Trade, Technology, and Plant Performance

J. Bradford Jensen
Economics and Statistics Administration
Bureau of the Census
Center for Economic Studies

and

Nathan Musick
Economics and Statistics Administration
Office of Policy Development
Office of Business and Industrial Analysis

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TABLE OF CONTENTS

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PREFACE*

Previous research shows that both exporting and the use of advanced technologies independently enhance the performance of U.S. manufacturing plants in a variety of ways. The research presented below shows that plants that *both* export and use advanced technology outperform other plants in a number of important ways: they increase their employment more rapidly, they pay higher wages, and they are less likely to fail. The research also shows that manufacturing plants that use advanced technologies are more likely to export.

Methodology

The results reported in this paper are based on the performance of a sample of U.S. manufacturing plants over 1987 and 1992.[1] Plants are divided into four groups based on whether or not they exported, and on whether they were high-tech or low-tech.[2] The split between high-tech and low-tech is based on the number of advanced technologies used at each plant. The relationship between exporting and technology and plant performance is gauged by comparing the performance of the four basic groups of plants. Simple regression techniques are used to control for the effects of plant size and industry. In general low-tech plants that did not export performed worse than the other three groups. The performance of the other three groups of plants is expressed relative to that of low-tech non-exporters. For example, Table 1 shows the extent to which employment growth in the three other groups of plants exceeded the employment growth of low-tech non-exporters, after controlling for the effects of plant size and industry.

Impact on Employment

Table 1 reflects changes in employment over 1987 to 1992 in those plants that operated in both years. The results are striking. Employment at plants that are both high-tech and exporters grew faster than employment at other plants. The top row of the left column indicates that employment at high-tech plants that export increased by 36 percentage points more than comparable low-tech plants that do not export. Both exporting and

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* Lewis S. Alexander, Chief Economist, Economics and Statistics Administration prepared the Preface to this report.

[1] Information was available on what advanced technologies the plants used in 1988, and whether the plants exported in 1987 and 1992. This was combined with standard data on employment wages, output, and industrial classification.

[2] The four categories are: high-tech plants that exported; high-tech plants that did not export; low-tech plants that exported; and low-tech plants that did not export.

technology use clearly contribute independently to plant performance: high-tech non-exporters (left-hand column, bottom row) increased employment by 13 percentage points more than comparable low-tech non-exporters and low-tech exporters (right-hand column, top row) increased their employment by 21 percentage points more. In this case exporter status is based on whether or not plants exported in 1992. This includes plants that exported in both 1987 and 1992, and those that started exporting during the period.[3]

Table 1:
Relationship BetweenTechnology Use, Exporting, and Employment Growth in Manufacturing Plants, 1987-1992
(percent)

	High-tech	Low-tech
Exporter	36	21
Non-exporter	13	-

Note: Difference in employment growth for each group of plants relative to employment growth in low-tech non-exporters. Exporter status is based on whether or not plants exported in 1992. Estimates are based on a regression that separately accounts for the effects of plant size and industry.

Wages

Table 2 shows the relationship between exporting and technology use and wages paid by manufacturing plants in 1992. Once again high-tech exporters out perform other plants. As shown in the top row of the left-hand column, high-tech exporters paid wages that were 16 percent higher than those paid at comparable low-tech non-exporters. Again, technology and exporter status have independent effects: high-tech non-exporters (left-hand column, bottom row) paid wages that were 7 percent higher than comparable low-tech non-exporters and low-tech exporters (right-hand column, top row) paid wages that were 8 percentage points higher.[4]

Higher wages may reflect differences in productivity levels. It has also been shown that exporting and technology use are associated with higher levels of productivity in comparable ways.[5]

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[3] Plants that exported over the whole period and those that began exporting during the period increased their employment by essentially the same amount. Similarly, there was no significant difference in the performance of plants that exported in 1987 but not in 1992 and those that did not export in either period.

[4] Results for 1987 were similar.

[5] The level of productivity among high-tech exporters was 27 percent higher in 1992 than at comparable low-tech non-exporters. Technology and exporter status had independent effects: productivity among high-tech non-exporters was 11 percent higher than at comparable low-tech non-exporters and low-tech exporters had productivity levels that were 15 percent higher than low-tech non-exporters. Similar results hold for 1987.

Table 2:
Relationship BetweenTechnology Use, Exporting, and Wage Rates in Manufacturing Plants, 1992
(percent)

	High-tech	Low-tech
Exporter	16	8
Non-exporter	7	-

Note: Difference in average wage rates paid in each group of plants relative to average wages paid in low-tech non-exporters. Exporter status is based on whether or not plants exported in 1992. Estimates are based on a regression that separately accounts for the effects of plant size and industry.

Plant Failure Rates

The average failure rate for low-tech non-exporters over the period 1987 to 1992 is 29 percent. Failure rates are lower for the other groups of plants. Table 3 shows the relationship between technology use and exporter status (in 1987) on plant failure rates after controlling for the effects of plant size and industry. The failure rate for high-tech exporters (shown in the top row of the left-hand column) is about 12 percentage points lower than failure rates of comparable low-tech non-exporters. This difference is more than 40 percent of the average failure rate of the latter group of plants. Again exporting and technology use have independent effects: failure rates for high-tech non-exporters (left-hand column, bottom row) are about 8 percentage points lower than comparable low-tech non-exporters and: failure rates for low-tech exporters (right-hand column, top row) that are about 9 percentage points lower.

Table 3:
Relationship BetweenTechnology Use, Exporting, and Failure Rates Among U.S. Manufacturing Plants, 1987-1992
(percentage points)

	High-tech	Low-tech
Exporter	-12.3	-9.1
Non-exporter	-7.9	-

Note: Difference in estimated failure rates for each group of plants relative to failure rates for low-tech non-exporters. Exporter status is based on whether or not plants exported in 1987. Estimates are based on a regression that separately accounts for the effects of plant size and industry. Probabilities are evaluated at the median plant size in the sample.

Impact of Technology Use on Exporting

The new research also considers the contribution of advanced technology to export performance. It is shown that high-tech plants are more likely to export. For, example among plants that did not export in 1987, those that used a large number of advanced technologies were more likely to export in 1992. Similarly, among plants that exported in 1987, high tech plants were more likely to keep exporting.

In summary, the success of individual manufacturing establishments depends on many factors. While it is not possible to infer causality from the simple results presented here, it is clear that exporting and the use of advanced technology are part of a set of strategies that successful manufacturing plants employ to grow. Previous work shows that these two factors are associated independently with plant performance. The new results presented here document that plants that both export *and* use advanced technologies perform better than those that do just one.

I. INTRODUCTION

Until now the associations between exporting and plant performance, and between advanced technology use and plant performance, have been addressed separately. Also, data available to the earlier studies do not go beyond 1987. Our work builds on this body of literature in two important ways.

First, we consider how robust earlier results are to an analysis using more recent (1992) and complete Census of Manufactures data on plant characteristics. Our newer dataset allows us to examine exporter performance under a different set of circumstances than those present for earlier studies. Much of the 1976-1987 interval considered by Bernard and Jensen (1995) corresponds to a period of sharp dollar appreciation. In contrast, the dollar declined steadily during the 5 years covered by our 1987-1992 data. Also, we utilize plant information on *both* exporting and advanced technology use. Thus, we can investigate whether the positive association with plant success, found for each activity when considered separately in earlier studies, continues to hold when both are incorporated into an investigation of plant performance.

Second, we investigate a possible link between exporting and advanced technology use. We ask whether current advanced technology use is associated with future exporting. Also, we test for an interaction effect—we ask whether plants that both export and use advanced technologies relatively intensively display a performance differential greater (or less) than the sum of the individual impacts of each activity?

In the remainder of this introduction, we briefly summarize important earlier research on the association of exporting, technology use and plant performance. (See also Alexander, 1994.) We then draw upon these findings to formulate our own hypotheses.

Regarding exporting, Bernard and Jensen (1995) find that, although exporter status turns out to be a poor predictor of future performance, a comparison of exporters with non-exporters at any given time during the 1976-1987 period reveals that exporters have characteristics typical of "winners." Exporters have more employees, higher productivity and wages, and greater capital intensity. The authors also find that successful exporters account for a sizable share of emerging trends observed in manufacturing overall: the shift from production to non-production workers, and the "wage-gap" between skilled and non-skilled workers. Thus, the fundamental result from Bernard and Jensen's work is that successful plants export.

On the link between technology use and plant performance, Doms, Dunne and Roberts (1994) estimate a two-equation model that incorporates both the possibility of failure as well as the potential for employment growth or decline among surviving plants. They find that plants using advanced technologies relatively intensively are more likely to survive, and that high-tech survivors increase their employment faster than do their competitors. With respect to technology and wages, Dunne and Schmitz (1995) and Doms, Dunne and Troske (1995) show plant wage levels to be positively correlated with the intensity of technology use.[6]

McGuckin, Streitweiser and Doms (1995) find that plants using advanced technologies also have higher productivity. However, because they find no correlation between changes over time in the level of technology use and plant productivity, they conclude that, while advanced technologies likely contribute to plant performance, superior plants are also more likely to use them.

Surveying these results, we expect first that exporting and advanced technology use have independent associations with plant success. For example, effectively-run plants can become more innovative and use advanced technologies to become more productive. As a consequence, these plants should have enhanced ability to thrive in their existing product markets, and to expand into new ones. Because of this, and in view of the statistical results reported above, we expect advanced technology use to be positively correlated with productivity, growth in plant employment, value of shipments, and wages and salaries. Results from the export literature cited earlier suggest a similar story applies to exporters, regardless of their level of technology use. Additionally, to exploit fully the information available on plants both exporting and using advanced technology, we test for synergy (a positive interaction effect) from simultaneously engaging in these activities.

We turn now to a description of our dataset and methodology (Section II). Section III presents the results of our analysis, and Section IV offers some concluding remarks.

[6] These technology studies define intensity of use based on the number of technologies used at the plant. Beede and Young (1996) find that results based on technology counts mask significant performance differences among plants using the same number, but different combinations of advanced technologies.

II. DATA DESCRIPTION AND METHODOLOGY

We draw on a rich dataset of plant level observations from the 1987 and 1992 Census of Manufactures. The statistics reported below are calculated for the approximately 10,000 plants in SIC Industries 34-38 sampled by the 1988 Survey of Manufacturing Technology (SMT).[7] Technology-use indicators come from this survey. All other variables are taken from the Census of Manufactures. These data are very detailed and provide considerable insight into plant operations, but a number of qualifications should be kept in mind: 1) the data represent only a sub-sample of manufacturing industries; 2) our exporting and technology-use indicators have some limitations; 3) the sample includes only plants that survive to 1992. We discuss these issues, and the methodology adopted for our statistical analysis, in more detail below.

Description of Sampled Industries

According to the 1987 Census of Manufactures, plants in SICs 34 - 38 accounted for 43 percent of all employees and 39 percent of value of shipments in 1987. Even though employment trends for these five industries do track closely those of manufacturing overall, in some important respects our sample may not represent all manufacturing. In particular, for the 5 industry groups in our sample both the fraction of exporting plants, and the export-to-shipments ratio, are higher than the corresponding averages for the manufacturing sector (see Bernard and Jensen, 1995).

Variable Definitions

To examine how different plant characteristics affect plant performance, we divide plants along a number of dimensions:

SIZE CLASS: Plants are grouped by plant employment in 1987: small plants have 1-99 employees, medium-sized plants have 100-249 employees, large plants have 250-499 employees, and the largest plants in our sample have more than 500 employees.

LOW- / HIGH-TECH PLANTS: A plant is classified as high-tech if the number of technologies it uses exceeds the median number of technologies used by plants in that size

[7] Specific industry categories are: SIC 34, Fabricated Metal Products; SIC 35, Industrial Machinery and Equipment; SIC 36, Electronic and Electric Equipment; SIC 37, Transportation Equipment; SIC 38, Instruments and Related Products.

class. This is not a direct measure of the intensity of advanced-technology use (which might be the most desirable variable for analysis), but we believe that it provides very reliable information on a plant's advanced technology orientation relative to its competitors. A small plant is low-tech if it uses 1 or fewer technologies listed in the 1988 SMT, and is high-tech if it uses more than 1 technology. A medium-sized plant is high-tech if it uses more than 3 technologies, a big plant is high-tech if it uses more than 5 technologies and a largest-sized plant is high-tech if it uses more than 8 technologies. The median level of technology use in the sample overall is 3 technologies.[8]

EXPORTER / NON-EXPORTER: A plant is classified as an exporter for a given year if it reported any direct exports during that time. Direct exports receive no further domestic manufacture once they have left the plant for shipment to foreign consumers. Thus, plants that produce only intermediate products for eventual export are not classified as exporters. Additionally, to complement the analysis based on exporter status we also group plants according to their export history. Plants that do not export in 1987 or 1992 are classified as "Neither" plants, plants that export in the first year and do not export in the second year are classified as "Stoppers," plants that do not export in the first year and export in the second year are classified as "Starters," and plants that export in both years are classified as "Through" plants.

AVERAGE PERCENT CHANGE IN PLANT EMPLOYMENT, VALUE OF SHIPMENTS, WAGES AND SALARIES, AND PRODUCTIVITY: We calculate these variables from establishment-level changes for 1987 and 1992.

Limitations of the Data and Analysis: Implications of Sampling Survivor Plants

Data used in this analysis come from the 1987 and 1992 Census of Manufactures. The observations on plant performance, therefore, come from only two points in time and—except for survival rates—are obtained solely from establishments surviving through 1992. This fact raises potential qualifications to the statistical results.

Since small establishments are more likely to fail than large ones, small plants that survive (and thus supply information on their performance) will likely represent more successful smaller establishments. Consequently, performance statistics reported for surviving small establishments may overstate the gains made by similarly-sized plants overall (both survivors and non-survivors). However, inter-plant performance differences related to size are controlled for in our regression results.[9]

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[8] Depending on how many plants within a size class use the median number of technologies for that group, the division of a size class into low- and high-tech users need not result in an equal number of plants in each technology-use category.

[9] Indeed, the regression analyses below may understate the impact of potential explanatory variables (e.g., exporting and advanced technology use) on relative plant performance. This can happen when the explanatory (or independent) variables

Methodology

Finally, we offer a few specifics of how we have applied the above definitions of plant exporting and technology use to estimate the degree to which each activity is associated with establishment performance. We discuss briefly here how we have incorporated information on these plant characteristics into our statistical analysis.

In our regression analysis, if a plant qualifies as an exporter in 1987, that plant is assigned a value of one for the variable "1987 Exporter;" otherwise, the plant receives a value of zero. The coefficients reported for "1987 Exporter" provide an estimate of how the mean performance for the group of 1987 exporters differs from that of non-exporters in this period. When establishments can be placed into one of multiple categories under a general plant characteristic (i.e., under export history: Starter, Stopper, Through, or Neither), the reported coefficients express the difference of the corresponding group mean relative to the omitted category (in Table 12, for example, the omitted category is Neither).

Further, our analysis is designed to determine the association of a particular variable with plant performance, holding fixed the influence of all other relevant plant characteristics. Table 7, for example, suggests that 1987 Exporter plants had on average 8% more employees than non-exporters in 1987, regardless of the level of technology use.

Finally, we believe it is important to emphasize that our analysis implies no clear causality running from a particular set of variables to another. Indeed, the 1987 data that this study uses for its first comparison of establishment performance actually predate (by one year) the earliest indicators available to us for plant technology use in the *1988 Survey of Manufacturing Technology*. Thus, while our results do suggest a strong association between exporting, technology use and plant performance, the direction and magnitude of causality between these variables remain subjects for further research.

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have a similar relationship both to plant survival and to the other performance measure of interest. The results discussed later suggest that this is in fact the case. However, for such a downward bias to occur the cumulative impact of unidentified factors in the analysis must also operate on plant survival and performance in the same way. Our study has not yet investigated this issue.

III. RESULTS

Probability of Exporting in 1992

We find that both high-tech plants and 1987 exporters are more likely to export in 1992 than either their low-tech or non-exporting counterparts. Table 4 presents results from a probit analysis[10] which shows that, when plant size and industry are controlled for, the probability of high-tech plants exporting in 1992 is about 8 percentage points higher than for low-tech plants. The corresponding advantage to 1987 exporters is about 38 percentage points. The estimated negative interaction effect from simultaneously exporting and using advanced technologies relatively intensively is not statistically significant.

Table 4:
Estimated Contribution of Independent Variables to the Probability of Exporting in 1992, Controlling for Plant Size and Industry

Independent Variable	Estimated Coefficient	Impact on Probability of Exporting in 1992
High-tech Plant	0.20** (26.71)	7.6%
1987 Exporter	0.98** (665.9)	37.4%
Interaction Term: High-tech Plant & 1987 Exporter	-0.09 (2.62)	-2.7%

Notes: Chi-square values are given in parentheses.

** denotes significance at the 0.01 confidence level.

Reported percentages are the difference in survival probability for plants identified by each independent variable, relative to low-tech, non-exporting plants in 1987, evaluated at the median plant-size in the sample.

We interpret the positive association between current use of advanced technologies and future exporting as evidence that these two activities are linked by the market niche served by American exporters. Although our analysis does not take into account overall foreign and domestic endowments of either technology or other productive resources, we suggest

[10] We estimate a probit model because values of the probability of survival are bounded by 0 and 1. Applying standard linear regression techniques in this instance could lead to estimated probabilities outside of this interval, and produce flawed tests of statistical significance of estimated coefficients.

that exporting is indicative of the United States' comparative advantage in high-tech products (which require advanced technologies for their manufacture).

Plant Survival

Table 5 shows that, for all plant size classes, exporters in 1987 are more likely to survive than non-exporters, and high-tech plants are more likely to survive than low-tech ones. Although larger, more stable plants are disproportionately represented among both exporters and high-tech plants, this relationship also holds when plant size is controlled for. These results are presented in Table 6.

Table 5:
Survival Rates, 1987-1992
by Exporter Status in 1987, Technology Use and Industry

	LOW-TECH PLANTS		HIGH-TECH PLANTS	
	Number of Plants	Survival rate	Number of Plants	Survival Rate
1987 NON-EXPORTERS				
Size Class				
1-99	2,146	0.69	1,361	0.78
100-249	766	0.72	476	0.84
250-499	276	0.77	143	0.83
500+	241	0.81	134	0.92
1987 EXPORTERS				
Size Class				
1-99	596	0.80	661	0.86
100-249	629	0.84	605	0.89
250-499	392	0.87	334	0.90
500+	615	0.91	539	0.93

From our probit analysis we see that, for establishments at the median plant-size in the sample, exporting and relatively intense use of advanced technologies are associated with a probability of survival which is approximately 8 and 9 percentage points higher, respectively, than that of low-tech, non-exporting competitors. The interaction term is negative and statistically significant. Consequently, while high-tech exporters in 1987 are more likely to survive to 1992 than are either high-tech non-exporters or low-tech exporters, this greater likelihood (15 percentage points after the negative interaction effect is included) is less than that predicted from summing up each activity's separate contribution (17 percentage points).

Table 6:
Estimated Contribution of Independent Variables to the Probability of Plant Survival from 1987-1992 Controlling for Plant Size and Industry

Independent variables	Estimated coefficient	Impact on probability of plant survival
High-tech Plant	0.33** (70.53)	7.9%
1987 Exporter	0.39** (86.29)	9.1%
Interaction Term: High-tech Plant & 1987 Exporter	-0.13* (4.41)	-1.7%

Notes: Chi-square values are given in parentheses.

* denotes significance at the 0.05, and ** at the 0.01 confidence level.

Reported percentages are the difference in survival probability for plants identified by each independent variable, relative to low-tech, non-exporting plants in 1987, evaluated at the median plant-size in the sample.

The independent contributions of exporting and advanced technology use to plant survival confirm results from previous studies, in which each activity figures separately. We emphasize here that the negative interaction effect from exporting and using advanced technologies does not imply that plants that do both do not perform well: these plants' survival rates are clearly higher than those of plants engaging in only one of these activities.

Employment, Value of Shipments, Wages and Salaries, and Productivity

Differences in Levels

The regression results reported in Table 7 and Table 8 confirm earlier analyses. For both 1987 and 1992, plants that export and plants that are high-tech are larger, more productive, and pay higher wages than their counterparts in the same industry and of the same size. An interaction effect from simultaneously exporting and using advanced technologies relatively intensively is significant for only employment and value of shipments in 1987.

Table 7:
1987 Levels Regressions of Selected Performance Measures on Exporting and Technology-Use Indicators Controlling for Plant Size and Industry

INDEPENDENT VARIABLES	DEPENDENT VARIABLES			
	Total Employees	Value of Shipments	Wages and Salaries	Labor Productivity
High-tech Plant	0.18** (11.59)	0.32** (14.03)	0.09** (9.02)	0.14** (7.37)
1987 Exporter	0.08** (5.15)	0.19** (8.18)	0.08** (8.12)	0.13** (6.47)
Interaction Term: High-tech Plant and 1987 Exporter	0.05** (2.38)	0.06∞ (1.93)	-0.01 (-0.97)	0.03 (1.17)

Notes: t-statistics given in parentheses

∞ denotes significance at the 0.10, and ** at the 0.01 confidence level.

Table 8:
1992 Levels Regressions of Selected Performance Measures on Exporting and Technology-Use Indicators Controlling for Plant Size and Industry

INDEPENDENT VARIABLES	DEPENDENT VARIABLES			
	Total Employees	Value of Shipments	Wages And Salaries	Labor Productivity
High-tech Plant	0.29** (11.76)	0.40** (12.75)	0.07** (6.27)	0.10** (4.67)
1992 Exporter	0.27** (11.68)	0.38** (13.09)	0.08** (8.19)	0.14** (6.87)
Interaction Term: High-tech Plant and 1992 Exporter	0.03 (0.89)	0.05 (1.26)	0.01 (0.74)	0.04 (1.44)

Notes: t-statistics given in parentheses

** denotes significance at the 0.01 confidence level.

Differences in Growth Rates: Exporters

Earlier research on exporting and plant performance (Bernard and Jensen, 1995) found that, for 1976 - 1987, exporter status in a given period is, in general, a poor predictor of a plant's future performance (expressed as percentage changes in wages and employment). We find the same to be true for our 1987 - 1992 data, which additionally include growth in value of shipments and productivity. To illustrate this, we compare group means of growth in employment and value of shipments, from 1987 to 1992, for plants classified by 1987 exporter status (Table 9 and Table 10) and by 1992 exporter status (

Table 11 and Table 12).

Table 9:
Average Percent Change in Employment, 1987-1992
by 1987 Export Status, Technology Use and 1987 Size Class

	LOW-TECH PLANTS		HIGH-TECH PLANTS	
	Number of Plants	Employment Change (%)	Number of Plants	Employment Change (%)
1987 NON-EXPORTERS				
Mean		**-16.2**		**-3.9**
Size Class				
1-99	1,472	-12.6	1,064	1.9
100 - 249	551	-17.1	401	-7.0
250 - 499	213	-22.6	119	-16.8
500 +	196	-34.1	123	-31.4
1987 EXPORTERS				
Mean		**-14.3**		**-6.4**
Size Class				
1-99	474	-1.9	566	6.2
100-249	530	-11.9	537	-1.0
250-499	342	-19.3	299	-11.1
500+	557	-24.2	500	-23.6

Table 10:
Average Percent Change in Value of Shipments, 1987-1992
by 1987 Export Status, Technology Use and 1987 Size Class

	LOW-TECH PLANTS		HIGH-TECH PLANTS	
	Number of Plants	Shipments Change (%)	Number of Plants	Shipments Change (%)
1987 NON-EXPORTERS				
Mean		**6.1**		**16.4**
Size Class				
1-99	1,472	6.6	1,064	20.2
100 - 249	551	9.0	401	17.8
250 - 499	213	4.3	119	-2.1
500 +	196	-3.7	123	-3.8
1987 EXPORTERS				
Mean		**6.7**		**14.3**
Size Class				
1-99	474	15.4	566	23.4
100-249	530	6.7	537	19.3
250-499	342	2.2	299	10.7
500+	557	2.2	500	0.9

Table 11:
Average Percent Change in Employment, 1987-1992
by 1992 Export Status, Technology Use and 1987 Size Class

	LOW-TECH PLANTS		HIGH-TECH PLANTS	
	Number of Plants	Employment Change (%)	Number of Plants	Employment Change (%)
1987 NON-EXPORTERS				
Mean		**-22.4**		**-11.4**
Size Class				
1-99	1,259	-16.3	945	-3.9
100 - 249	489	-26.2	352	-14.6
250 - 499	180	-34.9	112	-23.0
500 +	199	-39.7	143	-44.1
1987 EXPORTERS				
Mean		**-8.7**		**-0.5**
Size Class				
1-99	687	1.7	685	13.5
100-249	592	-4.8	586	3.0
250-499	375	-13.7	306	-8.9
500+	554	-22.1	480	-19.6

Table 12:
Average Percent Change in Value of Shipments, 1987-1992
by 1992 Export Status, Technology Use and 1987 Size Class

	LOW-TECH PLANTS		HIGH-TECH PLANTS	
	Number of Plants	Shipments Change (%)	Number of Plants	Shipments Change (%)
1987 NON-EXPORTERS				
Mean		**-2.0**		**7.9**
Size Class				
1-99	1,259	1.1	945	14.6
100 - 249	489	-2.8	352	6.6
250 - 499	180	-11.6	112	-7.2
500 +	199	-11.4	143	-21.7
1987 EXPORTERS				
Mean		**14.4**		**20.8**
Size Class				
1-99	687	22.7	685	30.7
100-249	592	16.6	586	25.8
250-499	375	9.8	306	12.2
500+	554	4.9	480	6.3

When we look at the mean changes in employment growth and shipments by export status in 1987, we see that neither low- nor high-tech exporters perform consistently better than their non-exporting counterparts. This is because plants that export in the initial period but stop exporting thereafter show relatively poor performance, while plants that begin exporting over the period show relatively strong performance. The results by size class for high-tech plants, however, show consistent gains from exporting. When exporter status is based on 1992 export status, as expected, both types of technology-using exporters generally perform better than non-exporting plants.

In Table 13 and Table 14 the category "1987 Non-Exporters" is further broken out into two groups of plants—"Non-Exporters Through 1992" and "Export-Starters After 1987." Likewise, the category "1987 Exporters" is divided between "Export-Stoppers By 1992" and "Exporters Through 1992." Plants in the first and third group above are classified as "1992 Non-Exporters"; plants in the second and fourth group fall into the "1992 Exporter" category of Table 11and Table 12. An explanation for the ambiguous pattern seen in comparing plants based on 1987 versus 1992 exporter status clearly emerges from the finer breakout. Performance gains (in terms of both employment and value of shipments) for 1992 Exporters (i.e., Export Starters After 1987 and Exporters Through 1992) are offset by losses from groups of plants paired with them according to 1987 export status (Non-Exporters Through 1992 and Export-Stoppers By 1992, respectively). In particular, both low- and high-tech plants that began exporting after 1987 display better employment and value of shipments trends than do corresponding technology-users in any other exporter category.

Table 15 reports regression results controlling for plant size, industry affiliation and degree of technology use. Continuing and starting exporters enjoy employment growth 19 percentage points higher than that for export-stoppers or non-exporter during the 1987 - 1992 period; the corresponding differentials for value of shipments growth are 16 and 21 points. Also, export-starters increase the wages and salaries they pay to employees at a rate 3 points greater than that of non-exporters through 1992.

Differences in Growth Rates: Technology Users

Table 13 and Table 14 also show that relatively intense advanced technology use is associated with a higher growth-rate of employment and value of shipments for plants *of any exporter history*. From Table 15 we see that when, along with exporting history, plant size and industry affiliation are held constant, plants above the median in advanced-technology use display growth in employment and value of shipments which is 12 and 8 percentage points greater, respectively, than that achieved by their low-tech competitors.

Table 13:
Average Percent Change in Employment, 1987-1992
by Exporting History, Technology Use and 1987 Size Class

	LOW -TECH PLANTS		HIGH-TECH PLANTS	
	Cell Count	Employment Change (%)	Cell Count	Employment Change (%)
1987 NON-EXPORTERS				
NON-EXPORTER THROUGH 1992				
Mean		**-21.6**		**-8.3**
Size Class				
1-99	1,106	-17.5	759	-3.3
100-249	353	-25.9	226	-13.5
250-499	114	-28.7	68	-21.5
500+	112	-41.2	64	-35.6
EXPORT-STARTER AFTER 1987				
Mean		**-4.1**		**4.5**
Size Class				
1-99	366	2.3	305	14.9
100-249	198	-1.5	175	1.3
250-499	99	-15.7	51	-10.5
500+	84	-24.5	59	-26.8
1987 EXPORTERS				
EXPORT-STOPPER BY 1992				
Mean		**-25.4**		**-19.4**
Size Class				
1-99	153	-8.1	186	-6.4
100-249	136	-27.1	126	-16.6
250-499	66	-45.7	44	-25.3
500+	87	-37.8	79	-50.9
EXPORTER THROUGH 1992				
Mean		**-11 .0**		**-2.5**
Size Class				
1-99	321	1.0	380	12.5
100-249	394	-6.6	411	3.8
250-499	276	-13.0	255	-8.6
500+	470	-21.7	421	-18.5

Table 14:
Average Percent Change in Value of Shipments, 1987 - 1992
by Exporting History, Technology Use and 1987 Size Class

	LOW-TECH PLANTS		HIGH-TECH PLANTS	
	Cell Count	Employment Change (%)	Cell Count	Employment Change (%)
1987 NON-EXPORTERS				
NON-EXPORTER THROUGH 1992				
Mean		**-0.7**		**10.4**
Size Class				
1-99	1,106	0.8	759	14.7
100-249	353	-0.8	226	8.2
250-499	114	0.6	68	-5.2
500+	112	-15.6	64	-18.2
EXPORT-STARTER AFTER 1987				
Mean		**21.3**		**27.7**
Size Class				
1-99	366	24.1	305	34.0
100-249	198	26.2	175	29.9
250-499	99	8.5	51	2.1
500+	84	12.3	59	11.1
1987 EXPORTERS				
EXPORT-STOPPER BY 1992				
Mean		**-7.2**		**1.6**
Size Class				
1-99	153	3.6	186	13.9
100-249	136	-8.0	126	3.8
250-499	66	-33.3	44	-10.3
500+	87	-5.7	79	-24.6
EXPORTER THROUGH 1992				
Mean		**10.9**		**18.1**
Size Class				
1-99	321	21.0	380	28.0
100-249	394	11.8	411	24.0
250-499	276	10.4	255	14.2
500+	470	3.5	421	5.6

Table 15:
1987-1992 Change Regressions of Selected Performance Measures on Various Combinations of Exporter and Technology-Use Status Controlling for Plant Size and Industry

INDEPENDENT VARIABLES	DEPENDENT VARIABLES			
	Total Employees	Value of Shipments	Wages and Salaries	Labor Productivity
High-tech Plant	0.12**	0.08**	-0.01	-0.33
	(5.12)	(3.07)	(-0.76)	(-1.21)
EXPORTER HISTORY				
Export-Starter By 1992	.19**	0.21**	0.03*	0.01
	(7.0)	(6.63)	(2.29)	(0.23)
Export-Stopper By 1992	0.01	-0.49	-0.03	-0.04
	(0.18)	(-1.30)	(-1.94)	(-1.13)
Exporter Through 1992	0.19**	0.16**	0.01	0
	(8.11)	(5.72)	(1.18)	(0.11)
INTERACTION TERMS:				
High-tech Plant & Export-Starter By 1992	-0.03	-0.01	-0.01	0.02
	(-0.65)	(-0.19)	(-0.55)	(0.49)
High-tech Plant & Export-Stopper	-0.06	-0.01	0	0.01
	(-1.23)	(0.22)	(0.03)	(0.1)
High-tech Plant & Exporter Through 1992	-0.03	-.02	0	-0.02
	(-1.05)	(-0.46)	(-0.19)	(-0.63)

Notes: t-statistics given in parentheses

* denotes significance at the 0.05, and ** at the 0.01 confidence level.

Differences in Growth Rates: Interaction Effects

The results from the previous two sections show that when the performance premia estimated separately for exporting and applying advanced technology are summed, continuing and starting exporters who also qualify as high-tech register the best performance among sampled plants across the 1987-1992 interval. This result is highly consistent with survey responses from successful Canadian plants, who identify "access to markets and technological ability" as two of the three strategies most important to them (see Alexander, p. 12).

However, Table 15 shows that none of the growth rate variables have statistically significant interaction effects from simultaneously exporting and using advanced technologies relatively intensively. This finding mirrors results from our analysis of levels differences. We conclude that, in contrast to our results on the probability of future exporting and plant survival, the remaining plant performance measures analyzed offer little evidence for an inter-relatedness of exporting and advanced technology use.

IV. CONCLUSIONS

This paper offers new results on the association between exporting, advanced technology use and several measures of plant success. We extend the existing literature in this area by applying new data and by using plant-level information on both exporting *and* advanced technology use.

Similar to prior studies in this area, we also find that both exporting (i.e., either continuing or starting to export across the 1987-1992 interval) and advanced technology use are independently and positively correlated with many measures of plant success: the level of and growth in employment, value of shipments, productivity, wages and salaries, and probability of plant survival. While export starters over the period do especially well, the best performance is turned in by both continuing and starting exporters who also qualify as high-tech plants.

We also find that after controlling for size, industry, and 1987 exporter status, high-tech plants in 1988 are more likely to be exporters in 1992. However, our specified interaction terms are statistically insignificant for most performance measures and negative for the probability of survival. Nonetheless, the new results presented here document that plants that both export *and* use advanced technologies perform better than those that do just one.

We conclude that advanced technologies and exporting are part of strategies pursued by successful plants.

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