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EXPORTING AND PRODUCTIVITY IN THE USA

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Exporting is often touted as a way to increase economic growth. This paper examines the interaction between exporting and productivity growth in US manufacturing. While exporting plants have substantially higher productivity levels, there is no evidence that exporting increases plant productivity growth rates. The higher productivity of exporters largely predates their entry into exporting. However, within the same industry, exporters do grow faster than non-exporters in terms of both shipments and employment. Exporting is associated with the reallocation of resources from less efficient to more efficient plants. In the aggregate, these reallocation effects are quite large, making up over 40 per cent of total factor productivity growth in the manufacturing sector. Half of this reallocation to more productive plants occurs within industries and the direction of the reallocation is towards exporting plants.

I. INTRODUCTION

Recent years have seen a resurgence in interest in the role of firms in international trade. At the same time, a sharp debate has focused on the links between international trade and economic growth. While the role of trade in promoting economic well-being has a long and venerable tradition, the interaction between international trade and long-run output and productivity movements is less well understood. In this paper, we combine these two research agendas and use microeconomic data to explore the relationship between productivity and exporting within economic units. We focus our analysis by asking whether there are productivity effects at a more aggregate level as a result of the reallocation

[1] We are grateful to seminar participants at the NBER, Dartmouth, Harvard, NYU, Toronto, Yale, the IMF, and the World Bank 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. 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.

of resources across plants or industries. We provide direct evidence based on microeconomic data of how trade might be related to aggregate total factor productivity (TFP) growth rates.

This paper examines the interaction between exporting and plant characteristics in increasing productivity growth in US manufacturing. We concentrate on the hypothesis that exporting has a positive impact on the growth rate of aggregate productivity. Within this general framework, we consider two distinct but not mutually exclusive paths for exporting to lead to increased productivity. First, we consider the possibility that firms become more productive when they enter the export market, the so-called *learning by exporting* hypothesis. Second, we examine the importance of productivity growth driven by the reallocation of economic activity from less productive domestic firms to more productive exporters. We use microeconomic data to look for evidence that participation in export markets leads to faster productivity growth for plants, industries, and manufacturing as a whole.

The relationship between exporting and productivity has important implications for several current areas of research and policy. The debate on the role of international openness in facilitating economic growth has been conducted almost exclusively with aggregate cross-country data. Several recent studies, including Ben-David (1993) and Sachs and Warner (1995), have provided empirical evidence that trade and growth are positively related. Ben-David (1993) shows that members of the EEC had faster output growth rates as trade increased following the removal of trade barriers.[2] Sachs and Warner (1995) conclude that a substantial fraction of the differences in cross-country growth rates over a 30-year period can be correlated with a measure of openness to trade. Marin (1992) finds that an outward-oriented regime is associated with productivity growth in industrialized countries. A recent collection of research on openness and growth (Proudman and Redding, 1998) conducts both cross-country and cross-industry analyses and strongly concludes that trade facilitates productivity growth. In all this work, the exact mechanism by which openness affects growth is not revealed. In this paper, we look at some of the underlying dynamics induced by increasing trade. We test whether international trade increases productivity growth within economic units or whether there are any productivity effects at a more aggregate level due to the reallocation of resources across plants or industries.

This paper is a natural extension of the recent work on the microeconomics of trade and exporting. There is substantial accumulated evidence that the act of exporting occurs in firms with very different observable characteristics, even within the same industry.[3] Exporting plants have higher productivity and shipments levels and are more technologically sophisticated than other plants in the same industry (Bernard and Jensen, 1995). However, a growing body of work has suggested that exporting confers little or no benefit in the form of faster productivity growth at the plant level (see, for example, Clerides *et al*., 1998; Bernard and Jensen, 1999; Delgado *et al*., 2002). We extend that work by considering not just the within-plant effects of exporting, but the importance of cross-plant and cross-industry reallocations.

Using plant data, we find strong evidence that exporters are more productive than non-exporters and that this productivity difference predates any entry into exporting. At the same time, we find little evidence that exporting increases productivity growth rates relative to domestic activity. However, exporters do grow faster in terms of both domestic and foreign shipments than do non-exporters. We confirm that, both within and across industries, exporting is associated with the reallocation of inputs, both labour and capital, from less efficient to more efficient plants. These effects are not predominantly associated with the changing fortunes of different industries as fully half of this reallocation occurs within industries. Our findings provide strong evidence that increased export opportunities can lead to aggregate productivity gains.

The paper proceeds as follows. First we present the micro evidence on the productivity–exporting nexus and results on the growth of exporters and non-

[2] See Slaughter (2001) for a discussion of the caveats in interpreting these results as causal.

[3] For evidence from other countries, see Bernard and Wagner (1997) on German plants, Aw and Hwang (1995) for Taiwanese firms, Baldwin and Gu (2004) for Canada, and Greenaway and Kneller (2004) for the United Kingdom.

exporters. In section III, we decompose changes in aggregate productivity in manufacturing into components due to within-plant productivity increases and the reallocation of resources across plants and industries. Section IV concludes.

II. TRADE AND PRODUCTIVITY

We begin by outlining several mechanisms by which trade might interact with productivity levels. We recognize the possibility that faster productivity growth allows firms, industries, and the economy to increase the flow of exports. Roberts and Tybout (1997) develop a model of exporting with sunk costs of entry and test it on a sample of Colombian firms.[4] In the presence of these entry costs, only the relatively productive firms will choose to pay the costs and enter the foreign market. The implied relationship between exporting and productivity is positive in a cross-section of firms or industries, but the causality runs from productivity to exporting. Substantial sunk costs of export entry are not limited to developing countries. Bernard and Jensen (2004) find significant sunk costs for US plants and Bernard and Wagner (2001) get similar results for firms in Germany, a relatively open, developed economy.

Traditional, static trade models yield predictions about the role of trade in improving productivity. For example, a simple one-factor Ricardian model with specialization after opening to trade yields increased welfare for all countries. By assumption, there is no role for within-industry productivity increases, but relative price changes increase the real output produced in each country and labour moves towards the industry with comparatively high labour productivity.

Several recent theoretical papers (Bernard *et al*., 2003*b*, 2004; Melitz, 2003) emphasize the importance of trade-driven reallocation effects in aggregate productivity. Bernard *et al*. (2003*b*) develop a Ricardian model of heterogeneous plants and trade. For individual plants, *ex-ante* productivity differences determine whether the plant exports or not; exporting does not drive productivity. However, reductions in trade barriers or other increases in openness will increase aggregate productivity as more productive plants grow and the least productive plants fail. Melitz (2003) develops a dynamic industry model with heterogeneous firms where trade causes reallocations of resources among firms in an industry. Only the most productive firms enter the export market and the least productive stop producing altogether. Increases in the industry's exposure to trade lead to additional inter-firm reallocations towards more productive firms. Bernard *et al*. (2004) extend the heterogeneous-firm framework to a world with comparative advantage and show that trade cost reductions can induce differential industry productivity effects in a world with endowment-driven comparative advantage.[5] Throughout the rest of this paper, we look for both within-industry, and within-firm, effects of trade, as well as reallocative effects owing to shifting composition of firms within industries, or across industries within manufacturing.

(i) Data Sources

The data used in this paper come from the Annual Survey of Manufactures (ASM) from the Longitudinal Research Database (LRD) of the Bureau of the Census. Since we are interested in behaviour before and after exporting, we choose our sample to contain the longest currently available period of continuous coverage on exports, 1983–92. For comparisons involving more than 1 year we are limited to plants included in the ASM. Its design imposes some structure on our analysis. Some plants are included with certainty in each ASM 5-year wave. These 'certainty' cases include all plants with more than 250 employees. Other, generally smaller plants, are included with some probability (<1) in each wave. However, if a non-certainty plant is included in one 5-year wave it will not be included in the next. See US Bureau of the Census (1987) for more information. All industries are classified on a 1972 Standard Industrial Classification (SIC) basis. This results in an unbalanced panel with 50–60,000 plants in each year. Owing to missing data on capital

[4] Clerides *et al*. (1998) also find evidence of sunk costs in Morocco and Mexico.

[5] Bernard *et al*. (2003*a*) find strong support for the reallocative predictions of these heterogeneous-firm trade models. In particular, they find that the probability of death and the likelihood of becoming an exporter both rise when trade costs decline.

stocks from 1988 to 1991 we are forced to construct our own capital stock series from the reported investment series.[6]

(ii) Exporting, Growth, and Productivity at Plants

To develop our understanding of the relationship between exporting and productivity, we look at data on individual plants in the manufacturing sector. Exporting plants have desirable performance characteristics relative to non-exporters, especially labour productivity. Bernard and Jensen (1999) report plant labour productivity differentials 16–19 per cent higher for exporters in the same four-digit industry. They also report TFP differentials of 13–16 per cent, assuming a common production function within the four-digit industry with time-varying coefficients. Here, since we are interested in the role of exporting in aggregate productivity growth, we estimate all our specifications with plant-level observations weighted by their sampling probabilities in the LRD. Throughout the paper, our productivity measures are derived from plant-level estimates of multi-factor productivity. All our estimates of this use an Olley–Pakes (1996) measure derived from a time-varying five-factor industry production function.[7] However, none of our results depends on the specific form of the productivity measure. Labour productivity and alternative TFP measures yield similar results.

If trade improves productivity at individual firms, we would expect firms involved in international trade to have faster productivity growth than firms engaged only in production for the domestic market. We look at the relationship between the export status of a plant today and subsequent productivity performance in Table 1. Regressions are of the form

$$\Delta \ln \text{Productivity}_{it+1} = \alpha + \beta \text{Exporter}_{it} + \gamma Z_{it} + \varepsilon_{it}. \quad (1)$$

The set of additional controls, Z_{it}, varies across specifications. Column 1 adds no controls and just compares mean productivity growth rates at exporters and non-exporters. Column 2 includes year dummies, while columns 3 and 4 add two-digit (SIC) and four-digit industry dummies, respectively. Thus, we are comparing the productivity growth rates within industries in the same year. Each observation is weighted by its sampling probability in the ASM to generate the universe of manufacturing plants in the USA.

We find no evidence that the export status of a plant this year is significantly positively correlated with 1 year ahead productivity growth. For all specifications, we obtain actually negative coefficients; exporters today have productivity growth rates 0.72 per cent per year lower than similar plants producing solely for the domestic market.

One possible explanation for the sub-par productivity performance of exporters is that we are mixing firms that continue exporting, so-called export successes, with those that stop, export failures. Similarly, non-exporters today may enter or remain out of the market. To address these issues, we rerun our regressions with three export-status dummy variables, one for exporters in both periods [1,1], one for firms that leave the export market, stoppers [1,0], and one for new exporters, [0,1].[8] The base group is the set of firms that export in neither year. The results, presented in Table 2, indicate that the four groups have very different productivity trajectories. In particular, in the year that they enter, starters have significantly faster productivity growth rates than other firms. The magnitudes of the TFP growth rate differences for starters are relatively large, from 1.2 to 2.5 per cent higher than plants that do not export in either year. This large effect of export entry on productivity has been identified in other studies. However, it is not possible to determine

[6] Unfortunately the data on plant-level capital stocks were not collected for the years 1988–91. To construct plant measures of TFP we must construct proxies for plant capital from initial- or ending-year capital stocks and the data on investment in the intervening years using a perpetual inventory method. Since we do not directly observe depreciation, we calculate an average depreciation from the years for which we have full information on capital stocks and investment. Every plant in our sample appears in either the 1987 or 1992 Census of Manufactures or both. We construct separate estimated capital stocks from each endpoint and for plants in the sample in both 1987 and 1992 we use the average of the estimates.

[7] The industry production function is given by $y_{it} = \beta_0 + \beta_a a_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it}$ where y_{it} is the log of the value of real production from the firm, a_{it} is the age of the firm, k_{it} is the capital stock, l_{it} is the vector of labour inputs, m_{it} is the vector of purchased material inputs, ω_{it} is the productivity, and ε_{it} is any unforecastable shock.

[8] We caution that by constructing our variables in such a fashion, we are using *ex-post* information on the right-hand side of the regression. No conclusions about directions of causality are warranted.

Table 1
Exporters and TFP Growth

	Dependent variable: annual plant TFP growth rates			
Export dummy	–0.0021	–0.0020	–0.0056***	–0.0072***
	(0.0013)	(0.0013)	(0.0014)	(0.0015)
Year dummies		X	X	X
Industry dummies (two-digit)			X	
Industry dummies (four-digit)				X

Notes: Observations are weighted by their sampling probabilities in the ASM. All regressions were run with Huber–White corrections. Standard errors are in parentheses. *** Indicates significance at the 1 per cent level. Plant controls include (log) total employment, average wage, and share of non-production workers in total employment.

Table 2
Plant Export Status and Productivity Growth

Export status	Dependent variable: annual plant TFP growth rates			
Stopper [1,0]	–0.0023	–0.0045*	–0.0075***	–0.0092***
	(0.0025)	(0.0025)	(0.0025)	(0.0025)
Throughout [1,1]	0.0000	0.0004	–0.0030**	–0.0040**
	(0.0015)	(0.0015)	(0.0015)	(0.0016)
Starter [0,1]	0.0250***	0.0200***	0.0170***	0.0156***
	(0.0024)	(0.0024)	(0.0024)	(0.0024)
Year dummies		X	X	X
Industry dummies (two-digit)			X	
Industry dummies (four-digit)				X

Notes: Coefficients represent differences from growth rates at plants that did not export in either year, [0,0]. Observations are weighted by the product of plant employment and the ASM sampling probabilities. All regressions were run with Huber–White corrections. Standard errors are in parentheses. *** Indicates significance at the 1 per cent level. ** Indicates significance at the 5 per cent level. * Indicates significance at the 10 per cent level. Plant controls include (log) total employment, average wage, and share of non-production workers in total employment.

whether exporting is responsible for the productivity surge or whether the productivity surge leads to the export decision. Similarly, plants that exit the export market have productivity growth rates 0.2–0.9 per cent lower than continuing non-exporters.

The results for continuing exporters depend on the specification. Unconditionally, exporters have TFP growth rates exactly the same as non-exporters. In part this is because exporting industries have higher TFP growth rates overall. Within industries, we again find that continuing exporters underperform non-exporters in terms of productivity growth.

The results in this section speak directly to the question of whether an export presence improves subsequent productivity performance at the micro level. Unconditionally, exporters fare no better, and often worse, than non-exporting plants. This is in large part because of the good productivity performance of entrants and the poor performance of exiting plants. Continuing exporters and continuing non-exporters in the same industry have virtually identical productivity trajectories. If exporting has a role in improving industry productivity growth it must come through some other channel than improving within-plant outcomes.

(iii) Productivity Before and After Entry (and Exit)

In this section, we consider the relationship between productivity paths and exporting in greater detail. The previous results show that productivity growth is higher at entrants, lower at exits, and slightly worse for continuing exporters than at continuing non-exporters. This still leaves open the question of what exactly is going on in plants that are entering and exiting the export market. To shed light on these changes, we run a regression of the form

$$\ln PR_{ijt} = c_{jt} + \sum_{e \in E} \sum_{x \in X} d_i^e \cdot d_{ijt}^x + \varepsilon_{ijt} \qquad (2)$$

where $\ln PR_{ijt}$ is the log level of the plant productivity measure, d_i^e is an indicator variable for the export firm type, and d^x_{ijt} is an indicator variable for the export status of firm that year. This regression allows us to calculate a productivity trajectory over time for different types of firms within an industry while controlling for aggregate year effects. We allow five firm export types, d_i^e, which are:

- always—exports in all years;
- starter—becomes an exporter during the period (and does not reswitch);
- other—switches export status more than once;[9]
- stopper—ceases exporting during the period (and does not reswitch);
- never—does not export in any year.

We consider 5-year intervals and thus are able to track firms from 2 years before entry (or exit), i.e. $d^x_{ijt} = -2$, through entry (or exit), i.e. $d^x_{ijt} = 0$, to 2 years after entry (or exit), $d^x_{ijt} = 2$. The interaction of the indicator variables will give us a picture of the relative productivity levels of all five types of firms as they move in and out of exporting.

Figure 1 shows the results for TFP for the different types of firms (omitting the 'other' category from the graphics but not the tables); Table 3 contains the coefficients and standard errors. Owing to the structure of the regressions, the figure and the table show us the productivity paths of plants net of any aggregate industry productivity increases. With this specification we can track the productivity path for plants for several years before and after they start exporting (or stop).

The differences in productivity levels between the types of plants are large, significant, and in the expected directions. Plants that always export are 8–9 per cent more productive than plants that never export. This confirms evidence from previous studies about the relative productivity of exporters and non-exporters and this does not change over time, confirming the results from the previous section that exporting is not changing the productivity paths of these plants.

The results for entering and exiting plants are of particular interest. New entrants into exporting have productivity levels significantly above continuing non-exporters, but significantly below continuing exporters fully 2 years before they start exporting. These plants are relatively good before they enter, improve through their first year of exporting, and then resemble the pool of continuing exporters. By the end of the 5-year window their productivity levels are not significantly below those of plants that exported throughout. Exits from exporting show comparable deterioration of their productivity levels. Several years prior to exit, these future export failures start at levels typically worse than their exporting counterparts and above non-exporters. But by the end of the period their productivity levels have fallen to those of plants that did not export at all.

These results offer two perspectives on the interaction between exporting and plant productivity. Times of transition, either in or out, are indeed associated with large productivity changes. However, these predate the start (or end) of exporting and are completed soon after entry (exit). In contrast, continuing exporting does not result in faster productivity growth rates.

(iv) Plant Growth—Shipments and Employment

One mechanism by which exporters may contribute to productivity gains in the industry or in the aggregate is through a combination of higher productivity levels and faster overall growth. The evidence

[9] This group is suppressed in the figures.

Figure 1
Paths of TFP (purged of industry and year effects)

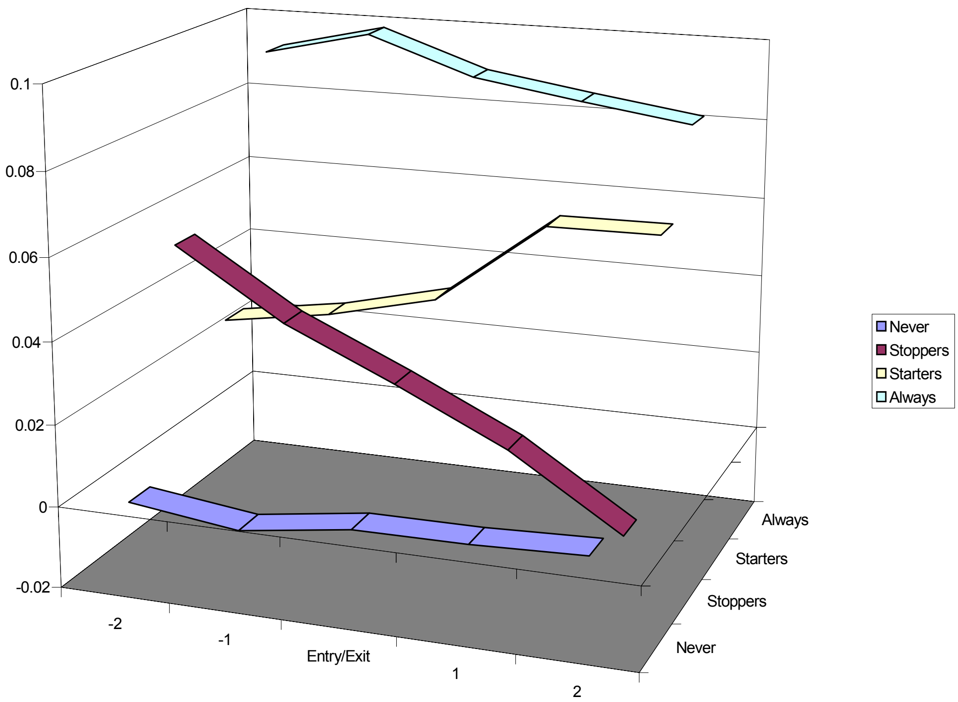

Table 3
TFP Levels by Plant Export Type Over Time

	Plant export type				
	Never	Stopper	Other	Starter	Always
2 years before entry/exit	0	0.055*+	0.024*+	0.029*+	0.093*
		(0.011)	(0.009)	(0.011)	(0.008)
1 year before entry/exit	–0.003	0.039*+	0.031*+	0.033*+	0.099*
	(0.006)	(0.010)	(0.008)	(0.010)	(0.007)
Year of entry/exit	0.001	0.027*+	0.020*+	0.040*+	0.090*
	(0.007)	(0.009)	(0.008)	(0.009)	(0.008)
1 year after entry/exit	0.001	0.014+	0.024*+	0.060*	0.085*
	(0.008)	(0.011)	(0.009)	(0.011)	(0.008)
2 years after entry/exit	–0.002	–0.004+	0.024*+	0.061*	0.082*
	(0.009)	(0.013)	(0.011)	(0.013)	(0.010)

Notes: The coefficients represent multi-factor productivity levels across years and plant types. Every plant is followed for one 5-year interval. All productivity levels are relative to that for continuous non-exporters in the first year. *Never* plants are non-exporters for five consecutive years. *Stopper* plants stop exporting in year 0. *Other* plants switch their export status more than once in the 5-year interval. *Starter* plants begin exporting in the middle year of the 5-year interval. *Always* plants continuously export for 5 years. * Indicates that the coefficient is significantly different at the 5 per cent level from plants that never export at the beginning of the 5-year interval. + Indicates that the coefficient is significantly different at the 5 per cent level from plants that always export at the end of the 5-year interval.

presented above suggests that high productivity firms enter the export market, rather than exporting leading to high productivity. However, if these high productivity exporters also grow faster, in terms of employment and output, we would expect to see rising industry productivity levels as economic activity (both output and employment) shifts to these high productivity exporting plants.

In this section we estimate the relationship between overall plant growth, both shipments and employment, and initial export status. We again estimate a regression of the form,

$$\Delta \ln \text{Size}_{it+1} = \alpha + \beta \text{Exporter}_{it} + \gamma Z_{it} + \varepsilon_{it}, \quad (3)$$

with similar sets of controls.

The results for employment, total value of shipments, and domestic shipments are given in Table 4. Unlike productivity growth rates, all measures of firm growth are strongly positively correlated with initial export status. Employment growth is 0.79–1.08 per cent per year faster at exporters than non-exporters. Results for growth in the total value of shipments range from 0.57 to 1.32 per cent. The results for domestic shipments are even more dramatic. Exporters expand their domestic shipments between 3 and 4 per cent faster than non-exporters.

(v) Employment Growth Before and After Entry (and Exit)

These results show that employment growth is high for both exporters and ongoing exporters. Again, this leaves open the question of what exactly is going on in plants that are entering and exiting the export market. We rerun the specification in equation (2) with employment growth rates as the dependent variable.

Figure 2 shows the results for employment growth for the different types of firms; Table 5 contains the coefficients and standard errors. The differences between the types of plants are significant and in the expected directions. Plants that always export have employment growth rates 2–4 per cent higher than plants that never export. New entrants into exporting start with higher employment growth rates than non-exporters, but lower than continuing exporters. These entrants see continued increases in their employment growth rates after they become exporters.

While exporting does not appear to improve productivity growth rates at the plant level, it is strongly correlated with increases in plant size. Both employment and shipments growth are significantly faster at exporters. In particular, these plants increase

Table 4
Exporting and Plant-size Growth

Dependent variable	Coefficients on exporter dummies in year-ahead growth regressions			
Employment growth	0.0108***	0.0091***	0.0096***	0.0079***
	(0.0013)	(0.0013)	(0.0013)	(0.0014)
Total shipments growth	0.0132***	0.0113***	0.0079***	0.0057***
	(0.0015)	(0.0015)	(0.0016)	(0.0017)
Domestic shipments growth	0.0364***	0.0344***	0.0337***	0.0302***
	(0.0015)	(0.0015)	(0.0016)	(0.0023)
Additional controls				
Year dummies		X	X	X
Industry effects (two-digit)			X	
Industry effects (four-digit)				X

Notes: Observations are weighted by their sampling probabilities in the ASM. All regressions were run with Huber–White corrections. Standard errors are in parentheses. *** indicates significance at the 1 per cent level.

Figure 2
Paths of Employment Growth Rates (purged of industry and year effects)

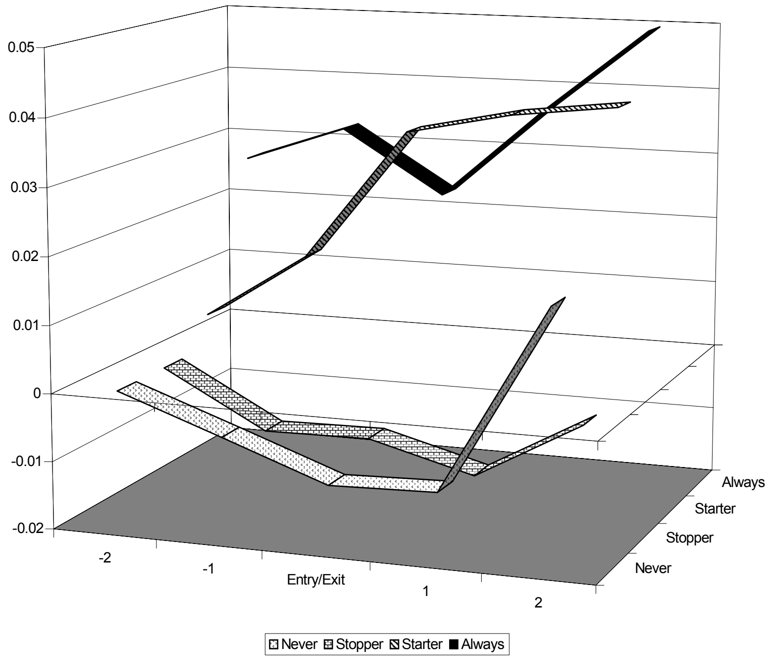

Table 5
Employment Growth Rates by Plant Export Type Over Time

	Plant export type				
	Never	Stopper	Other	Starter	Always
2 years before entry/exit	0	0.0000+	0.0097+	0.0050+	0.0271*
		(0.011)	(0.005)	(0.011)	(0.005)
1 year before entry/exit	–0.0055+	–0.0083+	0.0105	0.0151	0.0325*
	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)
Year of entry/exit	–0.0111+	–0.0081+	0.0062	0.0350*	0.0231*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
1 year after entry/exit	–0.0106+	–0.0122+	0.012	0.0383*	0.0370*
	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
2 years after entry/exit	0.017	–0.0033+	0.0412*	0.0402*	0.0496*
	(0.014)	(0.015)	(0.014)	(0.015)	(0.014)

Notes: The coefficients represent employment growth rates across years and plant types. Every plant is followed for one 5-year interval. All employment growth rates are relative to that for continuous non-exporters in the first year. *Never* plants are non-exporters for five consecutive years. *Stopper* plants stop exporting in year 0. *Other* plants switch their export status more than once in the 5-year interval. *Starter* plants begin exporting in the middle year of the 5-year interval. *Always* plants continuously export for 5 years. * Indicates that the coefficient is significantly different at the 5 per cent level from plants that never export at the beginning of the 5-year interval. + Indicates that the coefficient is significantly different at the 5 per cent level from plants that always export at the end of the 5-year interval.

their domestic shipments substantially faster than non-exporters. Combined with previous work on the productivity advantages in levels for exporters, these results suggest that the reallocation of resources across plants, both within and across industries, may be an important mechanism for trade to affect aggregate productivity growth. In the next section we attempt to quantify the aggregate impact of the rapid expansion of exporting plants.

III. REALLOCATION OF RESOURCES WITHIN AND ACROSS INDUSTRIES

The results from the previous section suggest that expansion of international trade, and exports in particular, may have effects predicted by the heterogeneous firm models of Bernard *et al*. (2003*b*, 2004) and Melitz (2003). Trade enables efficient producers within an industry, and efficient industries within the economy, to expand. As these relatively productive units grow, overall productivity levels rise. The lack of within-plant productivity effects indicates that the potential for higher long-run productivity growth rates is limited. In light of the evidence presented above, we decompose changes in industry and overall manufacturing productivity growth rates into within-plant and between-plant effects. Given our previous results, we expect to find significant between-plant effects for exporting plants. Some fraction of aggregate productivity growth will be due to the increased scope of activity at high-productivity, exporting establishments.

(i) Decomposing Aggregate Productivity Growth

The results on plant-level productivity changes suggest that continuous exporting plants do not have significantly higher productivity growth rates than continuous non-exporting plants (though they do have higher productivity levels), but that employment and shipments do grow faster at exporters. In this section, we attempt to quantify the importance of the increasing export orientation of US manufacturing on overall manufacturing TFP growth.

We can decompose the annual change in aggregate TFP into within-plant (own) and between-plant (reallocation) effects,[10]

$$\Delta PR_A = \sum_{i=1}^{I} \Delta(PR_i \cdot SH_i) = \underbrace{\sum_{i=1}^{I} \Delta SH_i \cdot \overline{PR_i}}_{ReallocationEffect} + \underbrace{\sum_{i=1}^{I} \Delta PR_i \cdot \overline{SH_i}}_{OwnEffect} \qquad (4)$$

where PR_i is the productivity at an individual plant and SH_i is the share of total output at the plant.

The *reallocation* effect captures productivity growth owing to the more rapid expansion of high-productivity plants relative to low-productivity plants. Formally, it is the product of the change in the output share from year $t-1$ to year t at the plant, SH_i, and the average TFP in year $t-1$ and t, $\overline{PR}_i$. The *own* productivity effect quantifies the importance of productivity growth at individual plants and is given by the product of the average output share and the change in the plant TFP.[11]

This decomposition allows us to quantify the degree to which aggregate productivity growth is driven by more productive plants growing larger or plants becoming more productive. A positive *reallocation* effect results from an increasing share of total output at plants with higher than average productivity. The *own* effect is positive if the mean of output-weighted, within-plant productivity growth is positive. This component will be dominated by plants with relatively large productivity changes in levels and/or large plants with positive productivity growth. Of course, if the high-productivity plants have the highest productivity growth rates then the *own* effect will be large.

An advantage of the decomposition presented above is that we can group plants into categories, e.g. by four-digit industries or by export status. We transform the decomposition given above into one for aggregate productivity growth rates,

[10] For our decomposition analysis, we work only with continuing plants, i.e. plants that exist in years t and $t+1$. The exclusion of plant failures and plant births does not have a significant effect on our results.

[11] We calculate the components year by year for each plant and then average across all the years in the sample.

Table 6
Plant-level Decomposition of Productivity Growth—Export Status of the Plant

Export status	Growth rates Reallocation effect	Own-productivity effect	Overall
Stopper [1,0]	–0.0041	–0.0003	–0.0044
Throughout [1,1]	0.0123	0.0055	0.0178
Starter [0,1]	0.0045	0.0014	0.0059
Neither [0,0]	–0.0067	0.0016	–0.0051
All	0.0059	0.0082	0.0142
% of total growth rate			
Stopper [1,0]	–28.90	–1.80	–30.70
Throughout [1,1]	86.80	38.70	125.50
Starter [0,1]	31.40	10.00	41.30
Neither [0,0]	–47.30	11.20	–36.10
All	41.90	58.10	100.00

Notes: The *reallocation* effect represents the effect on aggregate productivity of a change in output shares across categories. The *own-productivity* effect represents the effect on aggregate productivity of within-plant increases in productivity in the category.

$$\Delta PR_A = \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta SH_i \cdot \overline{PR_i}}_{ReallocationEffect} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta PR_i \cdot \overline{SH_i}}_{OwnEffect}$$

where *j* represents the group for plant *i*. We cluster plants into four groups based on their export status in the 2 years (starter, throughout, stopper, and neither). We can then compute the fraction of overall growth due to growth of plants in each category and due to within-plant productivity growth in each category.

In Table 6, we decompose annual average aggregate TFP growth for continuing plants in the manufacturing sector.[12] Overall TFP at continuing manufacturing plants grew at an average annual rate of 1.42 per cent from 1983 to 1992. While the dominant source of aggregate productivity growth was the own-productivity effect, accounting for 58 per cent of the total, changes in output shares among plants were surprisingly important in overall growth. Forty-two per cent of aggregate TFP growth came about because of increasing output shares at more productive plants. These estimates suggest important roles for the reallocation of resources towards more productive plants.[13]

Our results so far have suggested that continuing exporters grew substantially faster in terms of employment and output and thus should account for the preponderance of any reallocation effects. The decomposition results confirm this, as over 86 per cent of overall TFP growth comes from the expansion of continuing exporters. The net effect of entrants and exits from exporting is slightly positive in terms of the change in output shares, while continuing non-exporters show negative reallocation components owing to their slower than average output growth. Put in other terms, had there been no changes in relative output shares across plants, TFP growth in the manufacturing sector would have been 0.82 per cent instead of 1.42 per cent per year.

Turning to the own-productivity components, we find once again that continuing exporting plants are by far the most important group, with own-produc-

[12] The computer industry (SICs 3571, 3572, 3575, and 3577) represents a problem in the 1972 SIC classification owing to difficulties with the output deflator. Our general conclusions are not sensitive to the inclusion of these sectors.

[13] Baily *et al*. (1992) estimate reallocation effects of 31 per cent for the period 1972–87 using similar methods.

Table 7
Industry-level Decomposition of Productivity Growth

	Reallocation effect	Own-productivity effect	Overall
Growth rates			
All	0.0032	0.011	0.0142
% of total growth rate			
All	22.50	77.50	100.00

Notes: The *reallocation* effect represents the effect on aggregate productivity of a change in output shares across industries. The *own-productivity* effect represents the effect on aggregate productivity of within-plant increases in productivity in the industry.

tivity effects more than four times as large as continuing non-exporters. This may seem surprising after the plant-level results, which showed no relative productivity growth advantage for exporters (or even continuing exporters). However, plants with high initial productivity levels contribute more to aggregate productivity growth than plants with low productivity levels, even if they have the same growth rates. Exporters are substantially more productive than non-exporters in the same industry, and they are more likely to be located in high-productivity industries. This combination of level effects leads exporters to contribute disproportionately to aggregate growth.

One question is whether these reallocation effects are occurring within or across industries. Most trade theories use the industry as the unit of analysis and hypothesize gains from cross-industry changes. The decomposition above argues that cross-plant magnitudes are substantial. An industry-level decomposition reported in Table 7 shows that just over half of the reallocative activity (22.5 per cent) occurred within four-digit industries and half occurred because of changing output shares across industries (19.4 per cent). The big impact on manufacturing productivity of fast growth at exporting plants is as much a within-industry phenomenon as it is one of the relative rise and fall of different sectors.

These decompositions overstate the role of trade in the reallocation of resources and overall TFP growth. We know that domestic shipments also grow more quickly at exporting plants, and that exports typically make up only a small fraction of plant output (see Bernard and Jensen, 1995). To provide a better estimate of the relative importance of domestic and foreign shipments we further break down reallocation and own-productivity effects into domestic and foreign components. The decomposition is given by

$$\Delta PR_A = \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta DSH_i\cdot\overline{PR_i}}_{\text{Domestic Reallocation Effect}} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta FSH_i\cdot\overline{PR_i}}_{\text{Foreign Reallocation Effect}} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta PR_i\cdot\overline{DSH_i}}_{\text{Domestic Own Effect}} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta PR_i\cdot\overline{FSH_i}}_{\text{Foreign Own Effect}}$$

where DSH_i is the ratio of domestic shipments by the plant to total manufacturing output and FSH_i is the ratio of exports by the plant to total manufacturing output. We assume for this analysis that productivity levels are the same within plants for both types of shipments. The results are presented in Table 8.

As expected, continuing exporters show positive reallocation contributions for both domestic and foreign shipments. This confirms that these plants are in general growing faster. However, the increases in foreign shipments at these plants are the main source of reallocative activity. Fully 70 per cent of the reallocation effect at continuing exporters is due to export growth. In contrast, exports contribute relatively little to the own-productivity effects (12 per cent). This is because exports, while growing rapidly, remain a relatively small share of total shipments at exporting plants.

Table 8
The Contribution of Exports to Reallocation and Productivity Growth

Export status	Reallocation effect		Own-productivity effect		Overall
	Domestic	Exports	Domestic	Exports	
Growth rates					
Stopper [1,0]	0.0049	–0.0090	–0.0001	–0.0001	–0.0044
Throughout [1,1]	0.0037	0.0086	0.0048	0.0007	0.0178
Starter [0,1]	–0.0066	0.0111	0.0013	0.0001	0.0059
Neither [0,0]	–0.0067	0.0000	0.0016	0.0000	–0.0051
All	–0.0048	0.0107	0.0076	0.0007	0.0142
% of total growth rate					
Stopper [1,0]	34.30	–63.30	–0.80	–1.00	–30.70
Throughout [1,1]	26.00	60.90	33.80	4.90	125.60
Starter [0,1]	–46.60	77.90	9.30	0.70	41.30
Neither [0,0]	–47.40	0.00	11.20	0.00	–36.10
All	–33.60	75.50	53.50	4.60	100.00

Notes: The *reallocation* effect represents the effect on aggregate productivity of a change in output shares across categories. The *own-productivity* effect represents the effect on aggregate productivity of within-plant increases in productivity in the category. Plant output is separated into domestic shipments and exports. Plant productivity is assumed to be the same for both types of shipments.

Since these decompositions are not unique, we cannot use them to quantify precisely the importance of exporting to aggregate productivity growth. However, in an effort to provide a sense of their importance, we focus on two numbers which most likely bound the importance of the role of exporting to TFP growth. The first comes from the results reported in Table 8. Summing the reallocative effects and own-productivity effects for continuing exporters attributed to foreign shipments, we find an upper bound of 65 per cent of aggregate TFP growth. We caution that this is probably a large overstatement of the importance of exporting in aggregate manufacturing.

To calculate a lower bound, we assume that the paths for productivity and domestic shipments for plants would not change if they had no access to the foreign market. We then re-estimate our decomposition in Table 7, eliminating exports from total shipments and recalculating plant output shares. This increases the importance of non-exporters, but also assumes that in the absence of a foreign market, the more productive exporting plants could not further increase their domestic market share. The new counterfactual decomposition is given in Table 9. As expected, the bulk of the change in aggregate productivity is concentrated mostly in the reallocative effect which falls 15 per cent. Aggregate TFP growth under these assumptions falls by 7.8 per cent, which represents our lower bound for the importance of exporting to aggregate TFP growth.

IV. CONCLUSIONS

The interplay between productivity and international trade has implications for a wide variety of fields in economics, from the cross-country study of long-run growth to the evolution of inequality within countries. In this paper, we have explored the relationship between productivity and exporting in the US manufacturing sector. Building on previous research, we have found no evidence that exporting *per se* is associated with faster productivity growth rates at individual plants. The positive correlation between exporting and productivity levels appears to come from the fact that high productivity plants are more likely to enter foreign markets. The producti-

Table 9
Shutting Down the Export Sector—A Counterfactual

Export status	Reallocation effect	Own-productivity effect	Overall
Growth rates			
Stopper [1,0]	0.0057	–0.0001	0.0056
Throughout [1,1]	0.0092	0.0051	0.0143
Starter [0,1]	–0.0064	0.0014	–0.005
Neither [0,0]	–0.0035	0.0017	–0.0018
All (without exports)	0.0050	0.0081	0.0131
% of actual productivity growth	84.70	98.70	92.20
% of total growth rate			
Stopper [1,0]	43.40	–1.00	42.50
Throughout [1,1]	70.30	38.80	109.10
Starter [0,1]	–48.70	10.80	–37.90
Neither [0,0]	–26.70	13.00	–13.70
All	38.40	61.60	100.00

Notes: This counterfactual decomposition indicates how important exports are to aggregate productivity growth. Plant exports have been dropped from the calculation; domestic shipments and plant productivity levels are assumed to be unchanged. The *reallocation* effect represents the effect on aggregate productivity of a change in domestic shipment shares across categories. The *own-productivity* effect represents the effect on aggregate productivity of within-plant increases in productivity in the category.

vity path for a plant switching from non-exporter to exporter shows a rise in productivity levels before and during entry, and a flat trajectory thereafter.

High productivity before entry is not the end of the story. Our results show that employment and output growth rates are much higher at exporters and employment growth continues to increase after entry. This faster growth of exporting plants, coupled with their higher productivity levels, provides an alternative, reallocative mechanism for exporting to augment aggregate productivity growth. The magnitudes of these shifts of employment towards high productivity exporters are quite large. From 1983 to 1992, more than 40 per cent of TFP growth in the manufacturing sector resulted from changing output shares across plants. Almost all of these reallocative effects resulted because high-productivity exporters grew faster than lower-productivity non-exporters. Exporters account for 46 per cent of total employment in our sample, but contribute a far greater percentage to aggregate TFP growth.

Trade improves welfare by facilitating the growth of high-productivity plants, not by increasing productivity growth at those plants. The results contain both good news and bad news for long-run growth rates. Increased trade will contribute to aggregate productivity growth, but the effect is one of increased levels, rather than an increase in the long-run growth rate itself. However, the magnitudes of these 'one-time' level changes are large and, given the relatively low export shares for US industries, are far from being exhausted.

The results presented here suggest that the within-industry effects of trade may be as, or more, important than the cross-industry effects. Much work remains to be completed to develop our understanding of the impact of international trade on productivity growth, especially concerning the role of imports on productivity and employment. Of particular interest is an examination of the role of international trade as a force for efficient reallocation of resources in countries away from the technology and productivity frontier.

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