working paper department of economics

WHY SOME FIRMS EXPORT

Andrew B. Bernard
J. Bradford Jensen

No. 97-26 December 1997

massachusetts institute of technology

50 memorial drive
cambridge, mass. 02139

WORKING PAPER
DEPARTMENT
OF ECONOMICS

WHY SOME FIRMS EXPORT

Andrew B. Bernard
J. Bradford Jensen

No. 97-26 December 1997

MASSACHUSETTS
INSTITUTE OF
TECHNOLOGY

50 MEMORIAL DRIVE
CAMBRIDGE, MASS. 02139

Why Some Firms Export

Andrew B. Bernard*
Department of Economics
M.I.T.

J. Bradford Jensen†
Center for Economic Studies
Bureau of the Census

October, 1996 v2.0

Traditional trade models focus on aggregate and industry flows and usually ignore firm level factors. This paper presents a dynamic model of the export decision by a profit-maximizing firm. Using a panel of U.S. manufacturing plants, we test for the role of plant characteristics, spillovers from neighboring exporters, entry costs and government expenditures. Entry and exit in the export market by U.S. plants is substantial, past exporters are apt to reenter, and plants are likely to export in consecutive years. However, we find that entry costs, although present, are modest and spillovers from other plants negligible. Plant characteristics, especially those indicative past success, strongly increase the probability of exporting as do favorable exchange rate shocks.
KEY WORDS: hysteresis, export promotion, panel data, unobserved heterogeneity, dynamic binary choice
JEL Classification: F20, D21, L60

*Department of Economics, E52-262c, MIT, Cambridge MA 02139, tel: (617) 253-3488, fax: (617) 253-1330, email: abernard@mit.edu
We thank Gordon Hanson, Whitney Newey, Steve Pischke and participants in several seminars for helpful comments. We also thank Mark Roberts and Jim Tybout for sharing their Gauss programs. Bernard's research was supported by the Industrial Performance Center and the World Economy Laboratory at MIT. All errors are ours.

†Opinions expressed in this paper are those of the authors and do not necessarily reflect official positions of the Bureau of the Census.

1 Introduction

Politicians are convinced that helping exporters is a no-lose issue. The argument in its most elemental form goes as follows: exports are good and exporters are good firms, thus helping domestic firms export is good policy. The desire to promote exports is not limited to officials at the national level. All 50 states have offices to assist firms in selling goods and services abroad and the resources devoted to export promotion by states rose from $21 million to $96 million from 1984 to 1992 (NASDA, 1993). There has been a concurrent boom in export activity. Merchandise exports grew at a nominal annual rate of 11.7% from 1987 to 1992 while total manufacturing output rose 4% per year.[1]

Economists have had relatively little to say about the value of export assistance because little is known about the factors that influence exporting at the level of the firm. Theoretical trade models generally focus on industries not firms. Empirical work using firm or plant data has emerged only recently and has concentrated largely on exporters in developing countries.[2] Missing entirely from the academic literature is an analysis of which firms in advanced industrialized economies export and why. In this paper, for the first time, we provide empirical evidence on the export decision by U.S. manufacturing firms. In a dynamic framework, we consider the impact of individual plant attributes, barriers to entry, exchange rates, spillovers, and export promotion during a period of extraordinary export growth. In doing so we propose a simple estimation strategy to identify the role of sunk costs and unobserved plant heterogeneity.

We model the decision of the firm to export and test several hypotheses about the factors that increase the propensity for exporting. Starting with the characteristics of the firm itself, we ask whether size, labor force composition, product mix, and past performance are important for entry in foreign markets. Next, we directly address several ongoing debates in the trade literature about factors that might matter in the export decision. A set of theoretical models by Dixit (1989a,b), Krugman (1989) and others suggest that hysteresis in exports may be due to the sunk costs in entering the export market at the firm level. We test for the possible presence of

[1] See Bernard and Jensen (1995b) for more details.

[2] The emerging empirical literature includes: [Columbia] Roberts and Tybout (1994), [Taiwan] Aw and Batra (1994), [Mexico] Aitken, Hanson, and Harrison (1995), Bernard (1995), [United States] Bernard and Jensen (1995a,b, 1996), [Germany] Bernard and Wagner (1997).

entry costs by looking at the effects of exporting yesterday on exporting today. In addition we construct industry exchange rates and estimate the participation response to favorable price movements. The emerging literature on economic geography and trade (Krugman 1992) hypothesizes that activities of neighboring firms may reduce entry costs. We estimate the impact of spillovers from the activities of other firms in the same industry or region. Finally, we consider direct evidence on the efficacy of government intervention with data on state expenditures for export promotion.

There is relatively little prior work on the export decision by the firm. Heretofore, most trade theory and related empirical work has considered aggregate or industry level relationships. Two recent papers on firms in developing countries, Roberts and Tybout (1994) and Aitken, Hanson, and Harrison (1995), do examine factors influencing the export decision. Roberts and Tybout (1994) develop a dynamic model of the expcrt decision by a profit-maximizing firm and test for the presence and magnitude of sunk costs using a sample of Columbian plants. They find that sunk costs are large and are a significant source of export persistence. They also find that unobserved heterogeneity across plants plays a significant role in the probability that a firm exports. In a static framework, Aitken, Hanson, and Harrison (1995) examine the role of geographic and sectoral spillovers on exporting by plants in Mexico. They find that the presence of multinational exporters in the same industry and state increases the probability of exporting by Mexican firms.

Surprisingly, in the work on the export behavior of firms there has been almost no focus on the role of firm characteristics.[3] Comparing plants at a point in time, Bernard and Jensen (1995a,b, 1996) document large, significant differences between exporters and non-exporters among U.S. manufacturing plants. Exporters have more workers, proportionally more white collar workers, higher wages, higher productivity, greater capital intensity, higher technology intensity, and are more likely to be part of a multi-plant firm. However, these substantial cross-section differences between exporters and non-exporters cannot tell us about the direction of causality, i.e., do good firms become exporters or do exporters become good firms. Roberts

[3]Throughout this paper, we abuse terminology and freely interchange the terms 'firms' and 'plants', as has been the practice in the empirical literature on micro export behavior. As in other studies, due to limitations of the data, we use the plant as the unit of observation for the empirical work. This is not an innocuous restriction. For example, see Brainard and Riker (1995) on intra-firm decisions about the location of subsidiaries and outsourcing.

and Tybout (1994) include some plant characteristics in their work and find that plant size, plant age, and the structure of ownership are positively related to the propensity to export. Aitken, Hanson, and Harrison (1995) report evidence that plant size, wages, and especially foreign ownership are positively related to the decision to export.

We employ a rich set of plant variables including indicators of past success, labor quality, ownership structure, and product introductions to shed light on the role of plant characteristics in the export decision. We find that these plant attributes can explain a large fraction of the probability that a plant exports and, perhaps not surprisingly, past success is the best plant level indicator of future exporting.

Our estimates of entry costs are relatively modest for U.S. plants suggesting that plants should be able to move into the export market with little difficulty. However, we find that plant heterogeneity is substantial and important in the export decision; only a subset of plants have the necessary characteristics to be exporters. Favorable exchange rate shocks do increase participation in exporting but we find no role for geographic or industry spillovers, and no effect of state export promotion on exporting.

We begin by developing a simple model of the decision to enter the export market by the firm considering the role of entry costs and other forms of intertemporal spillovers. Next, in section 3, we discuss the characteristics of our sample of 13,606 plants from 1984 to 1992, including differences between exporters and non-exporters and rates of transition in and out of exporting. In section 4 we present the estimation strategy and issues regarding specifications and identification. Section 5 contains the main results. In Section 6 we consider alternative estimation strategies. We conclude with implications of the results for policy and future research.

2 Modelling the Export Decision

We model the decision to export by the rational, profit-maximizing firm as analogous to the decision to market a new product. The firm considers expected profits today and in the future from the decision to enter the foreign market net of any fixed costs. We proceed in several steps, first outlining the decision of the firm in the single period case and then incorporating multiple periods and entry costs.

We assume that the firm is always able to produce at the profit-maximizing level of exports, q_{it}^*, if it enters the foreign market. In the one period case with no entry costs, the firm receives profits

$$\pi_{it}(X_t, Z_{it}) = p_t \cdot q_{it}^* - c_{it}(X_t, Z_{it}|q_{it}^*) \tag{1}$$

where p_t is the price of goods sold abroad and $c_{it}(\cdot)$ is the variable cost of producing quantity q_{it}^*. Exogenous factors affecting profitability, such as exchange rates, are denoted as X_t, while firm-specific factors are denoted by Z_{it}.[4] Firm characteristics that might increase the probability of exporting include size, labor composition, productivity, product mix, and ownership structure. Besides shocks to demand, we focus on several additional exogenous factors which might affect the probability that the firm exports, including direct or indirect subsidies to exporting establishments and spillovers from the presence of nearby exporters who reduce or raise the costs of needed inputs such as high skilled labor or specialized capital. In section 4, we discuss the construction of specific variables to proxy for these factors.

If expected profits are greater than zero, then the firm will export. The export status of firm i in period t is given by Y_{it}, where

$$\begin{array}{l} Y_{it} = 1 \text{ if } \pi_{it} \geq 0 \\ Y_{it} = 0 \text{ if } \pi_{it} < 0 \end{array} . \tag{2}$$

2.1 Experience

Extensions of the single period model to multiple periods is fairly straightforward when there are no entry costs. The expected profits of the firm become

$$\Pi_{it}(X_t, Z_{it}) = \mathrm{E}_t \left(\sum_{s=t}^{\infty} \delta^{s-t} \left[p_s q_{is}^* - c_{is}(X_s, Z_{is}|q_{is}^*) \right] \right). \tag{3}$$

As long as the cost function does not depend on the level of output in a previous period, this version of the multi-period problem is identical to the single period model. However, if there is any effect of production today on costs tomorrow,

$$c_{it} = c_{it}(X_t, Z_{it}, q_{it-1}^*|q_{it}^*) \text{ and } \frac{\partial c_{it}(\cdot)}{\partial q_{it-1}^*} \neq 0,$$

[4]Prices faced by the firm presumably depend on X_t and possibly on elements in Z_{it} as well, i.e. $p_t = p_t(X_t, Z_{it})$. To simplify notation, we write prices as p_t throughout.

then export status of the firm today will play a role in the decision to export tomorrow. This might occur if there is learning by doing in production of the export good. The value function for the dynamic programming problem is given by

$$V_{it}\left(\cdot\right) = \max_{\{q^*_{it}\}}\left(\pi_{it}\cdot Y_{it} + \delta \mathrm{E}_t\left[V_{it+1}\left(\cdot\right) \mid q^*_{it}\right]\right). \tag{4}$$

and a firm will choose to export in period t, i.e. $Y_{it} = 1$, if

$$\pi_{it} + \delta \mathrm{E}_t\left[V_{it+1}\left(\cdot\right) \mid q^*_{it} > 0\right] > \delta \mathrm{E}_t\left[V_{it+1}\left(\cdot\right) \mid q^*_{it} = 0\right]. \tag{5}$$

2.2 Entry Costs

One focus of the existing literature on the decision to export has been on the role of sunk costs.[5] It is natural to think of costs associated with entering foreign markets that may have the character of being sunk in nature. These might include the cost of information about demand conditions abroad or costs of establishing a distribution system. We refer to these as entry costs and, for ease of exposition, we assume these costs recur in full if the firm exits the export market for any amount of time.[6] Profits for the firm in single period maximization problem with entry costs are given by

$$\widetilde{\pi}_{it}\left(X_t, Z_{it}, q^*_{it-1}\right) = p_t q^*_{it} - c_{it}(X_t, Z_{it}, q^*_{it-1}|q^*_{it}) - N\cdot\left(1 - Y_{it-1}\right) \tag{6}$$

where N is the entry cost for the firm.[7] The firm does not have to pay the entry cost if it exported in the previous period, i.e. if $Y_{it-1} = 1$. Firms will export if expected profits net of entry costs are positive, $Y_{it} = 1$ if $\widetilde{\pi}_{it} > 0$.

Incorporating entry costs in a dynamic framework provides an extra mechanism for today's export decision by the firm to influence future decisions to export. This formulation of entry costs as sunk costs yields an

[5]The theoretical literature on sunk costs and exporting is developed in papers by Dixit (1989a,b), Baldwin (1988), Baldwin and Krugman (1989), and Krugman (1989). Roberts and Tybout (1994) empirically address the question of entry and exit costs in the decision to export by the profit maximizing firm. In considering sunk costs, our model follows theirs with the addition of potential productive spillovers from past exporting.

[6]It is possible that there may be costs associated with exiting the export market, akin to one time charges for closing a plant, however they will not change the structure of the model or the estimation equation. In our empirical work, we test whether these entry costs recur fully after one period or whether there is some persistent benefit from having exported more than one year in the past.

[7]The entry cost may vary due to both exogenous and firm specific factors, $N_{it} = N(X_t, Z_{it})$. We will allow for such dependence in our estimation procedure in a subsequent revision.

option value to waiting and thus increases the region where the firm chooses not to act. The firm chooses a sequence of output levels, $\{q^*_{is}\}^{\infty}_{s=t}$, that maximizes current and discounted future profits,

$$\Pi_{it} = \mathrm{E}_t\left(\sum_{s=t}^{\infty}\delta^{s-t}\left[\tilde{\pi}_{is}\cdot Y_{is}\right]\right), \tag{7}$$

where period-by-period profits are given by equation 6 and, as usual, are constrained to be non-negative since the firm always has the option not to export. This is equivalent to the firm choosing whether to export in each period since we allow the firm to always pick the within period profit maximizing quantity. The value function is the same as before with the addition of potential entry costs in the within period profits,

$$V_{it}(\cdot) = \max_{\{q^*_{it}\}}\left(\tilde{\pi}_{it}\cdot\left[q^*_{it}>0\right] + \delta\mathrm{E}_t\left[V_{it+1}(\cdot)\mid q^*_{it}\right]\right). \tag{8}$$

A firm will choose to export in period t, i.e. $q^*_{it} > 0$, if

$$\begin{aligned} p_t q^*_{it} + \delta\left(\mathrm{E}_t\left[V_{it+1}(\cdot)\mid q^*_{it}>0\right] - \mathrm{E}_t\left[V_{it+1}(\cdot)\mid q^*_{it}=0\right]\right) \\ > c_{it} + N_{it}\cdot\left(1-Y_{it-1}\right). \end{aligned} \tag{9}$$

The difference in the multi-period models with and without entry costs comes through the added intertemporal link between exporting today and exporting tomorrow embodied in the cost of entry. However, without a structural model of the production function, and cost function, we will be unable to identify intertemporal spillovers due to learning and those due to sunk costs.[8]

While we choose to think about the export decision as the introduction of a new good, one might imagine that firms choose total production quantities regardless of the intended destination. Only after production do firms then decide which market, domestic or foreign, will yield the highest profits. This plausible alternative approach to exporting yields almost identical implications for the value function given above and for our estimation strategy with the notable exception that sunk costs should be negligible.

Our empirical work starts from the specification in equation 9. Rather than parameterize the cost function, we choose to employ a non-structural

[8]Previous work on estimating sunk costs has assumed no intertemporal spillovers in production, i.e. no learning, and thus has potentially overstated the role of entry and exit costs per se in the export decision. This problem of measuring the magnitude of sunk costs is compounded by potential persistence in shocks to the firm. See section 4 for further discussion.

model in testing hypotheses about the role of firm characteristics, externalities, entry costs, and government expenditures in the decision to export by the firm. Before outlining the estimation strategy, we discuss our panel of plants and their characteristics.

3 Exporting and Plant Characteristics

To develop an understanding of why particular firms export, we assemble a sample of continuously operating plants from 1984 to 1992. We use all such plants in the Annual Survey of Manufactures (ASM) from the Longitudinal Research Database of the Bureau of the Census. The choice of a continuous panel is motivated by two issues. To include observations on as many years as possible, we were obliged to look at plants in the ASM. Certain plants, primarily larger establishments, are sampled with certainty in each ASM, other plants are included as non-certainty cases in a particular 5 year wave. These non-certainty cases are automatically dropped in the subsequent 5 year wave. Given our need to estimate a dynamic specification with lagged endogenous variables, we chose to assemble as long a panel as possible.[9]

As a result of these criteria, the resulting sample of 13,606 plants is not representative of the far larger population of 193,000+ manufacturing establishments in the Census of Manufactures (see Table 1).[10] Plants in our sample are substantially larger and far more likely to be exporters than manufacturers generally. As a result, the plants we observe are among the most important in manufacturing, accounting for 41% of total employment, 52% of total output, and 69% of total exports in 1987. These features mean that we are not necessarily estimating the 'true' probability of exporting. In particular, we have little to say about the behavior of small plants. However, we do capture the preponderance of the export activity in the U.S. economy during the recent boom, suggesting that implications for policy from the sample should be robust.

Table 2 shows the export characteristics of the sample for 1984 and 1992. The export boom of the late 1980s and early 1990s shows up clearly in the

[9]We also dropped any plant that failed during the sample period. Including such plants would necessitate modelling the probability of death, seriously complicating the empirical work. This assumption is not innocuous, however, as exporting plants fail less frequently than non-exporters.

[10]The total population of manufacturing establishments is 300,000+ of which 193,000+ are surveyed directly in the Census of Manufactures. See U.S. Bureau of the Census (1987) for details.

sample. Exporters went from just under half of the plants in 1984 to more than 54% in 1992. At the same time, the real value of exports at the average plant rose from $10.5 million to $17.0 million. This rapid rise meant that the share of shipments exported was climbing from 8.5% to 11.4% even as the number of exporters increased.[11]

Table 3 reports means of plant characteristics for exporters and non-exporters in 1984 and 1992 for the sample. In addition, columns 3 and 6 present percentage differences between exporters and non-exporters after controlling for 4-digit (SIC - standard industrial classification) industry and state. In both periods, there are substantial differences between the two types of plants. Exporters are substantially larger, pay higher wages, have higher productivity, and are more likely to belong to a multi-plant firm. Controlling for industry and state in 1984, we find that exporters are substantially larger (44.3%-50.8%), pay higher wages to all types of workers (3.4%-10.6%), and are more productive (6.5%-11.1%).

The picture remains largely unchanged in 1992: exporters are still substantially larger, pay higher wages, and are more productive than non-exporters in the same state and industry. However, in every category, the difference between exporters and non-exporters has narrowed, and for white collar workers, the wage gap has disappeared. While exporting has become more commonplace in recent years, there still remain substantial differences between exporters and non-exporters.

3.1 Transitions In and Out of Exporting

The preceding results show clearly that exporters differ substantially from non-exporters, even within the same industry. To understand the magnitude of the flows in and out of exporting, we look at the transition rates in our sample of plants.

In Figure 1, we show the numbers of exporters and non-exporters in our sample as well as the fraction of each group that switched status from year to year. The export boom of the early 1990s is evident. Exporters accounted for just under half of the plants in 1984 but by 1992 there had been a net gain of 570 plants, raising the share of exporters to 54%.

Exporting is not a once and forever phenomenon. Year-to-year transition rates are large. On average over the period, 13.9% of non-exporters begin to export in any given year while 12.6% of exporters stop. Even in the later

[11]The increases occur largely after 1987. See Bernard and Jensen (1995b) for a discussion of the export boom by state and industry.

part of the sample, during the export boom, exits averaged over 10% per year and entries more than 14% per year. The rise in exporting comes more from a decline in exits than a rise in entrants. This substantial degree of mixing in the export market bodes well for testing our hypotheses. Unlike previous studies on the export decision, we have numerous observations both for exits and entries.[12]

While substantial numbers of plants enter and exit the export market each year and exporting became more prevalent during the period, there is still a large degree of persistence in the export status of an individual plant. Columns 1 and 2 of Table 4 report the fraction of exporters and non-exporters in 1984 who were also exporters in one of the subsequent eight years.[13] Among plants that exported in 1984, 80.3% were exporting four years later and 78.6% were exporting in 1992. Non-exporters show similar persistence, 78.2% remained non-exporters in 1988 and 70.4% were non-exporters in 1992.

Columns 3 and 4 of Table 4 report the predicted rates of persistence if exits and entrants were chosen randomly using the calculated annual transition rates. At all horizons, the predicted persistence is substantially lower than that observed in the sample. From this we conclude that there is a substantial amount of reentry by former exporters, i.e., they have higher probabilities of exporting after having exited the export market. Similarly, former non-exporters have a higher propensity to stop exporting.

We would like to know whether this persistence in exporting results from attributes of the plants themselves, i.e., certain plants are more export-oriented, or from sunk costs, i.e., exporting begets more exporting.[14] To provide some evidence on the relative importance of the two effects we look at the distribution of exporting sequences in the data. We make the assumption that plant heterogeneity affects the fraction of time that a plant is an exporter, but not the probability of exporting in consecutive periods. We then calculate the probability a plant follows a given sequence of exporting

[12]Roberts and Tybout (1994) report average entry and exit rates of 2.7% and 11.0% per year respectively for Columbian plants and fully 86% of the plants in their sample never change export status. In their sample of 2113 Mexican plants, Aitken, Hanson, and Harrison (1995) find only 245 plants changed export status from 1986-1989. During that same period 39.42% of the plants in our sample switched status.

[13]These percentages treat plants that exit and reenter the same as plants that export continuously. For example, the exporter percentage for 1986 includes plants that exported in 1984, 1985, and 1986 as well as those that exported just in 1984 and 1986.

[14]This is the fundamental problem we will face in the estimation of the decision to export, i.e. the identification of unobserved plant heterogeneity and sunk costs.

and non-exporting conditional on the fraction of the time the plant is an exporter. If plant effects are important, we expect to see concentrations of plants both exporting in most years and not exporting in most years. If sunk costs are important, we expect to observe runs of exporting and non-exporting rather than random switching.

Table 5 reports the distribution of plants across all the 128 possible sequences of exporting and non-exporting for the seven years from 1986-1992. Clearly, a large fraction of plants exports in all seven years, 28.2%, and an equally large fraction, 29.0%, never exports.[15] In addition, plants are more likely to export once (7.5%) or for six years (11.4%) than for three (5.0%) or four (5.9%). We also observe that runs of exporting and non-exporting are common events. Figure 2 reports the probability that a plant follows a given sequence conditional on the fact that it exported in 3 of 7 years. Sequences with runs, such as 1110000 and 0000111, are more prevalent than those without runs, 0010101 and 0101010.

To get some perspective on the heterogeneity of entry and exit across industries, we report the average annual entry and exit rates by two digit industry in Figure 3. Printing (SIC 27) and petroleum (SIC 29) and apparel (SIC 23) show lower entry and exit rates than the average, however most industries are remarkably similar to the overall pattern of switching.

Taken together the preceding results suggest that both unobserved plant heterogeneity and sunk costs are likely to be important in the decision to export. We turn now to the estimation of the model in section 2 considering the role of plant characteristics, sunk costs, spillovers and government export promotion.

4 Empirical Methodology

From the multi-period model with entry costs given in section 2, we find that a firm exports if current and expected revenues are greater than costs,

$$Y_{it} = \begin{cases} 1 & \text{if } \widehat{\pi}_{it} > c_{it} + N \cdot (1 - Y_{it-1}) \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

where

$$\widehat{\pi}_{it} \equiv p_t q^*_{it} + \delta \left(\mathrm{E}_t \left[V_{it+1}(\cdot) \mid q^*_{it} > 0 \right] - \mathrm{E}_t \left[V_{it+1}(\cdot) \mid q^*_{it} = 0 \right] \right). \tag{11}$$

[15] Alternatively, depending on one's priors, one could conclude that a surprisingly large fraction of the plants switches in and out of exporting.

Our goal is to identify and quantify factors that increase the probability of exporting. We estimate these effects using a binary choice non-structural approach of the form

$$Y_{it} = \begin{cases} 1 & \text{if } \beta X_{it} + \gamma Z_{it} - N \cdot (1 - Y_{it-1}) + \varepsilon_{it} > 0 \\ 0 & \text{otherwise} \end{cases} . \quad (12)$$

Plant characteristics are included in the vector Z_{it}, while other factors such as terms of trade shocks, industry demand shocks, state-industry spillovers, and government subsidies are included in X_{it}. X_{it} includes a plant subscript since we calculate some exogenous variables for individual plants.

4.1 Experience and Entry Costs

As noted previously, the most difficult, and most important, issue in the estimation of equation 12 concerns the identification of the parameter on the lagged endogenous variable. It is highly likely that there are unobserved characteristics such as product attributes or managerial ability which affect the decision to export by the firm. Since these characteristics are potentially permanent, or at least highly serially correlated, and unobserved by the econometrician, they will induce persistence in export behavior, either in or out of the market, and thus will cause us to overestimate the entry costs and experience effects discussed above.[16] In practice this means that the error term, ε_{it}, can be thought of as comprising two components, a permanent plant-specific element, κ_i, and a transitory component, η_{it}.

There are several potential estimation strategies for this dynamic binary choice framework with unobserved heterogeneity, including probit with random or fixed effects, conditional logit, and linear probability models with fixed or random effects. A starting point in choosing among the available specifications is the decision whether unobserved plant heterogeneity is better modelled as fixed or random effects. The use of random effects requires that the plant effects be uncorrelated with the regressors. Most fixed effects models, on the other hand, produce biased and inconsistent parameter estimates, especially for the coefficient on the lagged dependent variable.

The required assumption for random effects is quite likely violated in our export decision model as plant characteristics such as size, wage levels, and ownership characteristics are apt to be correlated with product attributes, managerial ability, technology and other unobserved plant effects. As a

[16]See Heckman (1981) for an analysis of the theoretical issues and Roberts and Tybout (1994) for a discussion in the exporting context.

result, unlike previous studies, we choose to work with a linear probability framework,

$$Y_{it} = \beta X_{it-1} + \gamma Z_{it-1} + \theta Y_{it-1} + \varepsilon_{it}, \tag{13}$$

for its computational simplicity and because it allows us to model the unobserved plant effects as fixed. In section 6, we argue that the linear probability model is better suited to identify the sunk cost parameter separately from the unobserved plant heterogeneity than a probit model with random effects and we provide results from a variety of specifications.

We proceed in several steps. First, we estimate equation 13 in levels, ignoring any plant effects. The levels specification gives us an upper bound on the importance of sunk costs.[17] Bernard and Jensen (1995a) show that plants switching export status from non-exporter to exporter, and vice versa, undergo dramatic contemporaneous changes in size, employment composition, and wages. However, the direction of the causality remains uncertain in that analysis so we lag all plant characteristics and other exogenous variables one year to avoid possible simultaneity problems.

Next, we explicitly consider the role of permanent plant effects, κ_i, as in

$$Y_{it} = \beta X_{it-1} + \gamma Z_{it-1} + \theta Y_{it-1} + \kappa_i + \eta_{it}. \tag{14}$$

We estimate equation 14 first in levels, i.e., fixed effects, and then in differences. The fixed effects estimates are almost surely biased downwards and inconsistent but give us a lower bound for the importance of the lagged endogenous variable. For the specification in first differences, we employ an instrumental variables estimator and use two lags of the levels of the right hand side variables as instruments, i.e. $(X_{it-2}, X_{it-3}, Z_{it-2}, Z_{it-3}, Y_{it-2}, Y_{it-3})$,

$$\Delta Y_{it} = \beta \Delta X_{it-1} + \gamma \Delta Z_{it-1} + \theta \Delta Y_{it-1} + \Delta \eta_{it}. \tag{15}$$

This specification avoids the serious problem of inconsistent estimates found in the fixed effects model.[18]

The structure of the error term, η_{it}, is important in the interpretation of the results. For example, if shocks are transitory, $cov(\eta_{it}, \eta_{it-1}) = 0$, then relatively large entry costs will lead to persistence in exporting (or

[17]The levels specification also allows us to observe the effects of time-invariant plant attributes on export probabilities. Any variables that do not change over time, such as multinational status, will be perfectly correlated with the fixed effect.

[18]See Holtz-Eakin, Newey, and Rosen (1988) and Keane and Runkle (1992).

non-exporting) while small entry costs will allow firms to enter and exit the market more often.[19] Persistent shocks, $\eta_{it} = \delta\eta_{it-1} + \nu_{it}$, with δ near one, can overcome the effects of large entry costs. Firms observing a positive shock today believe that their good fortune will persist and that the value of entry is large. Unmodelled persistence in the error structure would be picked up by the lagged endogenous variable and thus incorrectly interpreted as high entry costs. Our specification in first differences should help alleviate this problem as well, although we will suffer a loss in efficiency if the shocks are purely transitory.

4.2 Plant Characteristics

Drawing on the cross-sectional comparisons of exporters and non-exporters above and elsewhere, we consider several hypotheses about the role of plant characteristics in the export decision. Perhaps the most obvious plant attributes to consider are those related to past success. It would appear to be relatively uncontroversial to claim that good firms become exporters, however, a substantial fraction of export policy assumes instead that exporters become good firms. The measures of plant success we consider include size and productivity. Consistently in all samples and time periods, exporters are much larger plants. Size may proxy for several effects; larger firms by definition have been successful in the past, but size may be associated with lower average, or marginal, costs, providing a separate mechanism for size to increase the likelihood of exporting. We use productivity, measured by value-added per employee, as an additional measure of plant success.

We also consider the role of labor quality. If exported goods are of higher quality and thus have a higher value to weight ratio, then we would expect the quality of the workforce to be positively related with entrance into foreign markets. To proxy for workforce quality, we use lagged average wages and the ratio of white collar to total employees.

A sizable body of research has focused on the role of multinationals, and ownership more generally, in cross-border trade.[20] We include dummy variables for multinational status and multi-plant firms to capture these ownership effects.[21] Finally, we consider aspects of the products themselves.

[19] All discussions of large entry costs are relative to the magnitude of shocks hitting the firm.

[20] See Brainard (1993a,b).

[21] Since these characteristics do not change over time, they will be included only in the levels estimates.

To see whether firms export after introducing new products, we include a dummy for plants that have changed products. The product change dummy equals one if the 4-digit industry code of the plant switches.

4.3 Exchange Rates

In addition to considering the role of plant characteristics, we test a number of hypotheses from the literature on exporting. Of particular interest is the participation response to favorable exchange rate shocks. To our knowledge, there has been no previous work estimating the supply response of plants to exchange rates. Since aggregate exchange rate movements will be washed out by the inclusion of time dummies, we construct industry specific exchange rates. The exchange rate for each four digit industry is a weighted average of the real exchange rate indices for the top 25 US export destinations. The weights are the average shares of exports from that industry for that destination over the period.

The use of these industry exchange rates gives us a unique opportunity to estimate the supply response of exporters to price shocks. Of course, we will be estimating the differential response across industries and may be underestimating the response to aggregate exchange rate movements.

4.4 Spillovers

One emerging body of work focuses on the spillovers between the activities and locations of other firms and export behavior. Aitken, Hanson, and Harrison (1995) use a static model of the export decision to estimate the impact of other exporters, and in particular multinationals, in the same region and industry. They argue that externalities of this form reduce the cost of access to foreign markets. If there are significant entry costs and the proximity of exporters reduces these costs, then there will be a dynamic effect increasing the probability of exporting today and thus tomorrow. We test for spillovers using such a dynamic specification.

A separate form of externality might arise if the presence of other exporters lowers the cost of production, possibly by increasing the availability of specialized capital and labor inputs. This spillover enters directly through the cost function. We include spillover variables in our set of exogenous variables, recognizing that in a general equilibrium model such activities would be endogenously determined. Following Aitken, Hanson, and Harrison (1995), we construct measures of industry-state output concentration and export concentration as the share of state-industry activity (output or exports) in national activity divided by the state share of activity in national activity

$$\text{state-industry concentration of } X_{jk} = \frac{X_{jk}}{\sum_j X_{jk}} \Bigg/ \frac{\sum_k X_{jk}}{\sum_{j,k} X_{jk}} \tag{16}$$

where X_{jk} is either output or exports with j indexing states and k indexing industries.[22] This measure is high if exports in the state-industry are large after controlling for state export intensity and industry export intensity.

One problem with the measure is that general favorable output shocks in a state and industry may raise exports with no role for spillovers. To control for this, we include the output concentration measure for the state-industry in addition to the export measure.

We also construct measures of export concentration for states and industries

$$\begin{aligned} \text{state export concentration} &= \frac{\text{state exports}}{\text{national exports}} \Big/ \frac{\text{state output}}{\text{national output}} \\ \text{industry export concentration} &= \frac{\text{industry exports}}{\text{national exports}} \Big/ \frac{\text{industry output}}{\text{national output}} \end{aligned} \tag{17}$$

to identify whether any such spillovers are geographic or sectoral in nature.

4.5 Subsidies

The rapid growth in state government expenditures for export promotion suggests that policy-makers believe that there are substantial social benefits to assisting exporting. State export promotion has several potential benefits. By gathering information on foreign markets, states may reduce the cost of entry and thus promote export participation. This would be evident through a reduction in entry costs. Alternatively, states may provide a coordination role for potential, or current, exporters and thus decrease the costs of exporting. This might be seen through increased numbers of exporters within the state or through increased volumes by existing exporters. Of course, a positive effect of state expenditures on export participation is necessary but not sufficient to show that such outlays are beneficial.

We include state expenditures on export promotion in our set of regressors. Unfortunately, these figures are only available for alternating years in the sample. In addition, we recognize that public expenditures are not necessarily exogenous; increasing numbers of exporters in a state may induce state officials to commit resources to exporting.

[22] All measures of concentration are plant-specific, i.e. they exclude the plant in question.

5 Empirical Results

Due to the use of first differences and the requisite lags for instruments, our data set is trimmed to 7 years (1986-1992) for 13606 plants yielding 95242 observations for the levels regressions and 81636 for the IV in first differences. The lagged export status variable is 0 if the plant did not export last year, 1 if it did. Table 6 reports results from the linear probability specifications, levels, fixed effects, and differences, for the basic model. Table 7 contains the results for the basic model with exchange rates, spillovers and state export promotion expenditures.

5.1 Estimates without plant effects

Column 1 of Table 6 report the coefficients on plant characteristics, including lagged export status, on the probability of exporting from the linear probability model in levels. Dummies for 4-digit industry, state, and year are included. Plant level variables enter significantly in the export decision and confirm the hypotheses about the role of plant characteristics. Past success by the plant, as indicated by size and productivity, increases the probability of exporting. The indicators of labor quality, average wages and white collar employment share, also are significantly positively correlated with exporting, as are ownership characteristics such as multi-plant and multinational status. All increase the probability of exporting, as expected, and are significant at the 1% level.

We include two measures of product change, a dummy if the plant switched industry last year and a dummy if the last industry switch was two years ago. A recent industry switch enters with a positive and significant coefficient while more distant switches have no significant impact. This provides the first evidence that new product introductions increase the probability of exporting. The coefficients on the year dummies confirm our priors about the macroeconomic conditions for exporting during the period. Years early in the sample were bad for exporting, and over time the conditions improved steadily.

As discussed above, if there are significant unobserved plant effects, the levels specification will yield inconsistent estimates and, in particular, will produce an upward biased coefficient on the lagged endogenous variable, and thus overestimate the role of sunk costs in exporting. We find that the coefficient on lagged export status is positive, significant, and improbably large, suggesting that exporting last year raises the probability of exporting today by 66%. The coefficient on twice lagged export status is also very large, positive and significant. We now turn to the fixed effect estimates and our preferred instrumental variables specification in first differences.

5.2 Estimates with plant effects

Columns 2 of Table 6 reports results from the fixed effects model in equation 14. With the exception of plant size, the coefficients in the fixed effects specification are all substantially reduced.[23] Only indicators of past success, size and productivity, remain significant among the plant characteristics. Product changes are still positive and significant. The coefficient on lagged export status (our proxy for sunk costs and experience) is still positive and significant, although the magnitude is greatly reduced to 0.16. The second lag of export status is no long significant. These estimates give us a lower bound for sunk costs.

Columns 3-4 of Table 6 reports results from the IV differences specification in equation 15 with one and two lags of export status respectively. Among the plant characteristics, plant size and average wages remain positive and significant, and the magnitudes of both coefficients rise dramatically. These results provide confirming evidence that past success, as proxied by plant size, raises the probability that a plant will export. In addition, labor force quality, in the form of higher wage levels, also increases export probabilities. Other plant attributes, such as the fraction of white collar workers and productivity, are primarily level effects, as they are no longer significant in the differences specification and thus are indistinguishable from the plant fixed effect.

Lagged export status again enters with a positive and significant coefficient, again rejecting the hypothesis of no sunk costs.[24] In the specification with a single lag of export status, the magnitude of the sunk cost parameter is similar to the fixed effects estimate, having exported last period increases the probability of exporting today by 20%. This is a smaller role for sunk costs than is found in previous work.[25] With two lags, the estimate rises to

[23]This reduction results from the biased estimates of the fixed effects model in relatively short panels.

[24]We caution that separate identification of entry costs and experience effects is not possible.

[25]Using a random effects probit model on Columbian plants, Roberts and Tybout (1994) report that past exporting increases the probability of exporting today from 0.1% to 30% for the median plant and by 50-60% for a plant at the 75th percentile in the distribution of characteristics. In section 6, we argue that inadequate controls for unobserved plant

0.40 and the second lag of export status is positive and significant at 0.10.

Controlling for plant effects yields a significant estimate of the combined role of entry costs and experience. While the parameters vary according to the specification, these estimates provide a range of 0.20-0.40 for the estimate of sunk costs in our panel of plants. This confirms the earlier descriptive results where transition rates were high but, at the same time, a large fraction of plants did not change their export status. There are strong plant-specific components to the decision to export, but transitions in and out are relatively easy for those plants with the correct set of attributes.

To provide a check on the robustness of the estimates of the the sunk cost parameter we estimate the IV differences specification separately for each two digit manufacturing industry. In Figure 3 we saw that the amount of switching in and out of exporting was relatively stable across industries. In Figure 4 we show the point estimates on lagged export status for the IV difference specification by two digit industry.[26] The estimates are quite stable across industries generally ranging from 0.25 to 0.40 with only petroleum showing a dramatically higher estimate, 0.54, of the sunk costs.

5.3 Exchange Rates

The effect of exchange rates on export participation is reported in column 1 of Table 7. Industry exchange rates enter significantly with the expected sign. Favorable exchange rate shocks increase export participation, a 10% decrease in the exchange rate boosts the probability of exporting by 1.2%. To the extent that this is the first estimate of the effect of exchange rate movements on entry into exporting, it is difficult to evaluate the magnitude of the coefficient.[27] Other coefficients remain largely unchanged in the specification, lagged export status still enters positively and significantly with a point estimate of 0.38. Similarly total employment is still a significant indicator of exporting, although the product change variable is no longer significant.

heterogeneity may lead to overestimates of the role of sunk costs.

[26]Industries 21 and 25 (tobacco and furniture) were dropped due to insufficient observations.

[27]The volume response to exchange rate movements involves this participation increase as well as expansion of exports from existing exporters.

5.4 Spillovers

We consider the role of spillovers from neighboring export activity in column 2 of Table 7. In defining proximity to a plant for spillovers, we consider both the role of geography and industry. As discussed above, one potential identification problem in testing for spillovers is that a positive output shock to a state-industry may improve the prospects of all firms, thus inducing more firms to export without any role for spillovers. To avoid picking up such shocks with our export concentration measure, we include a measure of state-industry output intensity as well. The state-industry output and export concentration measures are highly correlated across firms in the sample, with a correlation coefficient of 0.60. We also include measures of state export intensity and industry export intensity. Interestingly, these measures are somewhat negatively correlated with the state-industry export measure and only modestly positively correlated with each other. This suggests that export intensity in one sector in a state is not evidence of export intensity of the sector or the state.

None of the concentration measures is significantly different from zero. The measure of state-industry exports is barely positive and while the output intensity and state export measures are both negative.[28]

5.5 Subsidies

Column 3 of Table 7 reports results with the measure of state export promotion. Since the measure is available only every other year, the sample is substantially reduced. Contemporaneous state export promotion is slightly positive but not significant. Again, as with spillovers, the selection of large plants may be exactly the wrong sample to observe the effects of state export promotion as most agencies explicitly target small and medium size firms.

The results presented in this section emphatically confirm the presence of entry costs in exporting. However, the magnitude of the sunk costs is relatively small, having exported last year increases the export probability by 20-40%. Plant characteristics, both observed (size, wage levels) and unobserved, play a major role in determining the export status of a plant. Exchange rate movements have the expected effect on export participation while spillovers and state government expenditures have no effect on export-

[28] If spillovers are present, it is possible that our sample of big plants may miss the most important type, those from larger to smaller establishments in the same region and industry.

ing probabilities.

6 Alternative Estimation Strategies

We recognize that the linear probability specification pursued above is not the normal first choice for binary choice problems. The potential problems of such a estimation method are well known, i.e. that the predicted probabilities may lie outside of the 0-1 range. In this section, we discuss issues surrounding another estimation strategy, probit with and without random effects, focussing on the coefficients on the lagged dependent variable.[29]

The difficulties in consistently estimating a dynamic specification in panel data with persistent plant-specific errors are well known. Fixed effects estimators in models with lagged endogenous variables produce biased and inconsistent estimates. Heckman (1981) discusses the issue of state-dependence and plant effects in a binary choice model. Heckman proposes a random effects probit estimator although he notes that if the heterogeneity of the unobserved plant effects is large, the random effects probit estimate of the coefficient on the lagged dependent variable may be biased upwards. Holtz-Eakin, Newey, and Rosen (1988) discuss the problem in a vector autoregressive framework with continuous dependent variables. They propose the differenced instrumental variable method that we employ in section 5.[30]

As discussed previously, there are compelling reasons to employ a fixed, rather than a random, effects specification as the fixed effects approach avoids the difficulty of correlated plant effects and regressors. If the time dimension of the panel is large enough, the bias induced by the fixed effects estimator will be small. However, in practice, it is difficult to determine the appropriate sample length. To provide some evidence on the dimension of the bias, we report the coefficient on the lagged endogenous variable for the sequence of fixed effects estimators allowing the panel to grow from length 2 to the full sample. (See Figure 3.) The coefficient in the shortest sample, $T = 2$, is hugely negative, -1.53, and clearly substantially biased. As the

[29] Coefficients on other variables are qualitatively similar across specifications. A full set of results for all variables is available on request.

[30] Card and Sullivan (1988) first consider a conditional logit estimator to deal with individual effects but show that a sufficient statistic for the individual effect requires the full path of outcomes, both forward and backward in time. They then use a random effects estimator where the random effects are parameterized by a discrete distribution with four nodes. Such a specification may improve upon the random effects probit specification discussed below if the distribution of plant effects is indeed bimodal as discussed above.

sample lengthens, the estimated coefficient rises rapidly to 0.16 when $T = 7$. This is close to the estimate from the IV differences specification with one lag and suggests that, for our sample of plants, the fixed effect estimator in levels performs fairly well although it is still biased..

Roberts and Tybout (1994), in their study of sunk costs in the export decision by Columbian plants, employ a version of the random effects probit estimator suggested by Heckman (1981). As in our specification, they assume the errors, ε_{it}, are comprised of a permanent plant-specific element and a purely transitory component, $\varepsilon_{it} = \kappa_i + \eta_{it}$. The permanent component, κ_i, is assumed to be uncorrelated across plants, $cov(\kappa_i, \kappa_j) = 0$, and the transitory component, η_{it}, uncorrelated across time, $cov(\eta_{it}, \eta_{it-s}) = 0$.

These assumptions allow them to estimate equation 12,

$$Y_{it} = \begin{cases} 1 & \text{if } \beta X_{it} + \gamma Z_{it} - N \cdot (1 - Y_{it-1}) + \kappa_i + \mu_{it} > 0 \\ 0 & \text{otherwise} \end{cases},$$

as a dynamic random effects probit, after assuming that the errors are normally distributed.[31] The random effects probit suggested by Heckman (1981) uses a single parameter, $\sigma^2_{\kappa_i}$, to parameterize the distribution of the plant effect. However, this is unlikely to provide a good fit to the underlying unobserved plant effects for the export decision problem as the distribution of plants is highly bimodal. Remember, that almost 30% of the plants in the sample never export and almost 30% continously export. Any failure to adequately capture the distribution of plant effects will increase the coefficient on the lagged endogenous variable.[32]

To evaluate the various estimation strategies, we present some additional results for the base model concentrating on estimates of the coefficient on the lagged endogenous variable. Recall that ignoring plant effects, the estimated coefficient from the linear probability model was 0.66. Row 4 of Table 8 shows that a probit without plant effects yields an almost identical effect of

[31] In practice, for a sample as large as ours with T=7 and N=13,606, the computational requirements for the random effects probit are intense. One run of the basel model required 250+ hours of CPU time on a dedicated HP Apollo workstation.

[32] One final, and important, problem remains in that the initial period export status, Y_{i0}, is not exogenous if there are permanent plant-specific components in the error term. Instrument for these initial values

$$\widehat{Y}_{i0} = f(X_{i,-1}, Z_{i,-1}) + \xi_{i0}$$

allow the errors to be correlated with the permanent plant-specific error, $cov(\kappa_i, \xi_{i0}) = \rho_1$.

0.66.[33] In row 5, we present the estimate from the random effects probit model for the entire panel. The effect of lagged export status is virtually unchanged at 0.62.

This result is quite surprising as it suggests that unobserved plant heterogeneity has a minor role in the persistence of exporting and that there are very large sunk costs. As suggested above, the source of this unchanged estimate is probably the poor fit of the underlying plant effect distribution. As a check, we estimate the random effects probit dropping plants that are continuous exporters or continuous non-exporters.[34] The coefficient on the lagged dependent variable drops substantially from 0.62 to 0.40, confirming our suspicion that the random effects probit is inadequately controlling for the underlying heterogeneity.

7 Conclusions

In this paper, we provide the first empirical evidence on the export decision by U.S. firms. In a dynamic framework, we consider the impact of barriers to entry, individual plant attributes, exchange rates, spillovers, and export promotion. In doing so we propose a simple estimation strategy to identify the role of sunk costs and unobserved plant heterogeneity.

The major results are that entry costs are relatively low for U.S. plants and plant heterogeneity is substantial and important in the export decision. The finding of moderate sunk costs is in contrast to previous work on the export decision and suggests that responses to favorable shocks should be relatively rapid. The role of plant heterogeneity is less surprising but means that only a subset of plant may have the characteristics necessary to take advantage of favorable shocks. The key unanswered question is how firms obtain the characteristics that allow them to easily enter the export market. While this paper confirms that successful plants with highly paid workers are more likely to become exporters, the companion question of whether exporting provides benefits to the firm remains an important subject for future research.

We also test hypotheses about spillovers and subsidies from the recent literature on trade and firms. We find almost no role for geographic spillovers and, similarly, no evidence for the importance of export activity by other

[33]The coefficients from the probit cannot be directly interpreted in terms of probabilities. We evaluate the increase in the probability of exporting from having exported last period at the mean of the regressors.

[34]This is analogous to, but not the same as, a conditional probit. See Heckman (1981).

firms in the same industry. In addition, state government export promotion has no noticeable effects on exporting in our sample. We caution that our results on spillovers and subsidies may result from our sample selection criteria which limit our analysis to large plants.

The major issue in estimating our model of the decision to export is that of unobserved plant effects. We use a simple linear probability model to control for unobserved heterogeneity but the difficulty of identification in models with discrete panel data and unobserved heterogeneity remains a topic for further work. Future research on the export decision should employ alternative specifications such as discrete random effects and semi-parametric estimators of the unobserved heterogeneity. However, the results presented here suggest that the computational advantages of the linear probability model should not be overlooked.

As microeconomic data on trade-related issues becomes increasing available, a wide range of questions arise concerning the interaction of macroeconomic policy and firm responses. These relatively unexplored areas include the export volume responses of U.S. firms to exchange rate shocks, the differences between small and large plants, between new and established plants, and between plants and firms.

References

Aw, Bee and Geeta Batra. (1994). "Exports, Firm Size and Wage Inequalities." Pennsylvania State University mimeo.

Aitken, Brian, Gordon Hanson, and Ann Harrison. (1995) "Spillovers, Foreign Investment, and Export Behavior." mimeo.

Baldwin, Robert. (1988) "Hysteresis in Import Prices: The Beachhead Effect." *American Economic Review*, 78(4) pp.773-785.

Baldwin, Robert and Paul Krugman. (1989) "Persistent Effects of Large Exchange Rate Shocks." *Quarterly Journal of Economics*, Vol. 104, No. 4 pp. 635-654.

Bernard, Andrew B. (1995)."Exporters and Trade Liberalization in Mexico: Production Structure and Performance." MIT Working Paper No.

Bernard, Andrew B. and J. Bradford Jensen. (1995a). "Exporters, Jobs, and Wages in U.S. Manufacturing, 1976-1987." *Brookings Papers on Economic Activity, Microeconomics.* Washington DC.

Bernard, Andrew B. and J. Bradford Jensen. (1995b). "Inside the U.S. Export Boom". MIT mimeo.

Bernard, Andrew B. and J. Bradford Jensen. (1996). Exporters, Skill-Upgrading, and the Wage Gap. *Journal of International Economics* forthcoming.

Bernard, Andrew B. and Joachim Wagner (1997). Exporters and Success in German Manufacturing. *Weltwirtschaftliches Archiv*, forthcoming.

Brainard, Lael. (1993a). "An Empirical Assessment of the Proximity/Concentration Tradeoff Between Multinational Sales and Trade." NBER Working Paper No.

Brainard, Lael. (1993b). "An Empirical Assessment of the Factor Proportions Explanation of Multinational Sales." NBER Working Paper No.

Brainard, Lael and David Riker. (1995) "U.S. Multinationals and Competition from Low Wage Countries ". MIT mimeo.

Card, David and Daniel Sullivan, (1988) "Measuring The Effect of Subsidized Training Programs on Movements In and Out of Employment." *Econometrica*, Vol. 56, No. 3, pp.497-530.

Dixit, Avinash. (1989a) "Entry and Exit Decisions Under Uncertainty." *Journal of Political Economy*, Vol. 97, No. 3 pp. 620-638.

Dixit, Avinash. (1989b) "Hysteresis, Import Penetration, and Exchange Rate Pass-Through." *Quarterly Journal of Economics*, Vol. 104, No. 2 pp. 205-228.

Heckman, James. (1981) "The Incidental Parameters Problem and the Problem of Initial Conditions in Estimating a Discrete Time-Discrete Data Stochastic Process." in Charles Manski and Daniel McFadden (eds.), *The Structural Analysis of Discrete Data.* Cambridge: MIT Press.

Holtz-Eakin, Douglas, Whitney Newey, and Harvey Rosen. (1988) "Estimating Vector Autoregressions in Panel Data." *Econometrica*, Vol. 56, No. 6, pp 1371-1395.

Keane, Michael and David Runkle (1992) "On the Estimation of Panel-Data Models with Serial Correlation When Instruments Are Not Strictly Exogenous." *Journal of Business and Economic Statistics*, Vol. 10, No. 1 pp. 1-29.

Krugman, Paul. (1989) *Exchange Rate Instability.* MIT Press, Cambridge MA.

Krugman, Paul. (1992) *Geography and Trade.* MIT Press, Cambridge MA.

National Association of State Development Agencies. (1993) *State Export Program Database 1992.* Washington D.C.

Roberts, Mark and James Tybout. (1994). "An Empirical Model of Sunk Costs and the Decision to Export." Pennsylvania State University mimeo.

U.S. Bureau of the Census. (1987). *Census of Manufactures General Summary MC87-S-1.* Department of Commerce.

Table 1: Representiveness of the Sample - 1987

	All Plants 1987		Continuing Sample 1987	
	Exporters	Non-exporters	Exporters	Non-exporters
# of Plants	28,266	165,225	6,623	6,983
% of Sample	14.60%	85.40%	48.68%	51.32%
Average Size	253	58	674	355
Exports/Shipments	9.87%	0.00%	9.45%	0.00%
% of total employment	42.65%	57.36%	26.65%	14.80%
% of total shipments	52.57%	47.43%	35.78%	16.59%
% of total exports	100.00%	0.00%	69.4%	0.00%

Table 2: The Export Boom 1984-1992[1]

(evidence from the sample)

	1984	1992
% Exporters	49.85%	54.04%
Total Exports[a]	$71,526	$ 124,717
Exports/Shipments	8.49%	11.39%
Total Shipments by Exporters[a]	$ 782,978	$ 939,435

[1] These numbers are drawn from the sample of 13,606 continuing plants. Aggregate numbers are reported in Bernard and Jensen (1995b).

[a] Millions of 1987$.

Table 3: Characteristics of Exporters and Non-Exporters
1984 and 1992

	1984			1992		
	Non-exporters	Exporters	% Difference[†]	Non-exporters	Exporters	% Difference[†]
Total Employment	352	701	0.443**	335	584	0.391**
Average Wage[a]	22,361	26,032	0.098**	22,959	26,469	0.058**
Wage - Blue Collar[a]	20,569	23,389	0.106**	20,482	23,366	0.067**
Wage - White Collar[a]	32,384	33,653	0.034**	33,524	34,713	-0.002
Shipments[b]	50,453	115,432	0.508**	57,573	127,762	0.456**
Shipments/ employee[c]	211,714	184,233	0.065**	240,527	229,828	0.066**
Value-added/ employee[c]	80,058	82,086	0.111**	101,134	105,842	0.103**
Multi-plant firm	94.3%	96.8%		95.1%	96.9%	

[†] Coefficient on export status in a regression of the plant characteristic on export status, 4-digit industry dummies and state dummies.
** Significant at the 1% level.
[a] 1987$ per year.
[b] Thousands of 1987$
[c] 1987$ per employee

Figure 1: Transitions In and Out of Exporting

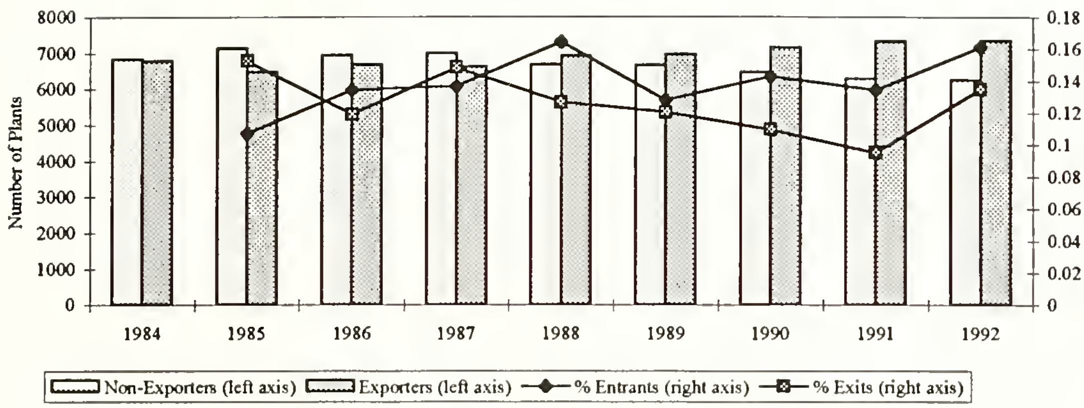


Table 4: Long Run Export Persistence

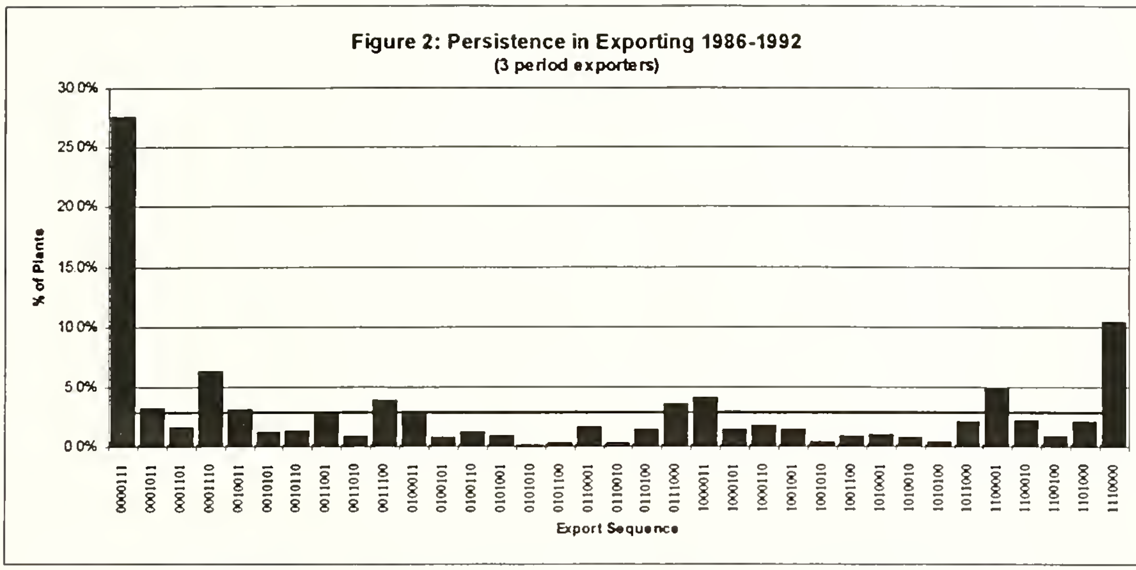
Fraction of 1984 Plants with Same Export Status[1]

	(1) Exporters Actual	(2) Non-Exporters Actual	(3) Exporters Expected	(4) Non-Exporters Expected
1985	84.7%	89.3%	84.7%	89.3%
1986	83.5%	85.4%	76.7%	78.6%
1987	79.6%	82.0%	68.5%	69.2%
1988	80.3%	78.2%	65.0%	58.9%
1989	79.4%	77.1%	61.7%	52.2%
1990	80.0%	74.9%	60.4%	45.4%
1991	80.5%	72.6%	60.0%	39.8%
1992	78.6%	70.4%	58.3%	50.2%

[1] The numbers in columns 1 and 2 represent the percentage of exporters (non-exporters) in 1984 who were also exporters in the listed year, i.e. 78.6% of the plants that exported in 1984 also exported in 1992. The numbers in columns 3 and 4 represent the expected percentages if entering and exiting plants were chosen randomly from the population with annual transition rates given by the data.

Table 5: Export Sequences 1986-1992

Export Sequence	Percentage of Plants	Export Sequence	Percentage of Plants
0000000	29.02%	0001111	1.21%
0000001	2.71%	0010111	0.23%
0000010	0.87%	0011011	0.17%
0000100	0.49%	0011101	0.13%
0001000	0.57%	0011110	0.40%
0010000	0.67%	0100111	0.16%
0100000	0.73%	0101011	0.06%
1000000	1.50%	0101101	0.04%
0000011	1.25%	0101110	0.04%
0000101	0.24%	0110011	0.09%
0000110	0.48%	0110101	0.04%
0001001	0.15%	0110110	0.06%
0001010	0.12%	0111001	0.14%
0001100	0.22%	0111010	0.11%
0010001	0.12%	0111100	0.15%
0010010	0.04%	1000111	0.29%
0010100	0.10%	1001011	0.07%
0011000	0.32%	1001101	0.02%
0100001	0.15%	1001110	0.10%
0100010	0.06%	1010011	0.10%
0100100	0.06%	1010101	0.03%
0101000	0.08%	1010110	0.03%
0110000	0.27%	1011001	0.09%
1000001	0.43%	1011010	0.04%
1000010	0.09%	1011100	0.20%
1000100	0.09%	1100011	0.22%
1001000	0.07%	1100101	0.10%
1010000	0.32%	1100110	0.09%
1100000	0.90%	1101001	0.07%
0000111	1.37%	1101010	0.04%
0001011	0.16%	1101100	0.08%
0001101	0.08%	1110001	0.29%
0001110	0.32%	1110010	0.19%
0010011	0.15%	1110100	0.12%
0010101	0.06%	1111000	0.68%
0010110	0.07%	0011111	1.97%
0011001	0.14%	0101111	0.33%
0011010	0.04%	0110111	0.19%
0011100	0.19%	0111011	0.15%
0100011	0.15%	0111101	0.21%
0100101	0.04%	0111110	0.33%
0100110	0.06%	1001111	0.46%
0101001	0.04%	1010111	0.21%
0101010	0.01%	1011011	0.11%
0101100	0.01%	1011101	0.12%
0110001	0.08%	1011110	0.32%
0110010	0.01%	1100111	0.47%
0110100	0.07%	1101011	0.15%
0111000	0.18%	1101101	0.08%
1000011	0.21%	1101110	0.25%
1000101	0.07%	1110011	0.35%
1000110	0.09%	1110101	0.11%
1001001	0.07%	1110110	0.21%
1001010	0.02%	1111001	0.35%
1001100	0.04%	1111010	0.28%
1010001	0.05%	1111100	0.78%
1010010	0.04%	0111111	2.85%
1010100	0.02%	1011111	1.84%
1011000	0.10%	1101111	1.19%
1100001	0.24%	1110111	1.29%
1100010	0.11%	1111011	0.91%
1100100	0.04%	1111101	0.94%
1101000	0.10%	1111110	2.34%
1110000	0.51%	1111111	28.23%



Solid line indicates the percentage if all sequences are equally likely.

Figure 3

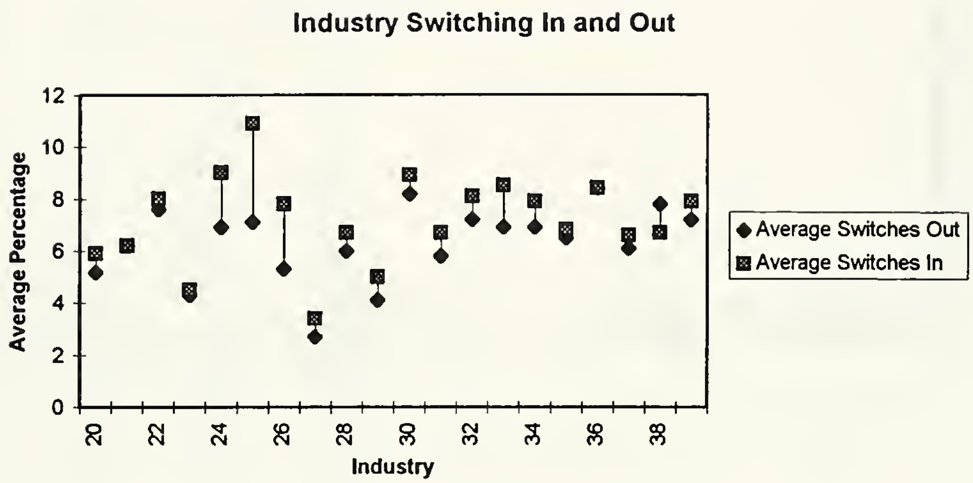

Industry Switching In and Out
Average Percentage
12
10
8
6
4
2
0
20
22
24
26
28
30
32
34
36
38
Industry
Average Switches Out
Average Switches In

Table 6: The Decision to Export
(Plant Characteristics and Entry Costs)

	Levels (1)	Fixed Effects (2)	First Differences (3)	First Differences (4)
Plant-Level Variables[1]				
Exported last year	0.659**	0.1622**	0.208**	0.403**
	(0.002)	(0.004)	(0.008)	(0.016)
Last exported two years ago	0.275**	0.007		0.106**
	(0.004)	(0.005)		(0.007)
Total Employment	0.027**	0.035**	0.179**	0.174**
	(0.001)	(0.005)	(0.065)	(0.072)
Wage	0.025**	0.009	0.067**	0.094*
	((0.005)	(0.008)	(0.037)	(0.041)
Non-production/Total Employment	0.023**	-0.003	-0.097	-0.089
	(0.002)	(0.015)	(0.087)	(0.095)
Productivity	0.011**	0.005*	0.005	0.008
	(0.001)	(0.002)	(0.008)	(0.009)
Multi-plant dummy	0.015**			
	(0.005)			
Multinational	0.010**			
	(0.002)			
Changed product since last year	0.027**	0.028**	0.018	0.028*
	(0.006)	(0.006)	(0.013)	(0.014)
Last changed product two years ago	-0.013+	-0.000	-0.010	-0.007
	(0.007)	(0.007)	(0.009)	(0.010)
Year Dummies	yes	yes	yes	yes
Industry dummies	yes			
State dummies	yes			
N	95242		81636	81636

** significant at the 1% level.
* significant at the 5% level.
+significant at the 10% level.

[1] All plant characteristics are lagged one year.

Figure 4: Industry Estimates - Lagged Export Status

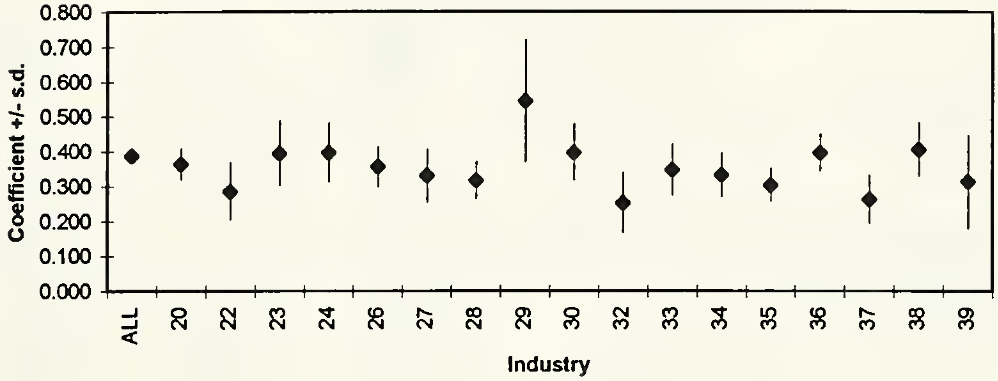


Table 7: Exchange Rates, Spillovers, Subsidies

	First Differences (1)	First Differences (2)	First Differences (3)
Plant-Level Variables[1]			
Exported last year	0.383**	0.388**	0.345**
	(0.017)	(0.017)	(0.025)
Exported two years ago	0.102**	0.104**	0.111**
	(0.008)	(0.008)	(0.012)
Total Employment	0.135**	0.154**	0.040
	(0.053)	(0.053)	(0.085)
Wage	0.029	0.052	-0.005
	(0.036)	(0.036)	(0.056)
Non-production/Total Employment	-0.135	-0.125	-0.060
	(0.094)	(0.095)	(0.145)
Productivity	0.005	0.011	0.014
	(0.009)	(0.009)	(0.016)
Changed product since last year	0.014	0.018	0.036
	(0.015)	(0.015)	(0.023)
Last changed product two years ago	-0.015	-0.011	-0.005
	(0.012)	(0.012)	(0.015)
Industry Exchange Rate	-0.120**		
	(0.031)		
State-industry output concentration		-0.001	
		(0.001)	
State-industry export concentration		0.0001	
		(0.0002)	
Industry export concentration		0.003	
		(0.006)	
State export concentration		-0.022	
		(0.015)	
Export Promotion			0.001
			(0.003)
N	72187	72138	30420

All RHS variables lagged one year. Year dummies included.
** significant at the 1% level.
* significant at the 5% level.
+significant at the 10% level.

[1] All plant characteristics are lagged one year; all spillover variables are contemporaneous.

Figure 5: Tracking the Bias in the Fixed Effects Estimator (Lagged Export Status)

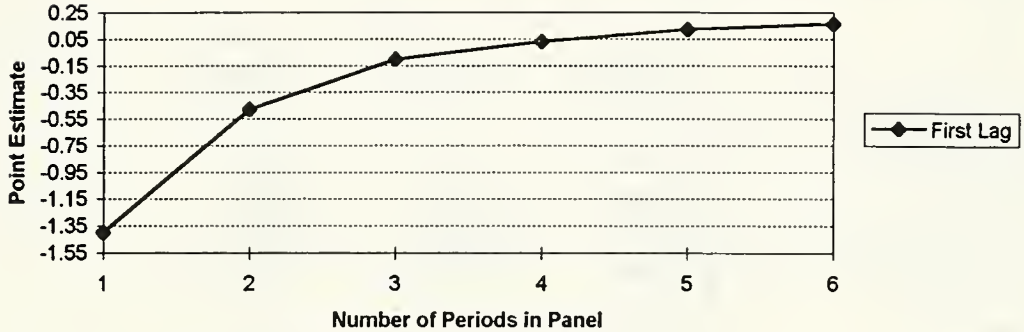


Table 8: Estimates from Alternative Specifications

	Lagged Export Status[1]
Linear Probability	
No Plant Effects	0.66
Fixed Effects	0.16
First Differences	0.40
Probit	
No Plant Effects	0.66
Random Effects - All Plants	0.62
Random Effects - Switchers	0.40

[1] Number represent point estimate for linear probability models, change in probability at means of other RHS variables for probit models. All are significant at the 1% level.