the US Consumer Price Index.

4. Data

The data in this paper come from two sources. In addition to the competition measures described above, the plant and firm data come from the Longitudinal Research Database (LRD) of the Bureau of the Census. We use data from the Censuses of Manufactures (CM) starting in 1977 and conducted every fifth year through 1997. The sampling unit for the Census is a manufacturing establishment, or plant, and the sampling frame in each Census year includes detailed information on inputs, output, and ownership on all establishments.[7]

From the Census, we obtain plant characteristics including location, capital stock at the plant, the quantity of and wages paid to non-production and production workers, total value of shipments, total value of exports, energy and purchased material inputs, the number of products produced at the plant, the primary Standard Industrial Classification (SIC), and age.

In constructing our sample, we make several modifications to the basic data. First, we drop any industry whose products are categorized as 'not elsewhere classified'. These 'industries' are typically catch-all categories for a group of heterogenous products. In practice, this corresponds to any industry whose four digit SIC code ends in '9'. Second, we combine some 4-digit SIC industries in order to match the import competition measures, leaving us with 337 industry categories. We use information on all manufacturing establishments in the 1977, 1982, 1987, and 1992 Censuses but must drop any establishment that does not report one of the input or output measures. We are left with 443,000+ plant-level observations across the four panels.

4.1. Plant Productivity

As noted above, productivity gains can play an important role in a plant's ability to survive low wage competition. As a result, we compute a TFP measure for each plant and include it as a control in our regression analysis. As is well known, accurately measuring multi-factor productivity

[7] While the LRD does contain basic information on small plants (so-called Administrative records), we do not include them in this study due to the lack of information on inputs other than total employees. Since our competition measures start only in 1972, we must start our sample with the 1977 Census.

at the plant is quite difficult. Since we have only single observations for many of the establishments in the sample, we are constrained in our choice of productivity measures. We estimate a simple five input production function in logs for each industry and year,

$$\ln Y_{ipt} = \beta^0_{it} + \beta^1_{it} \ln P_{ipt} + \alpha^2_{it} \ln NP_{ipt} + \beta^3_{it} \ln K_{ipt} + \beta^4_{it} \ln B_{ipt} + \beta^5_{it} \ln M_{ipt} + \epsilon_{ipt} \quad (4)$$

where Y is gross output of the plant in year t, P and NP are the number of production and non-production workers at the plant, K is the book value of machinery and equipment, B is the book value of buildings and structures and M is the value of purchased inputs and energy. Recognizing that we are unable to adequately control for the co-movement of markups and productivity, or the co-movements of variable inputs and productivity, we use ϵ_{ipt} as our measure of plant total factor productivity. By construction the measure is mean zero for each industry in each period.

4.2. Plant Factor Input Intensities

We measure plant capital intensity via the log of the ratio of the capital stock to total employment. Skill intensity is harder to measure in the LRD as there is relatively little information on the characteristics of the workforce. For our measure, we use the average wage paid to each type of worker, production and non-production, where $P + NP = L$, the total labor force.

4.3. Plant Survival

We examine employment and output growth on a subset of surviving plants as well as the full sample of surviving and dying plants. In performing regressions on surviving plants, we control for plant survival via a standard Heckman correction (Heckman 1976). The included mills ratio is an estimate of the probability of plant survival. Following Bernard and Jensen (2002), we estimate the probability of plant death as a function of a number of plant, firm, and industry characteristics. Plant characteristics include factor input intensities, age, size and productivity. Firm characteristics includes dummies for US multinational ownership, recent ownership changes, multi-plant status, as well as measures of product mix diversity.

At the industry level we include our measures of low wage competition, industry sunk cost of entry, and relative regional specialization and diversity. Results of this probit are reported in Table 4. The effects of entry costs and firm characteristics on plant deaths are large and significant allowing us to separately identify the selection equation from the growth rate regressions in the next section. As in Bernard and Jensen (2002), we find that plant survival is positively associated with skill and capital intensity and negatively associated with low wage competition. In addition, within industries that face high levels of low wage competition, plants with low capital and skill levels are more likely to close.

5. Empirical results

We compute and analyze two different growth rates. The first, due to Davis and Haltiwanger (1992), is the change in plant employment inclusive of plant births and deaths,

$$g_{pt}^{DH} = \frac{1}{5} \cdot \frac{E_{p,t+5} - E_{pt}}{\frac{1}{2}\left(E_{p,t+5} - E_{pt}\right)}, \tag{5}$$

where E_{pt} represents employment of plant p in year t. This growth rate is equal to 2 for new plants and -2 for dying plants. Because we cannot observe the characteristics of plants prior to their birth, we are unable to include birth observations in our empirical specifications below. As a result, g_{pt}^{DH} represents a lower bound on employment loss: within an industry job creation at newly born plants will offset some or all of this loss.

Our second growth rate is the annualized log difference of employment at continuing plants,

$$g_{pt}^{\ln} = \left(\ln E_{p,t+5} - \ln E_{pt}\right)/5. \tag{6}$$

The results that follow are based on regressions of employment and output growth on vectors of plant characteristics ($\mathbf{Z}_{pt}$), industry competition measures ($\mathbf{C}_{it}$) and interactions of plant characteristics with industry competition,

$$g_{pt} = \mathbf{Z}_{pt}'\boldsymbol{\alpha} + \mathbf{C}_{it}'\boldsymbol{\beta} + \mathbf{X}_{ipt}'\boldsymbol{\gamma} + \varepsilon_{pt}. \tag{7}$$

Plant characteristics include the logs of employment, age, productivity (TFP), capital intensity (k), the non-production wage ($npwage$) and the production wage ($pwage$). Numerous studies on mean reversion in plant employment growth have documented the relationship between initial size and subsequent changes (e.g. Hall 1987 and Blonigen and Tomlin 2001). While we are not interested in testing Gibrat's law per se, we include the log of initial employment as well as plant age in all our specifications.[8] Industry competition measures are NSH, VSH and their interaction, $NVSH$. The final vector, $\mathbf{X}_{ipt}$, contains the interacted competition variable, $NVSH$, interacted with the logs of plant capital intensity, non-production wage, production wage and productivity. For regressions examining growth at continuing plants, we include the mills ratio discussed in Section 4.3..

5.1. Plant Employment and Competition from Low Wage Countries

The first column of Table 5 summarizes the association between employment growth and plant characteristics on the full set of 443,000+ plants in the sample. These OLS regressions use g_{pt}^{DH} as the dependent variable. Consistent with our first two hypotheses, we find a strong, significant, and positive relationship between employment growth and capital and skill intensities as well as productivity.

The second column of the table adds our industry competition measures to the specification. Conditioning on competition, plant productivity and factor input intensities remain positive and significant. In addition, both measures of low wage competition measures as well as their interaction are significant at the 1% level. Consistent with Hypothesis 3, increased low wage competition reduces plant growth. Figure 2 provides one view of this relationship by mapping the competition regression coefficients to their effect on relative employment growth. The surface in the figure plots the deviation of a given industry's growth relative to that of an industry facing the average level of NSH_i and VSH_i. This surface slopes down toward the front of the figure, where competition is most intense. Thus, plants in industries with above average competition experience sharp declines in

[8] The LRD does not record the precise start year for any plant. Instead, we only know the first year the plant appears in a Census of Manufactures starting with the 1963 Census. Our measure of plant age is the difference between the current year and the first recorded Census year. Plants that are in their first Census are given an age of zero.

employment growth.

Figure 2 also summarizes the distribution of industries in terms of import competition for 1977 and 1992. The location of each industry in competition space is noted by a '77' or '92', depending upon the year. As indicated in the figure, most industries have low levels of import competition resulting in small effects on employment growth (i.e. they lie on the flatter part of the surface). This is especially true in 1977. Competition increases substantially between 1977 and 1992, as documented by the progression of industries across the surface. By 1992, the negative effect of low wage competition on employment growth for a number of industries is quite large.

An alternate view of effect of competition over time compares the distribution of industries across cohorts of relative employment growth. The first two columns of Table 7, for example, break down industries according to how much their employment growth deviates from the industry experiencing the median level of low wage competition. Thus, like Figure 2, results in this table are generated from the industry competition coefficients in the second column of Table 5.

In 1977, most industries had modest exposure to low wage competition. Even so, 45 industries (14%) faced enough competition from low wage countries to lower annual employment growth by at least 0.5 percentage points below that of a plant facing median competition.[9] Fourteen industries (4%), including Textile Bags (SIC2393) and Leather Gloves (SIC3151), faced enough low wage competition to lower their average annual plant growth by more than 1.5 percentage points below the median. By 1992, many more industries faced substantial competition from low wage countries. Twice as many (90) experienced growth rates at least 0.5 percentage points below the median, while the number of industries experiencing decreases of 1.5 percentage points relative to the median more than tripled, to 47.

The third column of Table 5 adds interactions of plant factor input intensities and productivity with $NVSH_i$. Consistent with Hypothesis 4, we find that capital intensive plants have significantly higher growth rates in industries facing low wage competition relative to their labor intensive

[9] Annualized employment growth for the industry facing median competition was 0.5% and 0.7% in 1977 and 1992, respectively.

counterparts. The interactions with plant skill intensities are also positive but not significant. Interestingly, the productivity interaction is not significant and has the 'wrong' sign.

As a check on our results we run a final empirical specification in the fourth column of Table 5 that includes plant fixed effects. These fixed effects absorb all time-invariant plant attributes that may be correlated with slower growth and high levels of low wage competition.[10] These 'within-plant' results support standard trade theory even more strongly. For a given plant, increases in capital and skill intensity are still positively correlated with plant employment growth. In addition, industry competition has an even more limiting effect on employment growth. Finally, the interaction between import competition and plant factor intensities is strongly positive and significant: increasing capital and skill intensities in the face of rising low wage competition is correlated with substantially higher employment growth.

Table 5 examines employment growth across the subset of 323,000+ plants that survive from one Census to the next. These regressions use $g_{pt}^{\ln}$ as our growth rate and include the selection correction from section 4.3.. Here, too, we find a strong positive and significant relationship between plant employment growth and plant input intensities as well as plant productivity. In the second column of the table, where we include our three import competition measures, the coefficients on these plant characteristics remain positive.

As with the entire sample of plants, the competition coefficient estimates in column 2 indicate that the net effect of low wage competition is to decrease plant employment growth. The final two columns of the upper panel of Table 7 reveal the effect of competition on the distribution of relative employment growth. Again the negative effects of low wage competition have increased over time, though more moderately than with respect to the full sample of plants.

In 1977, 66 industries (20%) faced sufficient competition from low wage countries to lower annual employment growth for survivors by at least 0.5 percentage points relative to a plant in the median industry. By 1992, the number of such industries increased to 82 (25%), with 4 industries, again including Leather Gloves (SIC3151), having their employment growth

[10] Including just industry fixed effects does not change the conclusions.

relative to the median fall by at least 1.5 percentage points.

The third column of Table 5 includes interactions of plant attributes with the industry competition. Unlike the results from the full sample of plants, however, these interactions are generally not significant, with the exception of the production wage. In the final column of the table, where we control for plant fixed effects, these interactions are positive and significant.

5.2. Plant Output and Competition from Low Wage Countries

The strong negative relationship between low wage competition and plant employment growth has two possible interpretations. One is that firms facing low wage competition are more likely grow slowly (or die). The other is that such firms are the most likely to substitute away from labor in production and while employment growth is lower, overall firm output may not be affected by low wage competition. To differentiate between these explanations, we report regressions of real plant output growth in Table 8.[11]

Results for output growth are quite similar to those for employment growth and confirm the idea that overall plant growth is lower when facing low wage competition. Consistent with Hypothesis 1, we find a strong, significant, and positive relationship a plant's growth in output and its capital and skill intensity. One difference is that higher productivity is associated with slower subsequent employment growth.

The three measures of low wage import competition are all significant at the 1% level. The net effect of increasing low wage competition in an industry is to sharply decrease plant output growth. Table 9, for example, reports the distribution of industries across relative output growth cohorts. In 1977, most industries had modest exposure to low wage competition. Even so, 35 industries (11%) faced enough competition from low wage countries to lower annual relative output growth by at least 0.5 percentage points.[12] In the same year, 16 industries, including Women's

[11] We report output results only for the full sample of plants; results for survivors are similar. We also omit the specification on plant characteristics alone; the sign, significance and magnitude of the unreported coefficients are nearly identical to those in the second column of the table.

[12] Annualized output growth for the industry facing median competition was 0.03% in

Blouses (SIC2331) and Curtains and Draperies (SIC2391), faced severe enough competition to lower output growth by more than 1.5 percentage points below the median. The number of industires subject to severe competition increased in 1992; 94 (28%) sectors were sufficiently exposed to low wage competition to lower their relative output growth 0.5 percentage points below the median. 57 (17%) industries were highly exposed and experienced relative output growth 1.5 percentage points below the median.

The second column of table 8 includes interactions of plant factor intensities and productivity with $NVSH_i$. Results are again consistent with the hypotheses of standard trade theory: capital intensive plants have significantly higher growth rates in industries facing low wage competition relative to their labor intensive counterparts. The interaction of plant skill intensities are also positive although not significant. The productivity interaction is significant and positive.

5.3. Industry Switching

Until now we have focused entirely on the employment and output growth of plants facing import competition from low wage countries. In this section, we consider another possible response by domestic plants to foreign competition, changes in their product mix. Using product-level trade data, Schott (2002) finds that US exports have significantly higher unit values than low-wage country imports in products where the US and low wage countries overlap. One explanation of this finding is that US producers of low unit value products shut down in the face of competition. Our evidence, and that of Bernard and Jensen (2002), indicate that low skill, low capital plants grow more slowly, primarily due to their increased probability of shutdown. To the extent that capital and skill intensities are correlated with within-industry product differentiation, plant exit could explain US unit value upgrading. Another possibility is that plants experiencing low wage competition alter their output mix to avoid it, either by vertically differentiating their products or by moving into a product category subject to lower competition. In both cases, such switches should involve capital or skill deepening.

Unfortunately, the LRD does not give us detailed information on the

1977 and -0.2% in 1992.

quantity or value of individual products made by the plant. We do, however, observe the primary 4-digit SIC code of the plant. Many, or even most, potential product changes would occur within an industry and thus not affect the 4-digit SIC code of the plant. However, some fraction of potential product upgrading may involve industry switching.[13] For surviving plants, we look at switches in the SIC code reported by the plants and ask if they are related in a systematic way to low wage competition.

The 4-digit SIC code reported by the plant corresponds to the classification for product(s) that comprises the majority of the plant's output. If a plant is producing roughly equal amounts of two products, small changes in output in the Census years could result in changes in the reported SIC code. This element of random variation in classification changes should bias us against finding any systematic changes in capital and skill intensity across the old and new industries. We test whether switching plants move to more skill and capital intensive industries. We compare the capital and skill intensities in the old and new industries in year t, both unconditionally and as a function of low wage imports. We expect to find higher capital and skill intensities in the new industries, especially for plants that face higher competition from low wage countries.

On average, 7.8% of the surviving plants in our sample report changes in their 4-digit SIC code across neighboring Censuses, i.e. over a five year period. For those switching plants, we look at the average input intensities for the old and new industries in Table 10. If firms are trying to reduce their exposure to low wage import competition through switching, we would expect them to move to more capital and skill intensive industries. On average, for the 25,000+ plants that switch, they *do* move to more capital and skill-intensive industries. The physical capital-intensity of destination industry in year t is 1.1% higher than that of the original industry in year t. Similarly, non-production and production wages are significantly higher in the new industries, by 0.7% and 0.1% respectively, although the latter is not significant.

Next, we regress the change in industry intensity for switching plants

[13] Bernard and Jensen (2001), for example, find that plants which switch industries have a higher probability of being exporters. This movement into more viable products is consistent with the view that plants escape low wage country comeptition by upgrading their product mix.

on our low wage competition measures,

$$\Delta f_{sdt} = c + C'_{st}\beta + \varepsilon_{sdt}$$

where Δf_{sdt} is the percentage difference in the factor intensity of the average plant in the destination industry d in year t relative to the factor intensity of the average plant in the starting industry s in year t. Table 11 reports the results for capital intensity, non-production wages and production wages. Increasing import competition from low wage countries has a strong positive relationship with all three measures of factor intensity. Plants that switch from an industry with high levels of low wage import competition move to industries with higher capital and skill intensities than the average switching plant. For example, a plant leaving an industry at the 75$^{\text{th}}$ percentile of low wage import competition lands in a new industry that is 8.7% more capital intensive and pays 1.4% higher non-production wages, and 2.8% higher production wages. For the average switching plant, the new industry is 1.1% more capital intensive and pays 0.7% and 0.1% higher non-production and production wages respectively.

Taken together these results suggest that surviving US firms employ a variety of responses to increased import competition from low wage countries.

6. Conclusions

Imports from low income countries were the fastest growing component of US trade from 1972 to 1997, increasing faster than overall imports. The rapid growth included both the value of shipments and the variety of products from those countries. In this paper we consider the role of import competition from low wage countries in changing the nature of the US manufacturing sector over the last 30 years. We find that low wage competition has been a powerful force for reallocation within and across US industries. In particular, the major effect of import competition from low wage countries has been to accelerate the process of capital deepening and skill upgrading in US manufacturing.

The restructuring induced by low wage competition takes three related forms: plant deaths, plant growth and product changes. Greater competition from low wage countries increases plant failure rates across industries.

Within industries, plants that are the best 'fit', i.e. the most capital and skill-intensive, are the least likely to close when low wage competition rises. Beyond plant shutdowns, we find that both employment and output growth rates are significantly lower at plants that face high levels of low wage import competition. Relative to the average plant, a 10 percentage point rise in low wage import shares decreases employment and output growth by 0.8% and 1.0% per year, respectively. Again, within sectors, growth is even slower for plants that are the most labor-intensive, i.e. the poorest fit.

Even within plants we see an impact of imports from low income countries. We provide evidence that some plants respond to low wage competition by changing their product mix. Plants that switch industries move to sectors that are more capital and skill intensive than the industries they leave behind. This is particularly true for plants that leave sectors with high levels of low wage competition.

This paper only begins to examine the role of increased trade with low income countries on firms and industries in the US. Additional research is also needed on the response by US firms to such competition in the form of investment, workforce upgrading, and product innovation. Given the differential impact across industries and plants, we expect to find significant regional effects of low wage competition including changes in industry structure, wage levels and inequality. The impact of rapidly rising trade flows from the poorest countries is not just limited to the developed world. However, to date, there has been little or no research on the response by firms and industries in middle income countries such as Chile and Argentina to this form of competition.

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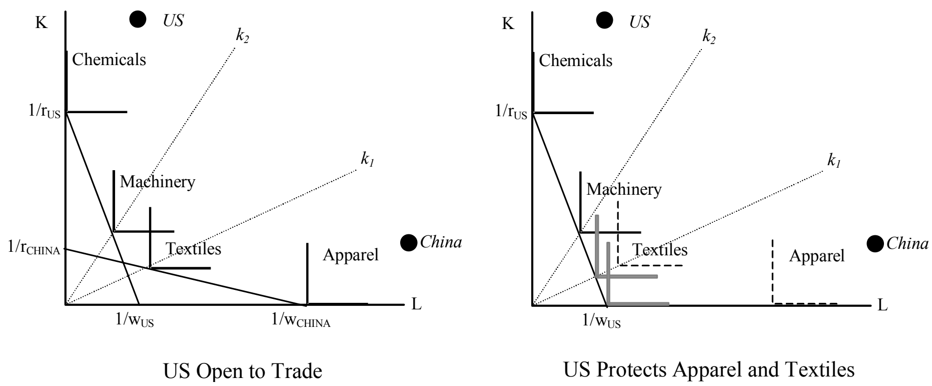

Figure 1: Specialization in the Factor Proportions Framework

Afghanistan	China	India	Pakistan
Albania	Comoros	Kenya	Rwanda
Angola	Congo	Lao PDR	Samoa
Armenia	Equatorial Guinea	Lesotho	Sao Tome
Azerbaijan	Eritrea	Madagascar	Sierra Leone
Bangladesh	Ethiopia	Malawi	Somalia
Benin	Gambia	Maldives	Sri Lanka
Bhutan	Georgia	Mali	St. Vincent
Burkina Faso	Ghana	Mauritania	Sudan
Burundi	Guinea	Moldova	Togo
Cambodia	Guinea-Bissau	Mozambique	Uganda
Central African Rep	Guyana	Nepal	Vietnam
Chad	Haiti	Niger	Yemen

Table 1: Low Wage Countries 1972 to 1992

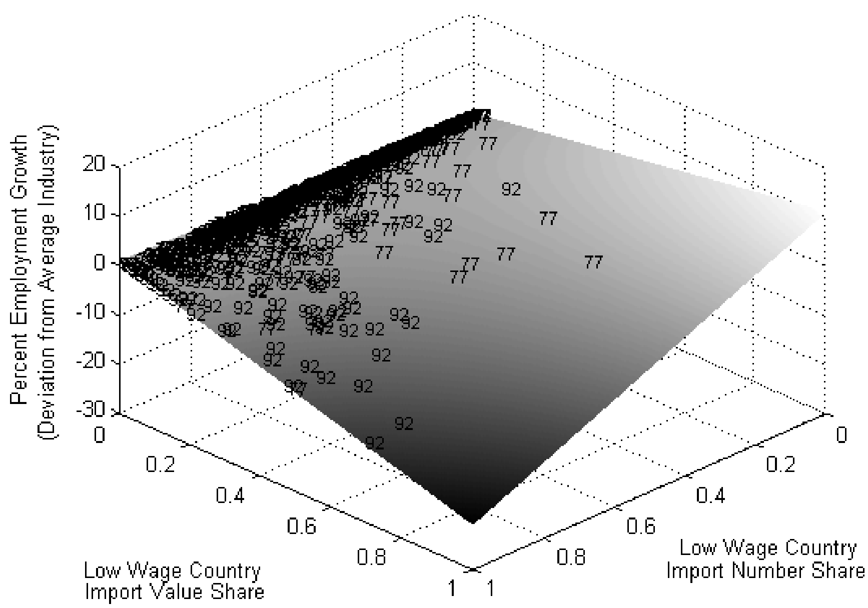

Figure 2: Plant Employment Growth and Low Wage Competition Relative to Average Industry (All Plants)

Competition Measure	1972-1976 Mean	1972-1976 Standard Deviation	1977-1981 Mean	1977-1981 Standard Deviation	1982-1986 Mean	1982-1986 Standard Deviation	1987-1991 Mean	1987-1991 Standard Deviation
NSH	0.387	0.253	0.427	0.248	0.544	0.237	0.621	0.237
VSH	0.034	0.082	0.035	0.071	0.048	0.086	0.075	0.115
Import Penetration	0.088	0.121	0.108	0.139	0.144	0.166	0.155	0.158
Change in Real Import Price Index	na	na	-0.034	0.028	-0.004	0.022	-0.013	0.018

Note: Import Price Indexes are recorded at the three digit SIC level, are deflated by the US CPI. They are unavailable for 1972 to 1976. Remaining competition measures are recorded at the four digit SIC level.

Table 2: Import Competition Summary Statistics

Competition Measure	NSH	VSH	NVSH	Penetration
VSH	0.31			
NVSH	0.39	0.94		
Import Penetration	0.12	0.10	0.13	
Change in Real Import Price Index	0.12	0.02	0.04	-0.02

Note: Import Price Indexes are recorded at the three digit SIC level, are deflated by the US CPI and are unavailable for 1972 to 1976. Correlations for the first three rows of the table are based upon four digit SIC industries. Correlations in the final row of the table are based upon three digit SIC industries. Correlation coefficients control for time effects: each competition measure is regressed on time dummies, and residuals from this regression are used to compute correlations.

Table 3: Import Competition Correlation Matrix

Independent Variables	All Plants Probit Regression Survival==0
$\ln(\text{Employment}_p)$	-0.132 ***
Age_p	-0.012 ***
$\ln(K/L)_p$	-0.022 ***
$\ln(NP/L)_p$	0.077 ***
$\ln(\text{NP Wage})_p$	-0.073 ***
$\ln(\text{P Wage})_p$	-0.117 ***
$\ln(TFP)_p$	-0.170 ***
Takeover	0.189 ***
Sibling (multi-plant firm)	0.088 ***
Orphan (multi-plant firm)	0.235 ***
US Multi-national	0.111 ***
Relative Regional Specialization	-0.001 ***
Relative Regional Diversity	0.148 ***
Entry Cost	1.460 ***
2 products	-0.082 ***
3 products	-0.207 ***
4+ products	-0.284 ***
NSH_i	-0.007
VSH_i	0.567 ***
$NVSH_i$	1.536 ***
$NVSH_i*\ln(K/L)_p$	-0.092 **
$NVSH_i*\ln(NP/L)_p$	-0.578 **
$NVSH_i*\ln(\text{NP Wage})_p$	-0.328 ***
$NVSH_i*\ln(\text{P Wage})_p$	-0.117
$NVSH_i*\ln(TFP)_p$	0.011
Year Dummies	Yes
Obs	448,566
Pseudo R^2	0.06

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Standard errors are heteroskedastic-consistent and adjusted for clustering at the plant level.

Table 4: Probability of Plant Death

Independent Variables	All Plants			
	Employment Growth	Employment Growth	Employment Growth	Employment Growth
$\ln(Employment_p)$	0.008 ***	0.009 ***	0.009 ***	-0.092 ***
Age_p	0.001 ***	0.001 ***	0.001 ***	-0.011 ***
$\ln(K/L)_p$	0.014 ***	0.013 ***	0.010 ***	0.008 ***
$\ln(NP\ Wage)_p$	0.023 ***	0.023 ***	0.022 ***	0.018 ***
$\ln(P\ Wage)_p$	0.030 ***	0.027 ***	0.027 ***	0.036 ***
$\ln(TFP)_p$	0.032 ***	0.033 ***	0.033 ***	0.024 ***
NSH_i		0.016 ***	0.010 ***	0.001
VSH_i		0.117 ***	0.074 ***	0.158 ***
$NVSH_i$		-0.336 ***	-0.528 ***	-1.320 ***
$NVSH_i*\ln(K/L)_p$			0.076 ***	0.076 ***
$NVSH_i*\ln(NP\ Wage)_p$			0.017	0.090 ***
$NVSH_i*\ln(P\ Wage)_p$			0.017	0.141 ***
$NVSH_i*\ln(TFP)_p$			-0.002	0.013
Plant Dummies	No	No	No	Yes
Year Dummies	Yes	Yes	Yes	Yes
Obs	443,755	443,755	443,755	443,755
R^2	0.04	0.05	0.05	0.77

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Standard errors are heteroskedastic-consistent and adjusted for clustering at the plant level.

Table 5: Employment Growth and Low Wage Competition (All Plants)

Independent Variables	Surviving Plants			
	Employment Growth	Employment Growth	Employment Growth	Employment Growth
$ln(Employment_p)$	-0.012 ***	-0.012 ***	-0.012 ***	-0.157 ***
Age_p	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***
$ln(K/L)_p$	0.010 ***	0.011 ***	0.011 ***	0.006 ***
$ln(NP\ Wage)_p$	0.019 ***	0.018 ***	0.019 ***	0.012 ***
$ln(P\ Wage)_p$	0.016 ***	0.017 ***	0.016 ***	0.022 ***
$ln(TFP)_p$	0.023 ***	0.022 ***	0.023 ***	0.014 ***
NSH_i		0.024 ***	0.023 ***	0.004
VSH_i		0.134 ***	0.126 ***	0.045
$NVSH_i$		-0.180 ***	-0.277 ***	-0.731 ***
$NVSH_i*ln(K/L)_p$			0.002	0.023 **
$NVSH_i*ln(NP\ Wage)_p$			-0.017	0.040 *
$NVSH_i*ln(P\ Wage)_p$			0.061 ***	0.145 ***
$NVSH_i*ln(TFP)_p$			-0.025	0.004
$Mills\ Ratio_p$	0.011 ***	0.013 ***	0.012 ***	0.020 ***
Plant Dummies	No	No	No	Yes
Year Dummies	Yes	Yes	Yes	Yes
Obs	323,601	323,601	323,601	323,601
R^2	0.05	0.05	0.05	0.76

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Standard errors are heteroskedastic-consistent and adjusted for clustering at the plant level.

Table 6: Employment Growth and Low Wage Competition (Surviving Plants)

Relative Employment Growth Percentage Point Deviation From Median Industry	Number of Industries			
	All Plants		Survivors	
	1977	1992	1977	1992
< -1.5%	14	47	0	4
[-1.5% to -0.5%)	31	43	66	78
[-0.5% to 0.5%)	260	240	152	233
[0.5% to 1.5%)	26	7	102	21
>1.5%	0	0	11	1

Note: Each cell reports the number of industries with the indicated relative employment or output growth. Relative growth for industry *i* is the growth implied by the relevant industry competition regression coefficients less the growth those coefficients yield for the industry with the median level of competition.

Table 7: Effects of Low Wage Competition on Employment Growth

	All Plants		
Independent Variables	Output Growth	Output Growth	Output Growth
$\ln(\text{Employment}_p)$	0.015 ***	0.015 ***	-0.074 ***
Age_p	0.001 ***	0.001 ***	-0.007 ***
$\ln(K/L)_p$	0.004 ***	0.000	-0.027 ***
$\ln(\text{NP Wage})_p$	0.020 ***	0.019 ***	-0.005 ***
$\ln(\text{P Wage})_p$	0.022 ***	0.021 ***	-0.010 ***
$\ln(\text{TFP})_p$	-0.021 ***	-0.023 ***	-0.098 ***
NSH_i	0.001	-0.006 ***	-0.002
VSH_i	0.170 ***	0.112 ***	0.215 ***
NVSH_i	-0.416 ***	-0.618 ***	-1.290 ***
$\text{NVSH}_i*\ln(K/L)_p$		0.108 ***	0.090 ***
$\text{NVSH}_i*\ln(\text{NP Wage})_p$		0.013	0.111 ***
$\text{NVSH}_i*\ln(\text{P Wage})_p$		0.008	0.066 *
$\text{NVSH}_i*\ln(\text{TFP})_p$		0.083 ***	0.062
Plant Dummies	No	No	Yes
Year Dummies	Yes	Yes	Yes
Obs	443,755	443,755	443,755
R^2	0.05	0.05	0.74

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Standard errors are heteroskedastic-consistent and adjusted for clustering at the plant level.

Table 8: Output Growth and Low Wage Competition (All Plants)

Relative Output Growth Percentage Point Deviation From Median Industry	Number of Industries (All Plants)	
	1977	1992
< -1.5%	16	57
[-1.5% to -0.5%)	19	37
[-0.5% to 0.5%)	291	238
[0.5% to 1.5%)	3	4
>1.5%	2	1

Note: Each cell reports the number of industries with the indicated relative employment or output growth. Relative growth for industry *i* is the growth implied by the relevant industry competition regression coefficients less the growth those coefficients yield for the industry with the median level of competition.

Table 9: Effects of Low Wage Competition on Output Growth

Plant Characteristic	Mean Difference Across Plants Between New and Old Industries	T Statistic (Mean=0)	P Value
Capital Intensity (K/L)	1.1%	3.24	0.00
Non Production Wage (NP Wage)	0.7%	8.73	0.00
Production Wage (P Wage)	0.1%	0.82	0.21

Note: Calculations based upon a sample of 25,425 plants that switched their four digit SIC industry over the four, five year sample periods.

Table 10: New vs Old Industry Characteristics of Plants Switching SIC4 Industries

Independent Variables	K/L Change	NP Wage Change	P Wage Change
NSH_i	0.234 ***	0.020 ***	0.088 ***
VSH_i	-0.038	0.125 ***	0.017
$NVSH_i$	0.699 ***	-0.063	0.189 ***
Obs	25,425	25,425	25,425
R^2	0.02	0.00	0.02

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Standard errors are heteroskedastic-consistent and adjusted for clustering at the plant level.

Table 11: Change in Switching Plants' Characteristics and Low Wage Competition