KÜRZERE AUFSÄTZE & KOMMENTARE
SHORTER PAPERS & COMMENTS

Export Activity and Productivity: Evidence from the Taiwan Electronics Industry

By

Jin-Tan Liu, Meng-Wen Tsou, and James K. Hammitt

Contents: I. Introduction. – II. Data and Descriptive Analysis – III. Productivity Differentials between Exporters and Non-Exporters. – IV. Productivity Prior to Exporting. – V. Productivity after Exporting. – VI. Entry and Exit. – VII. Conclusions

I. Introduction

It is often argued that developing countries that pursue export-oriented trade policies have better economic performance than those adopting import-substitution policies. To date, most empirical studies of this issue have used aggregate economy-wide data and provide mixed evidence on the linkage between export-orientation and productivity growth (Pack, 1988; Amoateng and Amoako-Adu 1996).

In recent years, there has been a considerable increase in research on export activity using firm- and plant-level data. The stylized facts that have emerged from this literature include: (*i*) successful firms are more likely to export, and (*ii*) firms that export tend to be more successful. With regard to the first point, Wagner (1995) finds that total sales growth is positively associated with increases in export intensity in the German manufacturing sector. Aitken et al. (1997) find that plant size, wages, and especially foreign ownership are positively related to the decision to export in Mexico. Bernard and Jensen (1995a) and Roberts and Tybout (1997) use a dynamic framework to examine the role of plant heterogeneity and sunk costs in the export decision. Bernard and Jensen find that entry costs are low for U.S. plants, but Roberts and Tybout find sunk costs are important in explaining export status in Colombia. Both papers find that plant heterogeneity plays a significant role. Bernard and Jensen emphasize that past success is the best indicator of future exporting, and Roberts and Tybout find that prior export experience increases the probability of exporting by up to 60 percentage points. The evidence that firms which export are more successful is based on cross-sectional firm-level data for Chile (Tybout et al. 1991), Morocco (Haddad 1993) and Taiwan's electronics industry (Chen and Tang 1987; Aw and Hwang 1995).

The direction of causality – whether good firms export or exporting improves firm performance – has been examined using firm-level panel data. Bernard and his colleagues examine this issue using manufacturing data for the U.S. (Bernard and Jensen 1995b, 1999), Mexico (Bernard 1996), and Germany (Bernard and Wagner 1997). These studies find exporters are much larger, more capital-intensive, pay higher wages and have substantially higher productivity than non-exporters. The evidence also shows that good firms become exporters; the benefits of exporting for the firms are less clear, as productivity performance grows more slowly when firms become exporters. Clerides et al. (1998) examine the causality between exports and cost changes using plant-level data for Colombia, Mexico, and Morocco. Their results reinforce the idea that it is the higher-productivity firms that enter the export market; the direction of causality is more likely to run from good performance to exports rather than the other way. Aw et al. (1998) find a different picture for Taiwan manufacturing plants. They suggest that both self-selection and learning play important roles in explaining the linkage between exporting and productivity.[1] Firms with higher productivity tend to enter the export market and exporters with low productivity tend to exit (the self-selection effect). In several industries, the exporters have relative productivity improvements. This result is consistent with a learning-by-exporting effect.

In this paper, we follow the framework of Bernard and Wagner (1997) to address three main questions: (1) Are there any major differences in characteristics and performance between exporters and non-exporters? (2) Are there productivity differentials before the plants enter the export market? (3) Do plants improve their productivity after they enter the export market? We use a balanced panel data set on 875 Taiwan electronics plants from 1989 to 1993. Most of our empirical results are consistent with the main findings in Bernard (1996) and Bernard and Wagner (1997). Exporters are larger, pay higher wages, and have higher labor productivity and total-factor-productivity growth than non-exporters. After controlling for plant characteristics, we find plants with higher productivity tend to enter the export market and there is little evidence that

[1] Aw et al. (1998) take this hypothesis from a recent model of firm and market dynamics by Hopenhayn (1992).

exporting itself can provide performance gains to the plants. We also find entry to the export market is associated with productivity improvement, while exiting from the export market is associated with worse performance. These patterns are consistent with the self-selection hypothesis, but not with the learning-by-exporting hypothesis.

The remainder of the paper is organized as follows. In Section II, we examine the differences between exporting plants and non-exporting plants for a variety of plant characteristics. Productivity differentials between exporting and non-exporting plants are examined in Section III. To understand the interaction between exporting and plant performance, we evaluate ex-ante productivity and ask whether good plants become exporters in Section IV. In Section V, ex-post productivity is evaluated for the plants that enter the export market. Section VI investigates the productivity differentials when plants enter and exit the export market. Conclusions follow in Section VII.

II. Data and Descriptive Analysis

The data are drawn from the annual manufacturing plants surveys conducted by the Taiwan Ministry of Economic Affairs.[2] Due to data availability constraints, we restrict our attention to plants in the electrical machinery and electronics industry. This industry comprises nine three-digit SIC industries, including Electrical machinery, apparatus, appliance and suppliers (311), Electrical appliances and housewares (312), Lighting equipment manufacturing (313), Data storage media processing equipment (314), Video and radio electronic products (315), Communication equipment and apparatus (316), Electronics parts and components (317), Batteries (318), and Other electrical and electronic machinery and equipment (319). The ID codes of the individual plants have been matched across four surveys, which include the years 1989, 1990, 1992, and 1993, to provide a balanced panel.[3] Our sample consists of 875 plants in each year. These data give us the ability to identify producer heterogeneity within industries. Plant sizes, sales, and propensity to export differ considerably across plants. Nevertheless, there are at least three limitations of our data set. First, the export data are only available for two years, 1990 and 1992. Second, the survey asks the plants to report the value of products to be shipped directly to foreigners. The products which were shipped for further manufacture or assembly in Taiwan or sold to a trading com-

---

[2] Data are available from the authors upon request.

[3] The ministry of Economic Affairs did not conduct the plant survey in 1991, when the Bureau of Census conducted a manufacturing census.

Table 1 – *Industry Characteristics, 1990 and 1992*

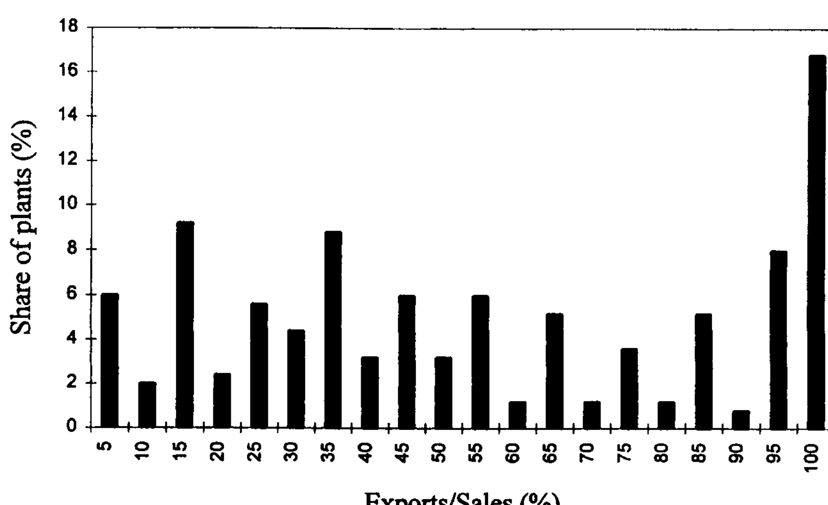
3-digit industry (SIC code)	Plants (number)	Plants exporting (%)	Export share of total sales (%)	Exporters (number of employees)	Non-exporters (number of employees)
			1990		
Electrical machinery, apparatus, appliance (311)	155	20.0	12.9	28	14
Electrical appliances (312)	65	18.5	21.2	23	8
Lighting equipment manufacturing (313)	81	32.1	56.0	25	12
Data storage media processing equipment (314)	31	41.9	47.7	41	19
Video and radio electronics products (315)	73	37.0	35.3	39	19
Communication equipment and apparatus (316)	25	24.0	37.4	17	11
Electronics parts and components (317)	248	23.4	23.3	41	21
Batteries (318) and Other electrical and electronics machinery and equipment (319)	197	27.9	26.1	31	12
Total	875	26.1	27.0	33	15
			1992		
Electrical machinery, apparatus, appliance (311)	151	21.2	21.1	32	14
Electrical appliances (312)	67	13.4	31.7	28	12
Lighting equipment manufacturing (313)	83	36.1	45.2	17	12
Data storage media processing equipment (314)	36	27.8	41.0	47	32
Video and radio electronics products (315)	76	42.1	48.7	40	14
Communication equipment and apparatus (316)	25	52.0	34.1	23	11
Electronics parts and components (317)	245	28.2	31.8	43	19
Batteries (318) and Other electrical and electronics machinery and equipment (319)	192	28.6	32.1	29	14
Total	875	28.6	33.2	33	16

pany were not included in the export values. The export value in the survey may be underestimated.[4] Third, a balanced panel necessarily omits the plants that enter and exit the market during this period. As a result, our analysis cannot account for this sample-selection bias.

Table 1 reports the percentage of exporting plants, share of exports in shipments, and average plant size of exporters and non-exporters by industry. It indicates that 26 percent and 29 percent of all plants exported in 1990 and 1992, respectively. The average export ratio is slightly higher, about 27 percent and 33 percent in 1990 and 1992, respectively. Exporting plants are most heavily concentrated in: Lighting equipment manufacturing (313), Data storage media processing equipment (314), Video and radio electronic products (315), and Communication equipment and apparatus (316). Exporters in these four sectors generally ship more than 40 percent of their total product abroad. As found in previous studies on U.S. and German firms (Bernard and Jensen 1995b; Bernard and Wagner 1997), exporters are substantially larger than non-exporters, employing about twice as many people on average.

Figure 1 shows the distribution of the export/shipment ratio across exporting establishments for 1992. More than one-quarter of the export-

Figure 1 – *Distribution of Exporting Plants by Export Intensity*



[4] According to Levy (1991), the large number of trading firms and the complete network of subcontractors imply that the transactions costs of entering the export market may be lower in Taiwan than in other countries.

Table 2 – *Descriptive Statistics (1992)*

Variable	Definition	Exporters	Non-exporters	t-statistic
SALE	Sales (1,000 NT$)	66,107.7 (127,936.9)	17,397.6 (28,008.7)	6.0***
VA	Value added (1,000 NT$)	29,237.8 (78,485.7)	7,896.9 (10,656.7)	4.3***
SAL	Sales per employee (1,000 NT$)	2,043.8 (2,008.3)	1,197.7 (1,311.5)	6.2***
VAL	Value added per employee (1,000 NT$)	799.5 (824.7)	530.2 (442.8)	4.9***
KL	Capital-labor ratio (1,000 NT$/employee)	617.9 (680.8)	576.5 (929.0)	0.7
EQL	Machinery investment per employee (1,000 NT$)	25.7 (83.3)	9.6 (52.8)	2.8***
WAGE	Wage (1,000 NT$)	241.0 (119.7)	195.2 (95.9)	5.4***
RDS	R&D expenditure to total sales (%)	1.09 (3.9)	0.17 (1.07)	3.6***
SUBS	Subcontracting revenues to total sales (%)	0.90 (6.8)	4.72 (19.2)	4.3***
AGE	Age of plant	7.2 (4.3)	6.9 (3.5)	1.0
N	Number of plants	250	625	

Note: Figures in parentheses are standard deviations. – The t-statistic tests the null hypothesis of equality between exporters and non-exporters. – *** represents statistical significance at the 1 percent level. – The 1992 exchange rate is 25.403 NT$/US$.

ing plants report export-to-shipments ratios larger than 95 percent. In particular, almost 17 percent of plants produce all their output for the foreign market. The average export intensity is 52 percent across the exporting plants.

In Table 2, we present plant characteristics for exporters and non-exporters in 1992. Exporters are nearly four times larger in terms of the value of shipments and of value added. Exporting plants are also more productive than their non-exporting counterparts. Labor productivity, measured in shipments and value added per employee, is 71 percent and 51 percent greater for exporters. Although capital-labor ratios are not significantly higher at exporting plants, the annual investment expenditures in machinery and equipment per employee are almost 2.7 times greater for exporters. In addition, exporters systematically pay higher wages. The average annual wage per employee is NT$241,000, about 24 percent higher than for non-exporters.[5]

We use the ratio of R&D expenditure and payment for technological imports as proxies for investment in technology. The R&D intensity is on average 1.1 percent for exporting plants, much higher than the corresponding figure, 0.2 percent, for non-exporters. The average ratio of revenues from subcontracting to total sales is 0.9 percent for exporting plants, much smaller than the 4.7 percent ratio for non-exporting counterparts. The average age is almost identical across exporters and non-exporters. With the exception of the capital-labor ratio and plant age, the Student's t-test suggests that we can reject the hypothesis that there are no differences in characteristics between exporters and non-exporters.

Table 3 – *Plant Age, Export Behavior, and Production Activity*

		Age (years)		
		1–5	6–10	> 10
Share of total industry sales (%)	1990	72.32	10.82	16.86
	1992	45.55	24.86	29.59
Exporting to total plants in category (%)	1990	24.27	24.18	34.52
	1992	31.25	21.96	34.86
Export sales to total sales in category (%)	1990	11.70	12.89	17.56
	1992	15.09	12.10	18.54
Export sales to total industry export sales (%)	1990	71.95	10.51	17.54
	1992	57.40	21.31	21.29

We examine the linkage between plant age, exporting behavior, and production activity in Table 3. We classify the plants into three categories according to age: 1–5, 6–10, and more than 10 years. There is little difference in export activity across age categories. The share of plants that export is between 22 and 35 percent, and the average export-to-shipment ratios are between 12 and 19 percent. Total and export sales are concentrated in the younger plants. Plants less than five years old account for between one-half and three-quarters of both total and export sales in 1990 and 1992.

[5] The 1992 exchange rate is 25.403 NT$/US$.

III. Productivity Differentials between Exporters and Non-Exporters

As we have shown, there are striking differences between exporters and non-exporters. However, other plant characteristics may account for the preponderance of these differences. To examine that possibility, we estimate productivity differentials controlling for plant characteristics and industry following Bernard and Wagner (1997). The regressions are estimated as the following form:

$$\ln(Y_{it}) = b_0 + b_1 \ln(KL_{it}) + b_2\, EXPORT_{it} + b_3\, X_{it} + u_{it}, \qquad (1)$$

where the dependent variables $\ln(Y)$ we use are three indicators of productivity, including the log of sales per employee (*SAL*), the log of value added per employee (*VAL*), and the log of wage per employee (*WAGE*). Among the independent variables, $\ln(KL)$ is the log of the capital-labor ratio. *EXPORT* is a dummy for current export status. In an alternative specification, we replace *EXPORT* with *EXS*, the share of exports in total sales. *X* is a vector of plant characteristics including the ratio of subcontracting revenues to total sales (*SUBS*), the ratio of R&D expenditure and payment for technological imports to total sales (*RDS*), and the three-digit industry-dummy variables. If the coefficient of the export-dummy or export-share variable is positive and significant, then an export premium for the plant characteristics exists (Bernard and Wagner 1997). Since the export data are only available for 1990 and 1992, we use these two years as a panel to estimate (1).

To account for unobserved heterogeneity among plants, both random-effects and fixed-effects models are estimated. The former assumes that firm-specific factors are uncorrelated with the regressors and the latter allows such a correlation. The hypothesis of no correlation can be tested using a Hausman test (1978).

Table 4 reports the results estimated using fixed-effects and random-effects models. The first three columns represent export status using a dummy variable and the next three columns use the export-share variable. The Hausman statistics show the fixed-effects model should be preferred for the regressions of the two labor-productivity measures, whereas the random-effects model is a more appropriate specification for the wage regressions. Consistent with the simple comparisons reported above, the coefficients of the export dummy and export-share variables are positive and statistically significant in all cases.[6]

[6] Because the export variable at the plant level may be endogenous, we also estimate the fixed-effect model by two-stage least squares. The coefficients of the export dummy and export share-variables remain statistically significant.

Table 4 – *Export Premiums (1990 and 1992 panel data)*

Variable	(1) ln (*SAL*)	(2) ln (*VAL*)	(3) (ln) *WAGE*	(4) ln (*SAL*)	(5) ln (*VAL*)	(6) (ln) *WAGE*
Constant			4.5299 (84.49)***			4.5299 (84.49)***
ln (*KL*)	0.1906 (11.03)***	0.1899 (10.02)***	0.1139 (13.03)***	0.1924 (11.13)***	0.1916 (10.12)***	0.1166 (13.27)***
EXPORT	0.1412 (2.86)***	0.1482 (2.73)***	0.1451 (6.14)***			
EXS				0.0017 (2.26)**	0.0021 (2.46)**	0.0015 (3.93)***
SUBS	–0.0019 (–2.44)**	–0.0001 (–0.10)	0.0003 (0.66)	–0.0019 (–2.44)**	7.74×10^{-5} (–0.09)	0.0002 (0.43)
RDS	0.0134 (2.57)***	0.0113 (1.98)***	0.0044 (1.47)	0.0122 (2.35)**	0.0101 (1.78)*	0.0045 (1.51)
R^2	0.825	0.725	0.118	0.825	0.725	0.104

Note: Regressions (1), (2), (4) and (5) are estimated using a fixed-effects model. Regressions (3) and (6) are estimated using a random-effects model. – Figures in parentheses are t-statistics. – ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

The two labor-productivity measures, sales per worker (ln *SAL*) and value added per worker (ln *VAL*), are about 15 percent higher at exporting plants than at non-exporting plants. Average wages are also about 15 percent higher in exporting plants. Since we have no controls for the human capital (education, experience and skill) of the workers, it is likely that the wage differential is biased upward.[7] The relationships are similar for the export-share variable in columns 4 to 6 in Table 4. Exporting plants have a productivity advantage over non-exporting plants as the export share rises.

The results are similar to those in the cross-section analysis reported in Table 2. Exporters differ substantially from non-exporters in terms of productivity and paid wages. This suggests that an export advantage exists even after controlling for observable and unobservable plant characteristics. Our findings are largely consistent with the evidence found in Taiwan by Aw and Hwang (1995) and Aw et al. (1997), in Mexico

[7] Tan and Batra (1997) examine the impact of exporting on the pattern of wages for non-production and production workers in Taiwan. Using the 1986 Census data for 10 industries, they find the average wage premium for exporters over non-exporters is about 30 percent for non-production workers and 14 percent for production workers.

by Bernard (1996), in the U.S. by Bernard and Jensen (1995b, 1999), and in Germany by Bernard and Wagner (1997).

IV. Productivity Prior to Exporting

The previous section documented that exporters have significantly higher productivity than non-exporters. However, the direction of the causality between exporting and productivity is not revealed in the two-year panel data. In the next two sections, we investigate the causal relationship.

The common wisdom suggests that "good firms or plants become exporters" (Feder 1982; McKinsey 1993). The main reason is that there are additional costs associated with exporting, including transportation costs, distribution and marketing costs, and extra production costs to modify current domestic products.[8] Clerides et al. (1998) and Aw et al. (1998) refer to this phenomenon as the self-selection hypothesis. That is, only the higher productivity producers will enter and survive in the export market.

If good plants become exporters, then we should expect to find significant differences in plants' performance measures before they enter the export market. To examine the self-selection hypothesis, we consider the growth performance of future exporters in the year prior to entry. We regress the ex-ante growth rates of productivity (from 1989 to 1990) on the export status of the plant in 1990. The regression is estimated as follows:

$$\Delta \ln (Y_i) = b_0 + b_1 \, \Delta \ln (KL_i) + b_2 \, EXPORT_i + b_3 \, X_i + u_i, \qquad (2)$$

where the dependent variable ($\Delta \ln Y$) is one of three measures for productivity-growth rates: shipments per employee (ΔSAL), value added per employee (ΔVAL) and total-factor productivity ($TFPG$). Following Griliches and Regev (1995), $TFPG$ for each plant is calculated from the percentage change in real output less the weighted changes in material and energy inputs, number of employees, and capital inputs, with weights given by the share of these inputs in total sales. Real output is defined as sales deflated by a three-digit product-price deflator. Material and energy inputs are deflated by a material-price deflator.[9] Because $TFPG$ includes the plant's inputs, the $\Delta \ln KL$ variable is excluded in the regression of $TFPG$.

---

[8] Roberts and Tybout (1997) use a firm's previous export status to explain the sunk entry cost.

[9] We assume that the production function for manufacturing firms can be approximated by a Cobb-Douglas function in the three inputs, i.e., physical capital, labor, and materials. Under constant returns to scale with respect to the three inputs, the sum of factor elasticities will be unity.

Table 5 – *Productivity Differentials Prior to Exporting (1989–1990)*

Variable	ΔSAL	ΔVAL	*TFPG*	ΔSAL	ΔVAL	*TFPG*
Constant	13.261	20.691	10.314	15.761	22.223	11.411
	(3.11)***	(4.61)***	(4.44)***	(3.75)***	(5.04)***	(4.99)***
$\Delta \ln (KL)$	0.2008	0.2185		0.1996	0.2178	
	(9.37)***	(9.70)***		(9.29)***	(9.66)***	
EXPORT	12.451	8.2299	6.0624			
	(2.27)***	(1.43)	(2.03)**			
EXS				0.0335	0.0325	0.0159
				(0.40)	(0.37)	(0.34)
SUBS	0.0262	0.0220	–0.0070	0.0068	0.0103	–0.0156
	(0.30)	(0.24)	(–0.15)	(0.08)	(0.11)	(–0.33)
RDS	–0.8727	–0.6040	–0.5329	–0.4886	–0.3644	–0.1112
	(–1.00)	(–0.66)	(–1.09)	(–0.57)	(–0.40)	(–0.24)
AGE	–1.4152	–1.1943	–0.6804	–1.3577	–1.1596	–0.6497
	(–2.25)**	(–1.80)*	(–1.97)**	(–2.15)**	(–1.75)**	(–1.88)*
R^2	0.100	0.103	0.009	0.095	0.100	0.004

Note: Figures in parentheses are t-statistics. – ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

The OLS results are given in Table 5. The first three columns present the estimates with the export-dummy variable and the last three columns present the estimates with the export-share variable. The relationship between the export-dummy variable and productivity growth is positive and significant in columns (1) and (3). The results indicate that exporting plants have 12 percent higher sales per employee and 6 percent higher *TFPG* than non-exporters in the same industry in the year prior to entry. Exporters also appear to have higher value added per employee, although the coefficient is not significant. In contrast, the export-share variable is insignificant for all three measures of productivity growth. A similar pattern is found by Aw et al. (1998) for Taiwan manufacturing plants. They find that there is a significant productivity difference between exporters and non-exporters, but it is impossible to reject the hypothesis that average productivity is the same across different export-intensity categories in the electrical machinery and electronics industry.[10] The export-ratio variable has little effect on plants'

[10] They classify export ratio into three categories: low (less than 25 percent of production exported), medium (25 to 75 percent), and high (more than 75 percent).

productivity. They also find similar patterns in other industries in Taiwan and Korea. In a study of German manufacturing, Bernard and Wagner (1997) find that plants which enter the export market outperform non-exporters in the years prior to entry. Growth in sales per worker is 1.6 percent higher prior to entering the export market.

V. Productivity after Exporting

Existing literature suggests two reasons for an improvement in firm performance after exporting. First, serving a larger market might allow a firm to take advantage of economies of scale in production or to cushion variations in domestic demand (Feder 1982). Second, exporting may improve the firm's productivity through the effect of learning-by-exporting (Clerides et al. 1998). Firms that participate in the export market may have better access to technical expertise, including both new product designs and production methods, from their foreign buyers or competitors. Pack (1992) finds that knowledge of quality control and design from foreign purchasers are important channels of technology transfer for Taiwan exporters.

To evaluate the effects of exporting on plant performance, we regress the changes of productivity measures, $\Delta\ln(Y)$, on initial export dummy or export ratio and control for other initial plant characteristics,

$$\Delta\ln(Y_{it}) = b_0 + b_1\Delta\ln(KL_{it}) + b_2\,EXPORT_{it} + b_3\,X_{it} + u_{it}\,, \quad (3)$$

where the export dummy and export ratio are taken from plant-level data in 1990 and 1992. We estimate the plants' behavior after exporting, using data for 1992 and 1993.

Regression results for two-year panel data are presented in Table 6. These regressions are estimated using a random-effects model. For all measures of productivity-growth rates, exporters show lower growth than non-exporters. All the coefficients of export dummy and export ratio are negative, and three of six coefficients are statistically significant. On average, exporters have an annual productivity growth 2.4 to 5.6 percent lower than non-exporting plants after the exporting activity.

These results contradict the literature showing that exporting by itself improves plant performance. Initial export status is negatively correlated with subsequent productivity growth. Our results are consistent with the findings in Bernard and Wagner (1997) for German manufacturing and Clerides et al. (1998) for Colombia, Mexico, and Morocco. To understand more about the nature of the export market, in the

Table 6 – *Productivity Differentials After Exporting (1990-1993)*

Variable	ΔSAL	ΔVAL	TFPG	ΔSAL	ΔVAL	TFPG
Constant	4.3056 (2.62)***	5.3639 (3.09)***	1.7977 (1.86)*	3.8570 (2.47)***	5.0108 (3.04)***	2.5015 (2.55)***
Δln (*KL*)	0.1459 (13.63)***	0.1341 (11.82)***		0.1459 (13.63)***	0.1341 (11.82)***	
EXPORT	-5.6114 (-1.89)*	-2.4961 (-0.80)	-0.6766 (-0.32)			
EXS				-0.0782 (-1.71)*	-0.0238 (-0.49)	-0.0583 (-1.99)**
SUBS	0.1596 (2.76)***	0.0824 (1.35)	-0.0248 (-0.66)	0.1625 (2.81)***	0.0848 (1.39)	-0.0309 (-0.82)
RDS	0.8280 (1.74)*	0.9684 (1.92)**	-0.2637 (-0.85)	0.7684 (1.63)*	0.9265 (1.86)*	-0.2057 (-0.66)
R^2	0.093	0.071	0.005	0.093	0.071	0.002

Note: All regressions are estimated using a random-effects model. Figures in parentheses are t-statistics. – ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

next section we examine the pattern of export behavior by plants and describe the changes at the plants as they enter and exit the export market.

VI. Entry and Exit

In this section, we evaluate the productivity differentials that occur during the transition years (from 1990 to 1992) in and out of exporting. We estimate productivity-growth-rate regressions of the following form:

$$\Delta\ln(Y_i) = b_0 + b_1\, START_i + b_2\, STOP_i + b_3\, BOTH_i + b_4\, \Delta\ln(KL_i) + b_5\, X_i + u_i, \qquad (4)$$

where X is a vector of plant characteristics in 1990, including subcontracting, R&D intensity, plant age, and three-digit industry dummy. The dummies for export status are defined as $START = 1$ if the plant does not export in 1990 but does in 1992, $STOP = 1$ if the plant exports in 1990 but not in 1992, and $BOTH = 1$ if the plant exports in both years. The plants that do not export in either year are the reference category. The coefficients b_1, b_2, and b_3 estimate the productivity differentials for

Table 7 – *Productivity Differentials Based on Export Status (1990–1992)*

Variable	ΔSAL	ΔVAL	*TFPG*
Constant	6.9000	10.724	12.447
	(3.19)**	(4.58)***	(4.32)***
START	8.6902	6.8691	5.0019
	(2.47)***	(1.80)*	(1.07)
STOP	–4.0052	–6.4208	–1.3818
	(–1.01)	(–1.49)	(–0.26)
BOTH	1.8861	0.4929	–3.7708
	(0.59)	(0.14)	(–0.89)
$\Delta\ln(KL)$	0.1770	0.1714	
	(10.35)***	(9.25)***	
SUBS	0.285	–0.0531	–0.0587
	(0.68)	(–1.18)	(–1.06)
RDS	1.1653	0.9285	0.5575
	(2.75)***	(2.02)**	(0.99)
AGE	–0.3737	–0.4423	–0.5949
	(–1.23)	(–1.34)	(–1.47)
R^2	0.131	0.108	0.008

Note: Figures in parentheses are t-statistics. – ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

the entrants, exits, and survivors in the export markets. For our sample, there are 108 plants that did not export in 1990 but enter by 1992, 85 plants that are in the export market in 1990 but exit by 1992, 141 plants that remain in the export market both years, and 533 plants that are non-exporters in both years.

The OLS estimation results are reported in Table 7. For the labor-productivity growth rates, plants entering the export market have a substantially higher growth by 6.9 to 8.7 percent relative to continuing non-exporters. Conversely, exiting plants are associated with bad outcomes by every measure. The coefficients for productivity-growth rates on *STOP* are all negative but statistically insignificant. For the survivors, we find mixed and nonsignificant results in the labor-productivity and total-factor-productivity growth. Survivors appear to have slightly higher labor-productivity growth (either in ΔSAL or ΔVAL) and somewhat lower TFPG than non-exporters.

Productivity-growth rates for new entrants are significantly higher than for non-entrants in almost every productivity measure, while plants that stop selling abroad show negative productivity growth. Overall, our findings are similar to the results for Mexico by Bernard (1996), the U.S. by Bernard and Jensen (1995b, 1999), Germany by Bernard and Wagner (1997), and Colombia, Morocco, and Mexico by Clerides et al. (1998). However, our results differ from those of Aw et al. (1998). They study productivity differences across plants based on their export-market participation using census data for 1986 and 1991, and find that electrical machinery and electronics firms that exit from the export market have 4.4 percent higher productivity than non-exporters. In four other Taiwanese manufacturing sectors, firms that exit the export market have 6.9 percent to 10.3 percent higher productivity than non-exporters. The group with lowest productivity is the one that stays in the domestic market.

VII. Conclusions

We use plant-level panel data for the Taiwanese electrical machinery and electronics industry to examine productivity differentials between exporters and non-exporters. Consistent with other recent literature, we find that exporters are larger, pay higher wages, undertake more investment expenditures in machinery, equipment, and new technology, and are substantially more productive than non-exporters.

To evaluate the importance of the self-selection and learning-by-exporting mechanisms, we test several hypotheses. Our results support the self-selection mechanism and challenge the learning-by-exporting mechanism. Good plants become exporters. The productivity-growth rates are higher in the year before entering the export market. However, once plants become exporters, there is no evidence that exporting by itself enhances productivity. In addition, we find that plants undergo substantial changes during the years they enter or exit the export market. Labor productivity growth for new exporters is significantly higher than for continuing non-exporters, while plants that stop selling abroad show decreases in every measure of productivity.

In conclusion, our results suggest that higher productivity among exporters relative to non-exporters does not result from the acquisition of knowledge or expertise by exposure to the export market, but rather that higher productivity is required to survive in the export market. These findings are important for the formulation of export policy. They suggest that government programs designed to assist current exporters may reward previous accomplishment rather than stimulate future success.

References

Aitken, B., G. H. Hanson, and A. E. Harrison (1997). Spillovers, Foreign Investment, and Export Behavior. *Journal of International Economics* 43 (1/2): 103–132.

Amoateng, K., and B. Amoako-Adu (1996). Economic Growth, Export and External Debt Causality: The Case of African Countries. *Applied Economics* 28 (1): 21–27.

Aw, B. Y., and A. R. Hwang (1995). Productivity and the Export Market: A Firm-Level Analysis. *Journal of Development Economics* 47 (2): 313–332.

Aw, B. Y., X. Chen, and M. J. Roberts (1997). Firm-Level Evidence on Productivity Differentials, Turnover, and Exports in Taiwanese Manufacturing. NBER Working Paper 6235. Cambridge, Mass.

Aw, B. Y., S. Chung, and M. J. Roberts (1998). Productivity and the Decision to Export: Micro Evidence from Taiwan and South Korea. NBER Working Paper 6558. Cambridge, Mass.

Bernard, A. B. (1996). Exporters and Trade Liberalization in Mexico: Production Structure and Performance. Department of Economics Working Paper. MIT, Cambridge, Mass.

Bernard, A. B., and J. B. Jensen (1995a). Why Some Firms Export: Experience, Entry Costs, Spillovers, and Subsidies. Department of Economics Working Paper, MIT, Cambridge, Mass.

— (1995b). Exporters, Jobs, and Wages in U. S. Manufacturing, 1976–1987. *Brookings Papers on Economic Activity: Microeconomics* (special issue): 67–119.

— (1999). Exceptional Exporter Performance: Cause, Effect, or Both? *Journal of International Economics* 47 (1): 1–25.

Bernard, A. B., and J. Wagner (1997). Exports and Success in German Manufacturing. *Weltwirtschaftliches Archiv* 133 (1): 134–157.

Chen, T.-J., and D.-P. Tang (1987). Comparing Technical Efficiency between Import-Substitution-Oriented and Export-Oriented Foreign Firms in a Developing Economy. *Journal of Development Economics* 26 (2): 277–289.

Clerides, S., S. Lach, and J. Tybout (1998). Is: 'Learning-By-Exporting' Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco. *Quarterly Journal of Economics* 113 (3): 903–947.

Feder, G. (1982). On Exports and Economic Growth. *Journal of Development Economics* 12 (1/2): 59–73.

Griliches, Z., and H. Regev (1995). Firm Productivity in Israeli Industry: 1979–1988. *Journal of Econometrics* 65 (1): 175–203.

Haddad, M. (1993). How Trade Liberalization Affected Productivity in Morocco. Policy Research Working Paper 1096. The World Bank, Washington, DC.

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica* 46 (6): 1251–1271.

Hopenhayn, H. (1992). Entry, Exit, and Firm Dynamics in Long-Run Equilibrium. *Econometrica* 60 (5): 1127–1150.

Levy, B. (1991). Transaction Costs, the Size of Firms and Industrial Policy: Lessons from a Comparative Case Study of the Footwear Industry in Korea and Taiwan. *Journal of Development Economics* 34 (1/2): 151–178.

McKinsey Global Institute (1993). *Manufacturing Activity*. Washington, DC: McKinsey and Company.

Pack, H. (1988). Industrialization and Trade. In H. Chenery and T. N. Srinivasan (eds.), *Handbook of Development Economics*. Volume 1. Dordrecht: Elsevier Science Publishing.

— (1992). New Perspectives on Industrial Growth in Taiwan. in G. Ranis (ed.), *Taiwan: From Developing to Mature Economy*. Boulder, CO: Westview Press.

Roberts, M. J., and J. R. Tybout (1997). An Empirical Model of Sunk Costs and the Decision to Export. *American Economic Review* 87 (4): 545–564.

Tan, H., and G. Batra (1997). Technology and Firm Size-Wage Differentials in Colombia, Mexico, and Taiwan. *World Bank Economic Review* 11 (1): 59–83.

Tybout, J., J. de Melo, and V. Corbo (1991). The Effects of Trade Reforms on Scale and Technical Efficiency: New Evidence from Chile. *Journal of International Economics* 31 (3/4): 231–250.

Wagner, J. (1995). Exports, Firm Size and Firm Dynamics. *Small Business Economics* 7 (1): 29–39.