Falling Trade Costs, Heterogeneous Firms, and Industry Dynamics*

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March, 2003

Abstract

This paper examines the response of industries and firms to changes in trade costs. We test the predictions of recent equilibrium models of international trade with heterogeneous firms. Using disaggregated U.S. import data, we create a new measure of trade costs over time and industries. As the models predict, productivity growth is faster in industries with falling trade costs. We also find evidence supporting the major hypotheses of the heterogenous firm models. Firms in industries with falling (relative) trade costs are more likely to die or become exporters. Existing exporters increase their shipments abroad. The results are strongest for industries most likely to be producing horizontally differentiated tradeable goods.

Keywords: Plant deaths, survival, exit, exports, employment, tariffs, freight costs, transport costs

JEL classification: F10

*We thank Marc Melitz, Jim Tybout and participants at the 2002 Tuck Trade Summer Camp and ERWIT 2002 for helpful comments. The research in this paper was conducted at the Center for Economic Studies. Research results and conclusions expressed are those of the authors and do not necessarily indicate concurrence by the Bureau of the Census or by the National Bureau of Economic Research. The paper has not undergone the review the Census Bureau gives its official publications. It has been screened to insure that no confidential data are revealed.v0.29

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1. Introduction

The inquiry into the relationship between countries' trade policy and their subsequent economic performance has two branches. The first seeks to relate cross-country differences in openness to cross-country variation in GDP growth. The second focuses on the extent to which becoming an exporter increases firm productivity. This paper uses several new firm-level models of international trade to explore a third channel, the evolution of aggregate productivity driven by the reallocation of activity across firms in response to changes in trade costs.

An increase in aggregate industry productivity as a result of falling trade costs is a key feature of three heterogeneous firm, general equilibrium trade models recently introduced by Bernard et al. (2000), Melitz (2002), and Yeaple (2002). These models emphasize productivity differences across firms operating in an imperfectly competitive industry consisting of horizontally differentiated varieties. In all three models, the existence of trade costs induces only the most productive firms to self-select into exporting. As trade costs fall, industry productivity rises due a reallocation of activity across firms: lower trade costs cause low productivity non-exporting firms to exit and high productivity non-exporters to increase their sales through exports, thereby increasing their weight in aggregate industry productivity. An important feature of these models is that the increase in aggregate productivity is *not* a result of faster firm productivity growth from exporting.[1]

This paper provides the first empirical examination of the relationship among industry trade costs, firm reallocation, and industry productivity in the U.S.. A key contribution of our analysis is the connection of *plant-level* U.S. manufacturing data to *industry-level* measures of trade cost changes. We define trade costs as the sum of *ad valorem* tariff and transport costs, and construct them using U.S. product-level trade data. Trade costs are found to vary substantially across both industries and time.

We report two main results. First, we find that aggregate industry productivity rises as trade costs fall. Second, we find strong support for two of the four firm-level implications, and weak evidence for a third, that

[1] Clerides, Lach, and Tybout (1998), Bernard and Jensen (1999), and Aw, Chung, and Roberts (2000) find that firm productivity growth is not improved after entry into exporting.

are integral to industry reallocation in the heterogeneous firm models. The probability of plant death is higher in industries experiencing declining trade costs, as is the probability of successfully entering the export market. In addition, existing exporters' exports grow as industry trade costs decline. These results highlight the heterogeneity of firm outcomes within industries, calling attention to the fact that there are both winners and losers within industries as a result of trade liberalization.

The relationship between falling trade costs and faster productivity growth is not uniform across industries. We find that within-industry reallocation in response to changes in trade costs is strongest for industries where the U.S. has high levels of imports from, and exports to, other high income countries. These industries are more likely to encompass trading in horizontally differentiated varieties, and therefore provide a closer fit with theory.

Identifying a connection between declining trade costs, firm reallocation and aggregate industry productivity gains has important implications for the literature examining the effect of trade liberalization on economic growth. This literature has been conducted almost exclusively with aggregate cross-country data using various measures of openness to proxy for changes in trade costs. Though several studies, including Ben-David (1993), Sachs and Warner (1995) and Edwards (1998), offer evidence of a positive correlation between trade liberalization and GDP growth, the robustness of this evidence has been challenged by Rodriguez and Rodrik (2000). By examining more direct measures of trade liberalization, and linking them to the responses of individual firms within industries, we provide direct evidence on the extent to which trade liberalization may affect productivity and therefore GDP growth. Our results suggest that *changes* in openness over time matter for productivity growth but that all industries are not affected equally.

The analysis in this paper is related to a broad empirical literature examining the link between import competition and plant performance surveyed in Tybout (2001). The general consensus of this literature is that foreign competition both reduces the domestic market share of import-competing firms and reallocates domestic market share from inefficient to efficient firms. Using explicit measures of trade costs, we also find strong evidence of reallocation. Our results suggest that the reallocation is driven by plant death and entry into exporting rather than through changing domestic market shares of surviving plants. Our results are also consistent with studies examining the effects of changes to particular trading regimes. Head and Reis (1999) and Trefler (2001), for example, find that the Canada-U.S. Free Trade Agreement induced substantial rationalization of production and employment.

The remainder of the paper is organized as follows: the next section assembles the predictions from the theoretical models on the responses to lower trade costs. Section 3 summarizes our dataset and describes how we construct our measure of trade costs. Section 4 presents the empirical results. Section 5 concludes.

2. Theory: Heterogeneous Firms and Trade

Three recent papers by Bernard et al. (2000), Melitz (2002), and Yeaple (2002) – henceforth BEJK, MM, and SY, respectively – develop firm-level models of intra-industry trade that are designed to match a set of stylized facts about exporting firms. These facts reveal that relatively few firms export and that exporters are more productive, larger, and more likely to survive than non-exporting firms. An important contribution of the models is their demonstration that such differences can arise even if exporting does not itself enhance productivity, a robust empirical finding (Clerides, Lach and Tybout (1998), Bernard and Jensen (1999), and Aw, Chung and Roberts (2000)).

In each paper, exporter superiority is shown to be the equilibrium outcome of more productive firms self-selecting into the export market. This selection is driven by the existence of trade costs, which only the most productive firms can absorb while still remaining profitable. All three papers relate reductions in trade costs to increases in aggregate industry productivity: as trade costs fall, lower productivity, non-exporting plants die, more productive non-exporters enter the export market, and the level of exports sold by the most productive firms increases. In this section, we summarize the foundation and intuition of these implications before taking them to a panel of plant-level data. Our discussion centers on MM and notes key differences between MM, BEJK and SY.

2.1. Melitz (2002)

MM builds a dynamic industry model with heterogeneous firms producing a horizontally differentiated good with a single factor, adapting Hopenhayn's (1992) framework to monopolistic competition in a general equilibrium setting. The paper also extends Krugman's (1980) representative firm intra-industry trade model by allowing for variation in firm productivity. The coexistence of firms with different productivity levels in equilibrium is the result of uncertainty about productivity before an irreversible entry decision is made: though firms may earn positive profits conditional on entry, expected profits net of sunk entry costs are zero. Entry into the export market is also costly, but the decision to export occurs after firms observe their productivity. Firms produce a unique horizontal variety for the domestic market if their productivity is above some threshold, and export to a foreign market if their productivity is above a higher threshold. MM restricts the analysis to countries with symmetric attributes to focus solely on the relationship between trade costs and firm performance.

In equilibrium, declining variable trade costs mean greater profits for exporters, which are also the most productive plants, because of their increased access to external markets and lower per unit costs net of trade. Higher export profits pull higher productivity firms from the competitive fringe into the market, raising the productivity threshold for market entry and forcing the least productive non-exporters to shut down. Higher export profits also reduce the productivity threshold for exporting, increasing the number of firms which export. In addition, declining trade costs invite more foreign varieties into the market and reduce the domestic sales of all domestic firms. The increased exports of the most productive exporters more than compensate for this decline in domestic market share.[2] A decrease in the fixed cost of exporting has effects similar to a reduction in variable trade costs. One difference is that export sales do not increase at existing exporters. Rather, the increase in exports comes entirely from new entrants.

These dynamics provide the following five testable hypotheses:

[2] An increase in trading partners has similar effects except there are no new entrants into exporting.

Hypothesis 1 *A decrease in variable trade costs leads to an aggregate industry productivity gain.*

Hypothesis 2 *A decrease in variable trade costs forces the least productive firms to exit.*

Hypothesis 3 *A decrease in variable trade costs increases the number of exporting firms; new exporters are drawn from the most productive non-exporters (or new entrants).*

Hypothesis 4 *A decrease in variable trade costs increases export sales at existing exporters.*

Hypothesis 5 *A decrease in variable trade costs reduces the domestic market share (and domestic revenue) of surviving firms.*

2.2. Bernard et al. (2000)

BEJK construct a static Ricardian model of heterogeneous firms, imperfect (Bertrand) competition with incomplete markups, and international trade. Plants use identical bundles of inputs to produce differentiated products under monopolistic competition. Within a country without trade, only the most efficient producer actually supplies the domestic market for a given product.

With international trade and variable trade costs, a plant produces for the home market if it is the most efficient domestic producer of a particular variety *and* if no foreign producer is a lower cost supplier net of trade costs. A domestic plant will export if it produces for the domestic market and if, net of trade costs, it is the low cost producer for a foreign market. With positive trade costs, exporters are plants with higher than average productivity. BEJK use a simulation to demonstrate that as trade costs fall, aggregate productivity rises (Hypothesis 1) because high productivity plants expand (Hypothesis 3 and 4) at the expense of low productivity plants, which fail (Hypothesis 2).[3]

[3] Declining trade costs force low productivity plants to exit the market in both BEJK and MM, but the mechanism by which this occurs differs subtly. In BEJK, low productivity plants exit because of increased import competition from foreign varieties. In

2.3. Yeaple (2002)

SY is a static, one factor model of trade in differentiated products that differs from MM and BEJK in three respects. First, firms choose between producing a homogeneous non-tradeable or a differentiated variety. Second, workers vary in terms of skill. Finally, firm labor productivity is determined endogenously as two production techniques are available to produce differentiated goods, either low fixed/high unit cost or high fixed/low unit cost.[4] With trade costs, firms with the highest productivity produce the differentiated good via the high fixed cost technique and export, while firms with the lowest productivity produce the homogenous good. Firms using the low fixed cost technology have intermediate productivity levels.

A reduction in trade costs increases the incentive for firms to adopt the high fixed cost production technique and export. As a result, a larger number of firms adopt this technology while the absolute number of "domestic" firms in the industry falls. Total employment falls and the least skilled workers leave the industry so that observed labor productivity rises. These relationships also correspond to Hypotheses 1 through 3 above.

3. Data

3.1. U.S. Manufacturing Plants Across Industries and Time

U.S. manufacturing plant data are drawn from the Censuses of Manufactures (CM) of the Longitudinal Research Database (LRD) of the U.S. Bureau of the Census starting in 1987 and conducted every fifth year through 1997. Though CM data are available for earlier periods, we cannot use them in this study because comprehensive collection of export information

MM, countries varieties do not overlap. As a result, an increase in imports raises the probability of death at all levels of productivity while the death of low productivity plants is actually driven by the entry into exporting of other domestic firms. In our empirical work, we will not be able to distinguish between these two competing sources of plant deaths.

[4] MM and BEJK model firms as differing in terms of exogenous total factor productivity (TFP). In SY, TFP is identical across firms, while labor productivity varies with choice of production technique. TFP and labor productivity are correlated in MM and BEJK due to the presence of fixed costs of production. As a result we avoid the complications of computing plant level productivity and focus instead on labor productivity in our empirical tests below.

did not begin until 1987. 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 and output on all establishments. Plant output is recorded at the four-digit Standard Industrial Classification level (SIC4).

The samples used in our econometric work below incorporate several modifications to the basic data. First, we exclude small plants (so-called Administrative records) due to a lack of information on exports. Second, we drop plants in any 'not elsewhere classified' industries, i.e. SIC4 industries ending in '9'. Third, we combine some four-digit SIC industries in order to match the set of industries for which we compute trade costs. These modifications leave us with two panels of approximately 234,000 plants in 337 manufacturing industries.

3.2. Trade Costs Across Industries and Time

An important contribution of our analysis is the construction of a new set of industry-level trade costs that can be related to plant behavior over time. We define variable trade costs for industry i in year t ($Cost_{it}$) as the sum of *ad valorem* duty (d_{it}) and *ad valorem* freight and insurance (f_{it}) rates, $Cost_{it} = d_{it} + f_{it}$. We compute d_{it} and f_{it} from underlying product-level U.S. import data complied by Feenstra (1996). The rate for industry i is the weighted average rate across all products in i, using the import values from all source countries as weights.[5] The *ad valorem* duty rate is therefore duties collected ($duties_{it}$) relative to the Free-On-Board customs value of imports (fob_{it}),

$$d_{it} = \frac{duties_{it}}{fob_{it}}.$$

Similarly, the *ad valorem* freight rate is the markup of the Customs-Insurance-Freight value (cif_{it}) over fob_{it} relative to fob_{it},

$$f_{it} = \frac{cif_{it}}{fob_{it}} - 1.$$

[5] We use the concordance provided by Feenstra et al. (2002) to match products to SIC4 industries.

We define the change in trade costs for census year t as the annualized change in tariff and freight costs over the preceding five years,

$$\Delta Cost_i^{t-5:t} = \frac{Cost_{it} - Cost_{i,t-5}}{5} = \frac{[d_{it} + f_{it}] - [d_{i,t-5} + f_{i,t-5}]}{5}. \qquad (1)$$

In the empirical work below, we relate changes in trade costs between years $t-5$ to t ($\Delta Cost_i^{t-5:t}$) to firm survival, firm export decisions, and changes in firm's domestic market share between t to $t+5$. The five-year spacing between time periods corresponds to the interval between Censuses.

Table 1 reports average tariff, freight and total trade costs across two-digit SIC industries for five-year intervals from 1982-1997 using the import values of underlying SIC4 industries as weights. Costs are averaged over the five years preceding the year at the top of the column. Table 1 reveals that *ad valorem* tariff rates vary substantially and are highest in labor-intensive Apparel and lowest in capital-intensive Paper. Tariff rates decline across a broad range of industries over time. Indeed, over the entire period, tariffs decline by more than one quarter in thirteen of twenty industries. The pace of tariff declines, however, varies substantially across industries.[6] Freight costs are highest among industries producing goods with a low value-to-weight ratio, including Stone, Lumber, Furniture, and Food. Freight costs also generally decline with time, though the pattern of declines is decidedly more mixed than it is with tariffs.

The average SIC4 industry saw trade costs fall 0.19 percentage points per year from 1982-92.[7] Of the 337 SIC4 industries, we find that 82% experienced declines in tariff rates from 1982 to 1987, while 53% experienced declines from 1987 to 1992. For freight costs, 44% of the industries experienced declines from 1982 to 1987, while 66% experienced declines from 1987 to 1992[8] In terms of overall trade costs, 79% of SIC4 industries saw

[6]The median percentage point reduction in product-level *ad valorem* tariff rates between 1989 and 1997 is 0.6%. Twenty five percent of products experience reductions greater than 1.5 percentage points. These differences do not account for changes in product codes during this interval or for changes in the non *ad valorem* component of tariffs, which varies across industries (Irwin 1998). A similar change cannot be computed for a longer interval because a change in the coding of imports in 1989 precludes direct product comparison with years after 1989.

[7]Data on the tariff and freight measures for all 337 (SIC4) industries and years is available at http://www.som.yale.edu/faculty/pks4/sub_international.htm.

[8]Using a different methodology, Hummels (1999) reports a similar decline in aggregate

trade costs decline between 1982 and 87, while 62% had declining trade costs between 1987 and 1992.

The trade cost measure constructed here is unique in several respects. It is the first to combine information about both trade policy and transportation costs. It also provides a perspective on the evolution of trade costs across industries and over time. In addition, it is derived directly from product-level data collected at the border.

Even with these advantages, two caveats should be noted. First, changes in the composition of products or importers within industries can induce variation in d_{it} and f_{it} even if actual statutory tariffs and market transportation costs remain constant. Shifts in U.S. consumption away from imports subject to high tariffs, or towards trading partners located closer to the U.S., for example, can decrease the measures of trade costs even if actual costs are unchanged.[9] This concern about the trade cost data is mitigated to some extent in this paper due to the focus on the relationship between trade costs and firm outcomes. The composition of competition (i.e. near or far importers, this product or that one) may be just as relevant as changes in actual costs in inducing a U.S. response.

A second caveat is that our trade cost measure is constructed from U.S. imports data. Each of the theoretical models described above contemplates symmetric reductions in trade costs across countries. To the extent that U.S. trade policy or transportation rates diverges from that of other countries, measured changes in trade costs may over- or underestimate the changes implemented by other countries. This problem is likely to be more severe for trade policy than for transportation rates. Unfortunately, because disaggregate tariff rates are unavailable for countries other than the U.S. during the period in question, we have no direct way of verifying the symmetry of trade policy across countries.[10]

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freight costs during the same period.

[9] One way to avoid this problem is to aggregate product-level changes rather than levels up to SIC4 industries. In principle, one could compute the change in tariff and freight rates across country-product pairs and then average across these changes for industry observations. In practice, however, such a procedure encounters a number of problems, the most severe of which is that the set of countries importing a given product can vary substantially from year to year.

[10] To check the appropriateness of using import data for both inward and outward U.S. trade costs, we compare U.S. and European Union tariffs changes across industries from 1992-1997 (after the end of our sample) using the TRAINS database compiled by the

3.3. Identifying Industries With Relatively High Varieties Trade

Each of the three models discussed in Section 2 is based upon international trade in horizontally differentiated varieties. In addition to examining trends across all manufacturing industries, we attempt to align the data more closely with the theory by also reporting results for a subset of industries most likely to capture trade in horizontally differentiated varieties. Starting from the assumption that U.S.-OECD trade is driven more by a taste for variety than by differences in endowments, we select SIC4 industries using U.S. import and export penetration ratios *vis a vis* the OECD.[11]

For industry i, we define the OECD import and export penetration ratios for the U.S., n_i^m and n_i^x respectively, as

$$n_i^m = \frac{fob_i^{OECD}}{fob_i + q_i - x_i} \qquad (2)$$

$$n_i^x = \frac{x_i^{OECD}}{q_i} \qquad (3)$$

where fob_i^{OECD} and x_i^{OECD} are the value of U.S. imports from and exports to the OECD in industry i, fob_i and x_i are total U.S. imports and exports in industry i, and q_i is the total value of U.S. production in i. Though n_i^m and n_i^x vary substantially across industries, they are relatively stable across time. We use values for 1987, the midpoint of our two panels, to construct our industry subsample. We refer to industries with import and export penetration greater than the 67^{th} percentile as *high bilateral OECD trade* industries (or high-OECD). The sixty-seven industries above these cutoffs are reported in Table 2.

United Nations Conference on Trade and Development. TRAINS tracks product-level tariffs for a growing set of countries starting in 1990. Using these data, we find that the correlation of U.S. and EU *ad valorem* tariff rate changes across SIC4 industries is positive and significant at the 1% level.

[11] Rauch (1999) divides two-digit SITC industries into differentiated and homogenous categories. The difficulties associated with concording these categories to SIC industries preclude their use here.

4. Empirical results

In this section, we examine the relationships between trade costs and industry- and firm-level outcomes described in Section 2.

4.1. *Industry Productivity Growth*

The most important implication of all three models presented above is that lower trade costs increase aggregate productivity (Hypothesis 1). As the models are all single factor models, they do not differentiate between labor productivity and total factor productivity. Here we report results for both, but in subsequent sections we concentrate on labor productivity.[12] We estimate a simple regression of the change in SIC4 industry productivity on the decline in industry trade costs in the previous five years,

$$\Delta Productivity_{it} = c_t + \beta^1 \Delta Cost_{it-5} + \delta_i + \delta_t + \varepsilon_{it}, \tag{4}$$

where $\Delta Productivity_{it}$ is the average annual percent change in industry productivity, either real value added per worker or TFP, from year t to year $t+5$, $\Delta Cost_{it-5}$ is the annualized percent change in total trade costs between years $t-5$ and t, and δ_i and δ_t are sets of industry and year fixed effects. Data on real value added per worker and five-factor total factor productivity are drawn from Bartelsman, Becker and Gray (2000). Our use of prior changes in trade costs to predict subsequent behavior is helpful for two reasons. First, it biases the empirical work against Hypotheses 1 to 5 by excluding contemporaneous reallocation. Second, it helps to mitigate problems of endogeneity and omitted variables.

One feature of all three models is that they are designed to focus on within-industry reallocation, rather than differences *across* industries. However, the theories are silent on the appropriate empirical scope of an industry. We estimate all our specifications with both two-digit and four digit fixed effects. The inclusion of two-digit industry fixed effects (SIC2) allows for potential substitution across 4-digit industries within a sector. Fixed effects at the four-digit level (SIC4) restrict the analysis to within-industry changes in trade costs over time.

[12] Constructing plant level total factor productivity levels and changes over time is especially difficult given the small number of periods in our data and the five year interval between observations.

The results with SIC2 industry fixed effects are reported in columns 1 (all industries) and 2 (high-OECD industries) of Table 3 with robust standard errors adjusted for clustering on four-digit industries. Consistent with the three models, both TFP and labor productivity are negatively associated with changes in trade costs, i.e. falling trade costs are followed by more rapid industry productivity growth. For the all-industry sample, the coefficients are relatively small and only significant at the 10% level for TFP.

For the sample of high-OECD industries, the coefficients are large and significant at the 1% level, suggesting a one percentage point annual decline in trade costs is associated with annual productivity growth rates 1.0 to 1.6 percentage points higher.

Results using SIC4 industry fixed effects are reported in columns 3 and 4 of Table 3. The same pattern of results holds. the coefficients on the change in trade costs for the all-industry sample are not significant for either TFP or labor productivity. However, in the high-OECD sample, both coefficients are again large, negative and significant.

The industry regressions suggest that falling trade costs are associated with faster industry productivity growth but this relationship is strongest for a sample of industries with high bilateral trade levels with OECD countries. We now turn to the specific within-industry predictions of the models (Hypotheses 2-5).

4.2. Plant Deaths

To examine the effect of changing trade costs on plant survival, we estimate a probit with levels and interactions of plant productivity, export status and the change in trade costs. The probability of death for a plant in industry i between year t and year $t+5$ is given by

$$\begin{aligned}\Pr\left(D_{pt+5}=1|X_{pt},Z_{it}\right) &= \Phi\big(c_t+\beta^1\mathrm{RP}_{pt}+\beta^2\Delta Cost_{it-5}+\beta^3\mathrm{E}_{pt} \\ &\quad +\beta^4\left[\mathrm{E}_{pt}\times\Delta Cost_{it-5}\right]+\beta^5\left[\mathrm{RP}_{pt}\times\Delta Cost_{it-5}\right] \\ &\quad +\beta^6\left[\mathrm{E}_{pt}\times\mathrm{RP}_{pt}\times\Delta Cost_{it-5}\right]+\delta_i+\delta_t\big)\end{aligned} \tag{5}$$

where RP_{pt} (relative productivity) is percentage difference in plant labor productivity from that of the mean plant in the SIC4 industry in year

t, $\Delta Cost_{it-5}$ is the annual average change in industry trade costs in the preceding 5 years, and E_{pt} is a dummy variable indicating whether the plant is an exporter in year t. As above, we report results with SIC2 and SIC4 industry fixed effects while allowing for robust standard errors and clustering in four-digit industries.

All three models predict that low productivity, non-exporters should be more likely to fail, and that a decline in trade costs should raise the probability of death (Hypothesis 2). Since all the plant-level empirical specifications include either SIC2 and SIC4 industry fixed effects, the implicit null hypothesis is that deviations from the average industry change in trade costs are correlated with plant outcomes.

Columns 1 and 2 in Table 4 report the results for plants in the all-industry and high-OECD samples respectively, controlling for SIC2 fixed effects.[13] Plant labor productivity and plant export status have large, negative, and significant coefficients. As expected, low productivity plants are more likely to die and exporters are substantially less likely to fail. As predicted by the models, declines in industry trade costs also increase the probability of death. While the coefficient on the change in industry trade costs is negative in both specifications, it is only significant (at the 1% level) for the industries with high OECD bilateral trade, i.e. precisely the industries most likely to be characterized by the theoretical models.

The signs of the coefficients on the interaction terms suggest that exporters are less likely to die as trade costs fall and that higher productivity among exporters reduces the probability of failure as trade costs fall. For non-exporters the probability of death rises more for high productivity plants as trade costs fall, significantly so for plants in the preferred sample of industries with high OECD trade. This latter coefficient is surprising, as the theory (and common sense) suggests that high productivity non-exporting plants should not face a higher probability of shutdown in the face of declining trade costs.

Columns 3 and 4 in Table 4 contain analogous specifications controlling for SIC4 fixed effects. For the all-industry sample, the coefficient on the trade cost variable has an unexpected positive, although insignificant, coefficient. Falling trade costs are not associated with an increased probability

[13] All coefficients reported in the table are changes in the marginal probability evaluated at the mean of the regressors.

of death in the wide sample of industries. However, for the sample of high-OECD industries, declines in industry trade costs significantly increase the probability of death.

The estimates from the OECD sample with SIC4 fixed effects suggest that the economic magnitude of the change in trade costs on the probability of death is substantial. For a plant with average productivity, a reduction in trade costs of 0.9 percentage points per year (equivalent to a one standard deviation change) leads to a 3.7 percentage point increase in the probability of death for a non-exporter and a 0.2 percentage point increase in the probability of death for an exporter. The average probability of death in the sample is 26.8%.

As with the industry productivity regressions, here we find that the predictions of the theoretical models are strongest for the high-OECD sample: falling trade costs lead to higher probabilities of death.

4.3. New Exporters

In addition to increasing the probability of plant deaths, all three models also predict that high productivity non-exporters start exporting as trade costs fall (Hypothesis 3). We estimate the probability that a non-exporter becomes an exporter as a function of plant labor productivity, the change in industry trade costs, and their interaction for the sample of non-exporters.[14] The probit is given by

$$\begin{aligned} \Pr\left(\mathrm{E}_{pt+5}=1|\mathrm{E}_{pt}=0,X_{pt},Z_{it}\right) &= \Phi\left(c_t+\beta^1\mathrm{RP}_{pt}+\beta^2\Delta Cost_{it-5}\right. \\ &\quad \left.+\beta^3\left[\mathrm{RP}_{pt}\times\Delta Cost_{it-5}\right]+\delta_i+\delta_t\right). \end{aligned} \tag{6}$$

The results reported in Table 5 again give strong support for the predictions of the model, especially for the high-OECD industries.[15] Plant

[14] A more complete specification on the decision to export would include an estimate of the sunk costs of exporting and include the entire panel of plants (for example, see Roberts and Tybout 1997 or Bernard and Jensen 2001). Here, we are interested in the change in the probability of exporting for non-exporters as trade costs fall.

[15] All coefficients reported in the table are changes in the marginal probability evaluated at the mean of the regressors.

labor productivity is strongly positively associated with entering the export market. Declines in industry trade costs significantly increase the probability of becoming an exporter for the high-OECD industries. For the all-industry sample, the effect is not significant and has the wrong sign with SIC4 fixed effects. The interaction between plant productivity and the change in trade costs also has the expected sign, although significant only for broad sample. High productivity non-exporters are even more likely to become exporters when trade costs decline.

The magnitude of the effect of falling trade costs is substantial. For a non-exporter with average productivity, a one standard deviation reduction in trade costs increases the probability of exporting by 5.8 percentage points while the average probability of becoming an exporter in the high-OECD sample is 27%.

These results, coupled with the increased probability of death as trade costs fall, offer support for the two major predictions of the models. In particular, they highlight the heterogeneity of outcomes across plants, even looking just at export status and plant labor productivity. In response to falling trade costs, some plants, typically low productivity non-exporters, are more likely to die, while higher productivity non-exporters take advantage of the lower trade costs and begin exporting. It is important to note that the results are far stronger for the set of industries that have high bilateral flows with the OECD.

4.4. Export Growth

BEJK and MM offer specific predictions that exports will increase at current exporters as trade costs decline (Hypothesis 4).[16] We estimate the percentage change in exports for current exporters as a function of the change in industry trade costs,

$$\%\Delta \text{EXP}_{pt} = c_t + \beta^1 \Delta Cost_{it-5} + \delta_i + \delta_t + \varepsilon_{pit} \quad (7)$$

where $\%\Delta \text{EXP}_{pt} = \frac{\text{EXP}_{pt+5} - \text{EXP}_{pt}}{2(\text{EXP}_{pt+5} + \text{EXP}_{pt})}$.[17]

[16] While SY does not offer a specific prediction on the response of exports at existing exporters, it does have plant exports rising with a decline in trade costs.

[17] This growth rate is bounded between 2 and -2. Plants that stop exporting have a growth rate of -2.

The results, shown in Table 6, are broadly consistent with the prediction that exports increase more rapidly for plants in industries with falling trade costs. While the trade cost measure is negative in both specifications, for high OECD trade industries it is smaller and not significant. As current exporters are higher productivity plants, this expansion of export sales serves to increase the reallocation effect of falling trade costs and boost aggregate industry productivity.

4.5. Domestic Market Share

The models offer a variety of predictions about output and employment growth across plants as trade costs decline. MM has the clearest predictions: domestic market share should fall for all surviving firms (and, of course, for firms that close) while the expansion in exports more than offsets the declining domestic shipments for all current exporters and some new exporters (Hypothesis 5). In the models output and employment covary perfectly at the plant level since there is no feedback from exporting to labor productivity; consequently we limit our attention to changes in domestic sales.

To test Hypothesis 5 from MM, we consider the change in market share for surviving firms,[18]

$$\Delta\left(\frac{\mathrm{D}_{pt}}{\mathrm{D}_{it}+\mathrm{M}_{it}}\right) = c_i + \beta^1\mathrm{RP}_{pt} + \beta^2\Delta Cost_{it-5} + \beta^3\mathrm{E}_{pt} \quad (8)$$

$$+\beta^4\left[\mathrm{E}_{pt}\times\Delta Cost_{it-5}\right] + \beta^5\left[\mathrm{RP}_{pt}\times\Delta Cost_{it-5}\right]$$
$$+\beta^6\left[\mathrm{E}_{pt}\times\mathrm{RP}_{pt}\times\Delta Cost_{it-5}\right]$$
$$+mills_{pt} + \delta_i + \delta_t + \varepsilon_{pit}. \quad (9)$$

where D_{pt} is the value of domestic sales by the plant and $\mathrm{D}_{it}+\mathrm{M}_{it}$ is the sum of domestic industry sales and imports in the industry and $mills_{pt}$ is a Mills ratio to account for the probability of death.[19] The dependent variable is the change in domestic market share of the plant.

The predictions of the MM model about domestic shipments are not confirmed by the results in Table 7. Trade costs have no relationship to

[18] The use of market share, rather than the change in domestic sales, accounts for differential growth at the industry level due to other factors.

[19] The specification for the probability of plant failure used to calculate the Mills ratio is given by Bernard and Jensen (2002) Table 4, column 1.

changes in domestic market share except at exporting plants. Exporters experience (significant) declines in domestic market share as trade costs fall. These results suggest that there is a dichotomy between failure and performance in the domestic market as trade costs fall. Plant failure increases but survivors do not grow more slowly.

We have presented results testing a series of predictions from the new round of trade models. The results confirm the general predictions and provide strong evidence that falls in trade costs will have asymmetric effects on different firms within the same industry. An important caveat is that the models are not designed to explain the responses of firms in every industry to changes in trade costs but rather focus on trade with similar countries in differentiated products. Our results are systematically strongest for the sample of industries that have high bilateral trade with the OECD, i.e. the industries most likely to be characterized by 'new' trade models with heterogeneous firms.

5. Conclusions

In this paper, we examine the response of industries and firms to changes in tariff and transport costs. Using three recent models of international trade with heterogeneous firms, we develop testable predictions on the reallocation of activity across firms within industries as a result of changes in trade costs. To test the hypotheses, we create a new dataset of trade costs by industry over a twenty year period and link the measures to plant level data on the entire U.S. manufacturing sector.

We identify an important new channel of reallocation by which trade policy can affect the performance of domestic industries in the U.S.. We find broad support for the predictions of the recent heterogeneous firm trade models. Industries with falling trade costs have higher subsequent productivity growth. The higher productivity growth is driven by three concurrent processes within the industry. First, lower trade costs increase the probability of plant death, especially for lower productivity, non-exporting plants. Second, surviving high productivity, non-exporters are more likely to enter the export market, thus expanding their sales. Third, existing exporters, already the largest and most productive establishments, see their exports grow more quickly as trade costs fall. The aggregate industry productivity response to falling trade costs reflects the reallocation of activity across firms, away from low productivity non-exporters towards high-productivity exporters.

The results in this paper provide a new round of evidence in favor of trade models designed to understand high bilateral trade flows between similar countries. In particular, the models perform best when we consider precisely those industries that are characterized by bilateral trade between countries at similar income levels. The results suggest that alternative theories, perhaps emphasizing comparative advantage, may be needed to explain the responses of firms in other industries to changes in trade costs.

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Two-Digit SIC Industry	*Ad Valorem* Tariff Costs (d_{it}) (Percent)			*Ad Valorem* Freight Costs (f_{it}) (Percent)			Total Costs ($Cost_{it} = d_{it} + f_{it}$) (Percent)		
	1982	1987	1992	1982	1987	1992	1982	1987	1992
20 Food	5.7	5.1	4.4	10.2	9.7	8.9	15.9	14.8	13.4
21 Tobacco	10.4	14.1	16.7	5.9	5.2	2.9	16.3	19.3	19.5
22 Textile	17.0	13.2	11.2	6.0	6.4	5.4	23.1	19.6	16.6
23 Apparel	23.3	20.7	16.9	8.6	7.6	6.3	31.8	28.3	23.2
24 Lumber	3.2	2.3	1.7	11.1	6.5	7.5	14.2	8.8	9.2
25 Furniture	5.9	4.1	4.1	9.4	8.6	8.5	15.3	12.8	12.6
26 Paper	0.9	0.8	0.6	3.9	3.1	4.4	4.7	4.0	4.9
27 Printing	1.7	1.2	1.1	5.9	5.5	5.1	7.5	6.6	6.2
28 Chemicals	3.8	4.3	4.4	6.4	4.8	4.5	10.1	9.1	9.0
29 Petroleum	0.4	0.5	0.9	5.2	5.1	8.3	5.6	5.5	9.3
30 Rubber	7.4	7.9	11.3	7.5	6.8	6.9	14.9	14.7	18.2
31 Leather	9.0	10.7	11.2	8.3	7.2	5.5	17.3	17.8	16.7
32 Stone	8.9	6.4	6.5	12.0	11.1	9.6	20.9	17.5	16.1
33 Primary Metal	4.6	3.8	3.4	6.9	6.3	6.0	11.5	10.1	9.4
34 Fabricated Metal	6.6	5.1	4.3	6.8	5.9	5.0	13.4	11.0	9.3
35 Industrial Machinery	4.2	3.9	2.4	4.0	4.0	2.9	8.2	7.9	5.3
36 Electronic	5.0	4.6	3.3	3.4	3.1	2.4	8.3	7.6	5.6
37 Transportation	1.9	1.6	2.3	4.5	2.5	3.1	6.4	4.1	5.4
38 Instruments	6.8	5.2	4.3	2.7	2.8	2.5	9.5	8.0	6.8
39 Miscellaneous	9.6	5.7	5.2	5.0	4.9	3.6	14.6	10.6	8.8
Average	4.8	4.4	4.2	5.6	4.4	4.1	10.4	8.8	8.3

Notes: Table summarizes *ad valorem* tariff, freight and total trade costs across two-digit SIC industries. Costs for each two-digit industry are weighted averages of the underlying four-digit industries employed in our empirical analysis, using U.S. import values as weights. Figures for each year are the average for the five years preceding the year noted (e.g. the costs for 1982 are the average of costs from 1978 to 1982). Final row is the weighted average of all manufacturing industries included in our analysis.

Table 1: Trade Costs by Two-Digit SIC Industry and Year

SIC	Industry	SIC	Industry
2091	Canned and cured fish and seafoods	3567	Industrial furnaces and ovens
2371	Fur goods	3571	Electronic computers
2421	Sawmills and planing mills, general	3572	Computer storage devices
2435	Hardwood veneer and plywood	3578	Calculating and accounting equipment
2611	Pulp mills	3593	Fluid power cylinders + actuators
2812	Alkalies and chlorine	3596	Scales and balances, exc. laboratory
2816	Inorganic pigments	3621	Motors and generators
2822	Synthetic rubber	3624	Carbon and graphite products
2833	Medicinals and botanicals	3652	Prerecorded records and tapes
2865	Cyclic crudes and intermediates	3672	Printed circuit boards
3111	Leather tanning and finishing	3674	Semiconductors and related devices
3211	Flat glass	3675	Electronic capacitors
3292	Asbestos products	3676	Electronic resistors
3297	Nonclay refractories	3678	Electronic connectors
3313	Electrometallurgical products	3692	Primary batteries, dry and wet
3334	Primary aluminum	3694	Engine electrical equipment
3341	Secondary nonferrous metals	3713	Truck and bus bodies
3425	Saw blades and handsaws	3714	Motor vehicle parts and accessories
3492	Fluid power valves + hose fittings	3724	Aircraft engines and engine parts
3511	Turbines and turbine generator sets	3743	Railroad equipment
3523	Farm machinery and equipment	3751	Motorcycles, bicycles, and parts
3532	Mining machinery	3822	Environmental controls
3533	Oil and gas field machinery	3823	Process control instruments
3541	Machine tools, metal cutting types	3825	Instruments to measure electricity
3542	Machine tools, metal forming types	3827	Optical instruments and lenses
3546	Power-driven handtools	3844	X-ray apparatus and tubes
3547	Rolling mill machinery	3845	Electromedical equipment
3552	Textile machinery	3851	Ophthalmic goods
3553	Woodworking machinery	3861	Photographic equipment and supplies
3554	Paper industries machinery	3914	Silverware and plated ware
3555	Printing trades machinery	3915	Jewelers' materials + lapidary work
3556	Food products machinery	3931	Musical instruments
3562	Ball and roller bearings	3951	Pens and mechanical pencils
3563	Air and gas compressors		

Notes: This figure lists four-digit SIC industries where the U.S. has high OECD import and export penetration (i.e. greater than the 67th percentile) in 1987. Industries are sorted by SIC code. OECD import penetration is U.S. import value from OECD countries divided by U.S. consumption. OECD export penetration is U.S. export value to OECD countries divided by U.S. production.

Table 2: Industries with High Bilateral OECD Trade

Regressor	ΔLabor Productivity	ΔLabor Productivity	ΔLabor Productivity	ΔLabor Productivity
ΔCost	-0.134 (0.122)	-1.594 *** (0.527)	-0.164 (0.174)	-1.456 ** (0.645)
R^2	0.21	0.18	0.52	0.58
Regressor	ΔTFP	ΔTFP	ΔTFP	ΔTFP
ΔCost	-0.098 * (0.058)	-1.047 *** (0.354)	-0.127 (0.095)	-0.880 ** (0.422)
R^2	0.07	0.09	0.42	0.49
Industry Fixed Effects	SIC2	SIC2	SIC4	SIC4
Year Fixed Effects	Yes	Yes	Yes	Yes
High OECD Penetration Industries Only	No	Yes	No	Yes
Observations	1,004	203	1,004	203

Notes: Industry-level OLS regression results. Robust standard errors adjusted for clustering at the four-digit SIC industry level are in parentheses. ΔLabor Productivity is average annualized change in value added per worker from years t+1 to t+5. Value added and total employment for each SIC4 industry are from Bartelsman, Becker and Gray (2000). ΔTFP is the average annualized change in Bartelsman, Becker and Gray (2000) five-factor total factor productivity from years t+1 to t+5. ΔCost is the change in total trade costs between years t-5 and t. Regressions cover the years 1982 to 1997. ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Coefficients for the regression constant and dummy variables are suppressed.

Table 3: Industry Productivity Growth, 1982-97

Regressor	Probit Plant Death	Probit Plant Death	Probit Plant Death	Probit Plant Death
ΔCost	-0.793	-5.233 ***	0.595	-3.358 **
	(0.678)	(1.681)	(0.541)	(1.622)
Relative Productivity	-0.043 ***	-0.023 ***	-0.043 ***	-0.024 ***
	(1.492)	(0.008)	(0.004)	(0.007)
x ΔCost	-0.204	-5.662 ***	-0.117	-5.606 ***
	(0.416)	(1.409)	(0.479)	(1.326)
Exporter	-0.119 ***	-0.139 ***	-0.121 ***	-0.134 ***
	(0.006)	(0.009)	(0.004)	(0.009)
x ΔCost	0.648	2.786	0.159	3.203
	(0.795)	(2.271)	(0.621)	(2.194)
x ΔCost x Relative Productivity	0.533	5.024 ***	0.726	4.969 **
	(0.733)	(2.208)	(0.786)	(2.079)
Industry Fixed Effects	SIC2	SIC2	SIC4	SIC4
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Sample	All	High Bilateral OECD Trade	All	High Bilateral OECD Trade
Observations	235,790	30,447	235,790	30,447
Log likelihood	-133461	-17235	-131096	-17009

Notes: Plant-level probit regression results where the reported coefficients represent the change the marginal probability of plant death at the mean of the regressors. Robust standard errors adjusted for clustering at the four-digit SIC industry level are in parentheses. Dependent variable indicates plant death between years t and t+5. ΔCost is the change in total trade costs between years t-5 and t. Relative Productivity is plant's labor productivity relative to its' industry's mean. Exporter is an indicator variable equalling unity if plant is an exporter in year t. Regressions cover two panels: 1982 to 1987 and 1987 to 1992. ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Coefficients for the regression constant and dummy variables are suppressed.

Table 4: Probability of Death, 1987-97

Regressor	Probit Export Next	Probit Export Next	Probit Export Next	Probit Export Next
ΔCost	-0.670	-7.928 ***	0.311	-5.192 ***
	(0.467)	(2.438)	(0.309)	(1.727)
Relative Productivity	0.028 ***	0.070 ***	0.031 ***	0.073 ***
	(0.004)	(0.009)	(0.003)	(0.009)
x ΔCost	-0.472 *	-0.434	-0.527 *	-0.324
	(0.277)	(1.548)	(0.305)	(1.628)
Industry Fixed Effects	SIC2	SIC2	SIC4	SIC4
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Sample	All	High Bilateral OECD Trade	All	High Bilateral OECD Trade
Observations	109,699	10,429	109,699	10,429
Log likelihood	-42663	-5758	-39294	-5622

Notes: Plant-level probit regression results where the reported coefficients represent the change the marginal probability of exporting at the mean of the regressors. Robust standard errors adjusted for clustering at the four-digit SIC industry level are in parentheses. Dependent variable indicates plant becomes an exporter between years t and t+5. ΔCost is the change in total trade costs between years t-5 and t. Relative Productivity is plant's labor productivity relative to its' industry's mean. Regressions cover two panels: 1982 to 1987 and 1987 to 1992. ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Coefficients for the regression constant and dummy variables are suppressed.

Table 5: Probability of Entering the Export Market, 1987-97

Regressor	OLS ΔExports	OLS ΔExports	OLS ΔExports	OLS ΔExports
ΔCost	-1.079 **	-2.419 *	-0.717 *	-0.173
	(0.484)	(1.490)	(0.425)	(1.692)
Industry Fixed Effects	SIC2	SIC2	SIC4	SIC4
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Sample	All	High Bilateral OECD Trade	All	High Bilateral OECD Trade
Observations	35,099	8,068	35,099	8,068
R^2	0.01	0.02	0.05	0.03

Notes: Plant-level OLS regression results. Robust standard errors adjusted for clustering at the four-digit SIC industry level are in parentheses. Dependent variable is plant's normalized real export growth between years t and t+5. (See text for description of normalization.) ΔCost is the change in total trade costs between years t-5 and t. Relative Productivity is plant's labor productivity relative to its' industry's mean. Regressions cover two panels: 1982 to 1987 and 1987 to 1992. ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Coefficients for the regression constant and dummy variables are suppressed.

Table 6: Growth of Exports, 1987-97

Regressor	OLS ΔMarket Share	OLS ΔMarket Share	OLS ΔMarket Share	OLS ΔMarket Share
ΔCost	-0.0010	0.0134	-0.0037	-0.0195
	(0.0032)	(0.0276)	(0.0046)	(0.0370)
Relative Productivity	-0.0005 ***	-0.0009 ***	-0.0005 ***	-0.0090 ***
	(0.0001)	(0.0003)	(0.0001)	(0.0003)
x ΔCost	0.0022	0.0661	0.0024	0.0631
	(0.0064)	(0.0615)	(0.0065)	(0.0638)
Exporter	-0.0001	0.0004 **	0.0001	0.0004 **
	(0.0001)	(0.0002)	(0.0001)	(0.0002)
x ΔCost	0.0214 **	0.0600 *	0.0220 **	0.0525 *
	(0.0099)	(0.0329)	(0.0110)	(0.0298)
x ΔCost x Relative Productivity	0.0384 *	0.0791	0.0391 *	0.0959
	(0.0207)	(0.1095)	(0.0206)	(0.1119)
Mills Ratio	-0.0011 ***	-0.0029 ***	-0.0015 ***	-0.0033 ***
	(0.0002)	(0.0007)	(0.0002)	(0.0009)
Industry Fixed Effects	SIC2	SIC2	SIC4	SIC4
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Sample	All	High Bilateral OECD Trade	All	High Bilateral OECD Trade
Observations	144,723	18,903	144,723	18,903
R^2	0.05	0.02	0.05	0.06

Notes: Plant-level OLS regression results. Robust standard errors adjusted for clustering at the four-digit SIC industry level are in parentheses. Dependent variable is change in plant's domestic market share between years t and t+5. ΔCost is the change in total trade costs between years t-5 and t. Relative Productivity is plant's labor productivity relative to its' industry's mean. Exporter is an indicator variable equalling unity if plant is an exporter in year t. Mills Ratio controls for plant survival. Regressions cover two panels: 1982 to 1987 and 1987 to 1992. ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. Coefficients for the regression constant and dummy variables are suppressed.

Table 7: Change in Domestic Market Share, 1987-92