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Firm Structure, Multinationals, and Manufacturing Plant Deaths

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Abstract: Plant shutdowns shape industry productivity, the dynamics of employment, and industrial restructuring. Plant closures account for more than half of gross job destruction in US manufacturing. This paper examines the effects of firm structure on US manufacturing plant closures. Plants belonging to multi-plant firms and those owned by US multinationals are less likely to exit. However, the superior survival chances are due to the characteristics of the plants rather than the nature of the firms. Controlling for plant and industry attributes, we find that plants owned by multi-unit firms and US multinationals are much more likely to close.

Keywords: Exit, shutdown, closure, multi-plant firms, multinational firms, takeovers, entry costs, agglomeration, specialization

JEL codes: D21, D24, F23, L20, L6

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I. INTRODUCTION

Plant shutdowns shape industry and aggregate productivity paths and play a major role in the dynamics of employment, the evolution of regional economies, and industrial restructuring. Over a typical five-year period, more than 30 percent of US manufacturing plants shut down, accounting for more than 17 percent of manufacturing employment.[1] Between 1992 and 1997, plant closures eliminated more than 2.8 million jobs and accounted for 58 percent of gross job destruction in the US manufacturing sector (see table 1). Plant births and deaths contribute disproportionately to industry productivity growth, accounting for as much as 35 percent of average annual multifactor productivity growth (Foster et al. 2001). Plant shutdowns are not only an important contributor to macroeconomic trends but also one of the few unambiguous observed signals of plant performance and thus of inherent interest at a micro level.

The importance of plant shutdowns has led to a growing literature on the determinants of plant exit. However, this literature has focused on plant characteristics and has largely ignored the role of the firm in the shutdown decision. If single-plant firms account for the bulk of employment and output in the US economy or if plants owned by multi-unit firms behave no differently from single-unit firms, the exclusion of firm characteristics would be a minor oversight. This paper examines the role of firm structure in the decision to close a plant.

The need to examine the role of firm characteristics is highlighted by the prevalence of multi-unit and multinational firms. US manufacturing is dominated by both multi-plant and multinational firms.[2] While multi-unit firms account for 17 percent of US manufacturing firms, and 39 percent of all manufacturing plants, they employ 78 percent of the manufacturing workforce and produce 88 percent of the output (see table 2). US multinationals are even more important than their small numbers would suggest. US-based multinational firms, i.e. those with more than 10 percent of their assets abroad, represent only 1 percent of all firms in manufacturing and own only 6 percent of all manufacturing plants. However, these multinationals employ 26 percent of the workforce and produce 34 percent of total manufacturing output. In addition to being significant in terms of employment, multi-unit and multinational firms are also important contributors to employment dynamics—plant shutdowns at multi-plant (multinational) firms account for 68 (21) percent of employment at closing plants.

[1] Data tabulated by the authors from the Longitudinal Research Database of the Bureau of the Census.
[2] The importance of multinationals in the US economy is large and rising over time. Multinationals based in the United States accounted for 26 percent of total employment in 1993 rising to 29 percent in 2000, and these global firms control more than 90 percent of all US trade, both exports and imports (Bernard, Jensen, and Schott 2005).

Given the prevalence of multi-unit and multinational firms, this paper considers the importance of firm structure in the operating decision to close a plant. We focus on three aspects of the firm's role. First we ask whether the existence of other plants within the firm affects the shutdown probability; are multi-plant firms more or less likely to close a plant than a single-plant firm? Second, we look at the effect of operations outside the United States on the survival of domestic plants; do US multinationals shut down their plants more or less frequently? Finally, we examine the effect of a change in ownership on plant survival; do takeover targets close more often?

The existing theoretical literature is largely silent on these issues of firm characteristics and plant survival. Multi-plant firms may be less likely to close a plant because they can shift resources within the firm in bad times, or they may be more likely to close a plant since such plant closures do not also shut down the firm. Similarly, US multinationals may have lower plant shutdown probabilities because of their international reach, or they may have higher probabilities because of their ability to shift production around the world in response to adverse shocks at home. Ownership changes produce similar ambiguity: A takeover target may have desirable features and thus a lower shutdown probability, or may be an ex-post poor match for the firm and thus more likely to close.

While the theoretical possibilities are ambiguous, our empirical results are quite clear. The probability of death is substantially lower for those plants that are part of a multi-plant firm. Similarly, domestic plants owned by US multinationals are far less likely to close than plants in purely domestic firms. Finally, the unconditional probability of death is substantially lower for plants that have recently changed ownership.

However, the lower probability of closure for these plants is driven by characteristics of the plants and the industries where they are active. We show that plants at multi-unit and multinational firms are substantially larger, older, and more productive than single-plant firms. Once we control for these plant attributes known to reduce the probability of shutdown, we find that plants at multi-unit or multinational firms have significantly *greater* chances of being closed. In particular, a plant that differs substantially in its production technique from the rest of the firm is the most likely to be closed by a multi-plant firm. Our findings suggest that firms with multiple production locations, either domestic or foreign, are more likely to use plant shutdown as a margin of adjustment.

Our findings contribute to a wide range of research in industrial organization and to literatures in international trade and investment. A large body of theoretical and empirical research in industrial organization has considered the role of plant attributes in determining plant survival.[3] Our findings strongly suggest an important role for broader firm characteristics in the decision to close

[3] See the empirical work of Dunne, Roberts, and Samuelson (1988, 1989), Dunne and Roberts (1991), Olley and Pakes (1996), and Disney et al. (2003). Theoretical contributions include Jovanovic (1982) and Hopenhayn (1992a).

plants, especially those linked to firm structure and ownership. The role of plant dissimilarity within the firm in the shutdown decision suggests that the overall composition of the firm's activities matters for plant survival.

In addition to examining the role of firms and firm structure in plant survival, we extend the existing literature on the role of plant attributes themselves. While numerous studies have recognized that plant size, age, and productivity are important determinants of plant survival, we find additional positive effects of capital and skill intensity at the plant. Within and across industries, survival probabilities are greater for plants with high capital-labor ratios and those with relatively skilled, high-wage workers. In addition, single-product plants are much more likely to fail in any five-year period than establishments producing multiple goods. Our results add to the literature on firm and plant heterogeneity, which emphasize the importance of reallocation and the Darwinian selection process by which failing plants exit and successful plants prosper.

Our work is also linked to emerging literatures in international trade and investment. Recent work in international trade has focused on the interaction between exporting and firm performance, highlighting the causality from high productivity to exporting and the lack of causality from exporting to productivity gains (see Bernard and Jensen 1999, 2004; Roberts and Tybout 1997; Clerides, Lach, and Tybout 1998). We find evidence that (high productivity) exporting plants are also significantly less likely to die. The export status of the plant reduces the probability of shutdown by as much as 15 percent even after accounting for plant size, productivity, factor intensity and ownership structure. A large body of research on multinationals has established that multinationals pay higher wages than non-multinationals. Our findings on the role of multinationals in plant closure suggest a potential (partial) explanation for the wage premium. Higher wages at multinationals may partially compensate workers for the increased risk of plant closure and job loss. Newer work on multinationals has emphasized the interaction between cross-border activity and the structure of the firm (see Antras 2003; Antras and Helpman 2004; Grossman and Helpman 2004; Grossman, Helpman, and Szeidl 2005). Our findings on the role of multinational ownership in plant shutdowns points to further links between contracting, cross-border investment, and employment outcomes in the domestic market.

We also provide some of the first direct evidence on the link between rising cross-border investment and domestic labor market outcomes. Rodrik (1997) suggests that multinationals will be more likely to adjust employment levels than nonmultinationals, hypothesizing a more elastic labor demand curve. We focus only on adjustments along the extensive margin but indeed find that multinationals are more likely to close comparable plants than nonmultinationals. However, beneficial attributes of multinational plants such as larger size and higher productivity mean that the rise of multinationals will not necessarily lead to aggregate increases in employment volatility.

The remainder of the paper is organized as follows. The next section briefly summarizes the literature on firms and plant deaths and describes the competing hypotheses on the role of firm structure. In section III, we give a brief overview of the data and describe the construction of the firm-level variables. Section IV reports the relationship between the unconditional probability of plant shutdown and a wide range of firm, plant, and industry characteristics. Section V presents the main results on plant death from our multivariate empirical specification and estimates the effect of firm ownership controlling for plant attributes. Section VI concludes.

II. FIRMS AND PLANT CLOSURES

The determinants of plant deaths have been an active area of empirical and theoretical research. Dunne, Roberts, and Samuelson (1988, 1989) established the strong comovement of industry exit and entry rates as well as the relationship between plant survival and plant age, size and type of ownership. Their work emphasized the importance of sunk entry costs in determining death rates as well as the large degree of heterogeneity across plants within industries. Subsequent theoretical work has resulted in a number of models of industries with heterogeneous firms, in part designed to match the stylized facts of the empirical literature (see Jovanovic 1982; Hopenhayn 1992a, 1992b; Ericson and Pakes 1995; Olley and Pakes 1996; Melitz 2003). While these papers have emphasized the importance of understanding the shutdown decision in modeling the dynamics of industry and aggregate productivity, they have all maintained the assumption of single-plant firms.

The existing literature linking plant closure to firm type usually considers exit only in the context of a declining industry. Typically in such studies the focus is on the pattern of plant closure within an industry, with the 'decline' of the industry taken as exogenous. Ghemawat and Nalebuff (1985) show that in a duopoly with Cournot competition, equal costs, and declining demand, the largest firm exits first as the smaller producer will be a successful monopolist for longer. Allowing for cost advantages for large firms can overturn the theoretical results if the cost differentials are substantial enough. Whinston (1988) shows that the single-plant assumption is important for the results on size and exit and argues that plants in multi-plant firms may be more likely to exit. Reynolds (1988) and Dierickx, Matutes, and Neven (1991) predict that high variable cost plants should exit first.

The results from the related empirical literature on plant deaths in declining industries are mixed, although all studies confirm the finding of Dunne, Roberts, and Samuelson (1989) that larger plants are less likely to exit. Lieberman (1990) [chemicals] and Baden-Fuller (1989) [steel casings] find that diversified firms are more likely to close plants, although Deily (1991) finds no such effect in the steel industry. Gibson and Harris (1996) examine plant exit during a period of trade liberalization and

quota reduction in New Zealand. They find that large, old, low-cost establishments are more likely to survive the liberalization, and diversified multi-plant firms are more likely to close plants.

Studies of a wider range of industries typically report lower death rates for plants at multi-unit firms. Dunne, Roberts, and Samuelson (1989) find lower failure rates for large multi-unit plants than for large single-unit plants. Disney et al. (2003) estimate hazard rates for UK manufacturing plants. They also find survival probabilities are higher for establishments that are part of a larger group and that hazards decline more slowly at these plants. Their results suggest that group ownership reduces the probability of plant death, and they argue that there may be evidence for models of market selection based on learning.

The literature on the role of multinationals in plant shutdowns is small and relatively recent. Gibson and Harris (1996) [New Zealand], Gorg and Strobl (2003) [Ireland], and Bernard and Sjöholm (2003) [Indonesia] all find that plants with some foreign ownership are more likely to close than purely domestically owned plants, conditional on controlling for plant characteristics. In all these studies, the focus is on the effect of foreign ownership in the shutdown process. In contrast, we consider the role of ownership by a domestic multinational firm on plant shutdowns in the home country.

Firms and Plant Survival

While the focus of this paper is on empirics, we first offer a brief discussion of the role of firm structure in increasing or decreasing the probability of plant failure. The focus of our analysis on plant deaths is to identify the role of firm structure separately from that of plant characteristics.

We consider two related hypotheses in our empirical work: First, a plant that is part of a larger firm, either multi-plant or multinational, is more likely to survive, and, second, ownership by a larger firm enhances a plant's survival probability. The first hypothesis is about the unconditional relationship between plant survival and ownership while the second hypothesis focuses on the marginal effect of ownership structure on plant survival conditioning on plant characteristics.

Large firms tend to have large plants and other characteristics that are associated with higher survival probabilities (see table 5 and the discussion in section IV below). This fact alone should lead to lower death probabilities for plants that are part of both multi-plant and multinational firms. Plant attributes that increase survival tend to be more common in larger firms, and we expect to find higher survival probabilities at plants in these firms.

However, once one controls for the features of the plant, it is unclear whether ownership by a multi-plant or a multinational firm is positively or negatively associated with survival. On the one hand, multi-plant and multinational firms may improve the survival chances of their constituent

plants. These larger, and potentially diversified, firms may have access to resources, e.g. external or internal sources of capital, that can help them avoid plant shutdown in the face of negative shocks such as a temporary drop in demand for one of their products.

On the other hand, ownership of a plant by a multi-unit firm or a multinational may actually increase the probability of death if such firms have the flexibility to reduce production by closing a plant without exiting the market altogether. Single-plant firms cannot cease production and continue to exist as a viable firm.[4]

Plants that experience an ownership change have a similar ambiguity in their survival outcomes. Such plants may have relatively desirable ex-ante characteristics that make them attractive acquisitions and reduce their probability of failure. Even controlling for the quality of the plant, an ownership change may be associated with an improved match of plant to firm and thus a reduced chance of closure. However, there is uncertainty in the profitability of any new match and this may lead to higher ex-post shutdown rates for plants that experience a change in owners. In addition, firms may acquire plants in order to reduce capacity in the industry by shutting them down.

III. DATA

The data we use to examine these hypotheses come from the Longitudinal Research Database (LRD) of the Bureau of the Census. We use two panels from the Censuses of Manufactures (CM), one running from 1987 to 1992 and the second from 1992 to 1997.[5] The sampling unit for the Census is a manufacturing establishment, or plant, and the sampling frame in each Census year includes detailed information on inputs, output, and ownership on all establishments.

We define a plant to have died if it is in the LRD in year t but absent from the Census in year $t + 5$ and beyond. Plant deaths are separately recorded from other potentially confounding events such as a change in ownership, a temporary shutdown, or a fall in employment. From the Census, we obtain plant characteristics including location, capital stock, the quantity of and wages paid to nonproduction and production workers, total value of shipments, total value of exports, energy and purchased material inputs, the number of products produced at the plant, the primary four-digit Standard Industrial Classification (SIC), and age. We also can match plants to their parent firms and obtain information on the number of manufacturing plants in the firm, the share of total firm assets held overseas, and changes in ownership.

[4] If there are distinct sunk costs of creating a plant and creating a firm, then a single-plant firm will have a wider hysteresis band than a plant in a multi-plant firm.

[5] Due to limitations of the multinational and export measures, we must start our sample with the 1987 Census.

To develop our sample of plants we make several modifications to the basic data in the LRD after creating our indicator of plant death. First, we drop any plants classified as Administrative Records in year *t*. These plants are quite small, typically with fewer than 10 workers, and have no information on inputs other than total employment. Next, we drop any industry whose products are categorized as 'not elsewhere classified.' These 'industries' are typically catch-all categories for groups of heterogeneous products. In practice, this corresponds to any industry whose four-digit SIC code ends in '9.' Finally, we also drop any establishment that does not report one of the input or output measures. We are left with 236,000+ plant-year observations across the two panels.

Firm Characteristics

In this section we describe the construction of the variables related to multi-plant firms, multinationals, and ownership change. We also summarize the additional plant and industry characteristics. A detailed description of the other plant and industry controls is given in the data appendix.

Multi-Plant. A plant is said to belong to a multi-plant firm if there is at least one other plant with the same firm ownership number,[6]

$$multi_t = \begin{cases} 1 & \text{If } \exists \text{ at least one other plant with the same FirmID} \\ 0 & \text{otherwise} \end{cases}$$

Dissimilarity. To assess whether a plant is relatively similar to or different from other plants in the firm, we create a measure of dissimilarity based on input cost shares of the plant and firm,[7]

$$dissimilarity_t = \left[\sum_j \frac{|w_{jp} - w_{jf}|}{2} \right]^{1/2} \quad (1)$$

[6] The multi-plant dummy equals zero for single-plant firms.
[7] Gollop and Monahan (1991) use this measure to capture product similarity in their construction of an index of diversification.

where w_{jp} is the input cost share of the j^{th} input in the plant and w_{fp} is the input cost share of the j^{th} input in the firm (excluding the plant).[8] We consider five inputs— production workers, nonproduction workers, materials, energy, and capital—and impose constant returns to scale. The *dissimilarity* measure is zero when the plant has an identical cost structure to the firm, e.g. for a single-plant firm, and approaches one as the cost structures diverge.

Stand-Alone. We construct an additional measure of plant-firm similarity based on the industry of the plant's output. This measure is an indicator variable, which equals one if the plant is part of a multi-plant firm and is the only establishment in the firm producing in the SIC4 industry,

$$standalone_t = \begin{cases} 1 & \text{if } multi_t = 1 \text{ \& other plants in the firm in the same industry (SIC4) do not exist} \\ 0 & \text{otherwise} \end{cases}$$

Multinational. We construct a measure of multinational status as a function of the share of firm assets held overseas. We define a US multinational to be a firm with at least 10 percent of its assets held outside the United States in 1987,

$$USMNC = \begin{cases} 1 & \text{if } \frac{\text{Foreign Assets}}{\text{Total Assets}} \geq 0.1 \\ 0 & \text{otherwise} \end{cases}$$

The assets measure is only available for US firms so we cannot construct a measure of foreign multinational ownership in our sample.[9] This means that plants owned by foreign multinationals are grouped into the category that includes firms with no foreign presence.

Ownership Change. A plant is said to have changed owners in the previous five years if the firm ID in the dataset changes,

[8] Firm cost share are constructed as output-weighted averages of the constituent plant cost shares.
[9] See Doms and Jensen (1998) for a description of this measure.

$$takeover_t = \begin{cases} 1 & \text{if } \text{FirmID}_t \neq \text{FirmID}_{t-5} \\ 0 & \text{otherwise} \end{cases}$$

For plants that did not exist in year *t–5* we assume there was no change in ownership. Unfortunately, we cannot distinguish between various types of ownership changes, e.g. between hostile and friendly transfers.

Plant Characteristics

In order to identify the role of firms in plant shutdowns, we need to control for a comprehensive set of plant and industry characteristics. Both the existing theoretical literature and previous empirical work suggest that plant age, size, and productivity play important roles in determining plant survival. We construct plant measures of log employment, years of operation, and multi-factor productivity.

Beyond these attributes we include measures of plant capital and skill intensity. Capital intensity at the plant is measured by the log of the capital-labor ratio. Skill intensity is harder to measure in the LRD as there is relatively little information on the characteristics of the workforce. We include the average wages paid to each of the two types of labor, production and nonproduction, to crudely proxy for skill.

Recent models of heterogeneous plants and international trade by Melitz (2003) and Bernard et al. (2003) predict that an exporting plant should have a lower probability of failure than a nonexporter. In these models, the positive relationship between exporting and productivity is driven by the interaction of positive trade costs and variation in productivity across plants. We recognize that exporting may proxy for other unobservable, desirable characteristics of the plant. Our export measure is an indicator variable that is one when the plant exports and zero otherwise.

We also consider a measure of the market heterogeneity of the plant's output through the number of products that it makes. If every new product requires additional sunk costs of entry, then multi-product plants will have lower failure probabilities.

Industry and Geography

As we are using information from the entire manufacturing sector, we would like to ensure that our results are robust to unobserved industry and geographic factors that cause variation in plant deaths.

The magnitude of the sunk costs of entry is of primary importance in determining the steady state rate of firm births and deaths within an industry (see Dunne, Roberts and Samuelson 1988, 1989). Since our focus is not on the estimation of industry sunk entry costs and because entry costs

may covary with, or be determined by, plant characteristics such as capital or skill intensity, we attempt to control for entry costs in our multivariate empirical specification. We control for industry heterogeneity in two ways. First we include industry fixed effects. The industry fixed effects represent the primary four-digit SIC industry of each plant. Second, we construct a measure to proxy for unobserved industry sunk costs of entry or exit (see the data appendix for details). Our results are robust to the inclusion of either one or both types of industry controls.[10]

Recent work in economic geography has emphasized the importance of regional industrial structure for the survival and death of plants, e.g. Duranton and Puga (2000). To control for variation in regional industrial structure and other regional characteristics we include a full set of regional fixed effects in all our specifications. The regions correspond to Labor Market Areas (see the data appendix for details).

IV. PLANT SHUTDOWN ESTIMATES

We start by reporting the unconditional relationship between the complete set of variables and the probability of plant death. Table 3 reports the mean of each variable for two types of plants, deaths and survivors. Column I of table 4 gives the marginal effect on the probability of plant shutdown from a univariate probit of plant death of the form:

$$\Pr\left(D_{pt} = 1 \mid X_t\right) = \Phi\left(c_t + \beta X_t\right) \qquad (2)$$

where X_t is the characteristic in year t and c_t is a full set of year dummies. Column II includes SIC4 industry fixed effects. The probits are run on the full sample of plants from 1987–1997. Standard errors are robust to repeated observations on individual plants.

Firm Characteristics

The two panels have 236,092 plant-year observations and, on average, over a five-year period, 26.9 percent of the plants in the sample shutdown.[11] 40.1 percent of surviving plants belong to multi-plant firms as opposed to 35.9 percent of plants that exit (table 3). Unconditionally, belonging to a multi-plant firm is associated with a 3.4 percentage point reduction in the probability of death for the plant

[10] We allow for time-variation in our measure of industry entry costs so it is feasible to include both industry fixed effects and the sunk cost measure.
[11] This is lower than the rate for all manufacturing plants, 32 percent, as the sample excludes most establishments with 10 or fewer employees.

(column I in table 4). This is a large reduction relative to the 26.9 percent overall probability of plant failure. However, once we control for industry fixed effects we find no difference in the shutdown probability for multi-plant establishments (column II in table 4).

The similarity of the plant to the firm also differs significantly between survivors and shutdowns. The measure of dissimilarity is higher for deaths, 0.532, than at survivors, 0.472. When we add the dissimilarity measure to a probit with a multi-plant dummy (bottom panel of table 4), we find a much bigger effect for multi-plant status; the probability of death is 10.1 percentage points lower. The coefficient on dissimilarity is positive and significant, indicating that plants that have less similar cost shares to the firm as a whole are more likely to close. Controlling for industry effects, we find a similar pattern of results although the magnitudes are reduced: The multi-plant dummy is negative and significant while the dissimilarity measure is positive and significant.

Turning to multinational ownership, we find that domestic plants owned by US multinationals are more likely to be found among survivors (7 versus 5 percent) and unconditionally, these plants have a 6.4 percentage point reduction in their probability of death. Even controlling for industry effects, we see that plants at US multinationals have a significantly lower shutdown probability.

Finally, looking at changes in ownership, we again find 'takeover' targets are more likely to have survived to the next Census; they represent 9.7 percent of survivors and only 8.5 percent of deaths. The probability of closure was 2.8 percentage points lower for plants that experienced an ownership change in the previous five years than at plants without an ownership change. With industry controls, the takeover variable is no longer significantly different from zero.

Plant and Industry Characteristics

Considering the role of plant attributes in shutdown, we confirm the findings of prior research that survival is positively associated with size, age, and productivity in our data. Survivors are more than 40 percent larger in terms of employment than exits (table 3), and the marginal probability of death is sharply declining in plant size (table 4). Plants that die are 9.5 years old in year *t* in our sample while plants that survive are 3.8 years older according to this measure. The marginal effect of age on the probability of death is negative and significant. Survivors are 1 percent more productive (TFP) than the average plant in the industry and 3.8 percent more productive than plants that fail (table 3). The marginal effect of our productivity measure on the probability of death is negative and significant.

Besides being large, older, and more productive, surviving plants are more capital- and skill-intensive than exiting establishments. Survivors are 29 percent more capital intensive than exits, and the marginal effect of capital intensity on the probability of death is negative and strongly significant.

Similarly, both types of wages are significantly higher at surviving plants, 12 to 13 percent in each case. The probit estimates show a strong negative relationship between log wages and the probability of plant shutdown.

Finally, we look at plant characteristics related to products and markets. As seen in table 3, surviving plants are much more likely to be exporters (22.1 percent) than are failing plants (12.1 percent). The results from the unconditional probit show that exporting by the plant is associated with a 12.6 percentage point reduction in the probability of death, even when controlling for industry. This magnitude is enormous given that the unconditional average probability of death is 26.9 percent. 67.6 percent of survivors produce multiple products while 54.7 percent of deaths do.[12] Multi-product plants have a failure probability that is 9.1 to 11.5 percentage points lower than that for single-product establishments.

Previous studies have shown that plant death rates vary substantially across industries and we also find evidence for industry-level variation in death probabilities. The mean of our industry entry cost measure for deaths and survivors is given in table 3. As expected, industry entry costs are significantly lower on average for plants that die, 0.645, than for plants that survive, 0.681. The marginal effect on the probability of death for the average plant is large, negative, and significant.

Plant Characteristics at Multi-Plant and Multinational Firms

In every case, our results strongly support the hypothesis that firm characteristics are associated with differences in plant outcomes. In particular, we find that all three firm attributes—ownership by a multi-plant firm, ownership by a US multinational, or a recent ownership change—are associated with lower shutdown rates. However, we caution that all these results on firm ownership are unconditional and do not establish a causal link between the firm attributes and increased survival probabilities. For example, we cannot conclude that multinational ownership conveys benefits to a plant in the form of increased survival. In particular, plants that are part of larger firms and of multinational groups also have 'good' plant characteristics.

Size, age, productivity, capital intensity, export status, and wages are all positively and significantly correlated with each of the firm measures. Table 5 shows the means of these variables by ownership type. Establishments that are part of a multi-plant firm are larger (125 percent)[13] and older (3 years) than stand-alone establishments. In addition, plants that are part of a larger group are more

[12] Single-product plants account for 39 percent of the sample. Plants that produce 2, 3, or 4+ products account for 20, 11, and 30 percent respectively.
[13] These estimates based on log differences underestimate the true differences between the plant types.

capital-intensive (70 percent), pay higher wages (13 to 14 percent), are more productive (4 percent), and are far more likely to be exporters (29 percent versus 13 percent) than solo plants.

Multinational ownership is associated with even larger differences in these important plant characteristics.[14] Multinational plants are far larger (149 percent), older (4.6 years), and more productive (6 percent) than nonmultinational plants. They are substantially more capital-intensive (89 percent) and pay higher wages (14 to 20 percent), and 50 percent of multinational plants export as opposed to 17 percent of nonmultinationals. Table 6 reports the correlations across plant characteristics including ownership. Ownership by a US multinational or a multi-plant firm is positively and significantly correlated with all the plant attributes known to improve plant survival. In the next section, we control for the attributes of the plant and attempt to isolate the effects of firm structure on plant shutdowns.

V. PLANT SHUTDOWNS AND FIRM STRUCTURE—CONDITIONAL

Table 7 reports our multivariate specification pooled across years for all plants in the sample. We estimate a probit of the form

$$\Pr\left(D_{pt} = 1 \mid \overline{Z}_t\right) = \Phi\left(c_t + c_r + \beta^f (Z_t)^f + \beta^p (Z_t)^p + \beta^i (Z_t)^i\right) \qquad (3)$$

where Z_t^f , Z_t^p , and Z_t^i are the vectors of firm, plant, and region/industry characteristics in year t , and c_t and c_r are full sets of year and region dummies. The probits are run on the full sample of plants from 1987 to 1997. We report seven variations with and without industry entry costs and industry fixed effects. Standard errors are robust to repeated observations on individual plants. All plant, industry, and region characteristics are included along with our measures of firm structure and year dummies. The reported numbers are the change in the probability of death for a marginal increase in the independent variable.

Firm Characteristics

Relative to the unconditional results reported earlier, we find substantial changes in the role of firm characteristics in shutdowns once we condition on plant characteristics. Unconditionally, plants that are part of a multi-plant firm are less likely to be shut down than those of single-plant firms. However, this is driven entirely by the 'good' characteristics of plants that are part of larger firms.

Controlling for plant size, age, factor intensity, etc., we find that being part of a larger firm significantly *increases* the probability of death at the margin by 7.9 percentage points. Adding the entry cost control increases the estimate to 9.2 percentage points (column III in table 7). These estimates represent large increases in the probability of closure, a 29 to 34 percent increase for the average plant in the sample.

We check to see if this result is driven by the dissimilarity of the plants to the firms. However, adding the measure of dissimilarity, we still find a positive and significant coefficient on the multi-plant dummy. Across our specifications, we find plants that are part of a multi-plant firm have death probabilities from 3 to 5 percentage points higher even when they are identical to the other plants in the firm. In addition, the coefficient on the dissimilarity measure is large, positive, and significant. The average plant at a multi-plant firm has a dissimilarity measure of 0.48, which increases the probability of shutdown by more than 2.5 percentage points. At the mean of the dissimilarity measure, a plant that is part of a multi-plant firm has a probability of shutdown that ranges from 5.9 to 7.2 percentage points higher than a comparable single-plant firm (depending on the specification). Even including both industry fixed effects and industry entry costs (column VI), the dissimilarity coefficient is large, positive, and significant. Finally we check to see whether this result on cost-structure dissimilarity is being driven by the output of the plant. We include a dummy variable for so-called stand-alone plants, i.e. plants producing in an SIC4 industry that is not found elsewhere in the firm. While these orphan plants within the firm are significantly more likely to be shut down (4.9 percentage points), the role of cost structure remains strong and significant.

The stronger effects for less similar plants match the theoretical predictions from the declining industry literature that diversified firms are more likely to close plants. Multi-plant firms are able and willing to use the plant shutdown margin to adjust employment and output. The difference in the shutdown probability may point to separate sunk costs of entry for the firm and for the plant.[15]

We next consider whether the multinational status of the owning firm is related to the probability of shutdown. Once again the unconditional relationship suggests that domestic plants owned by US multinationals have 'good' attributes, which make them less likely to fail. Controlling for plant and other firm ownership characteristics, we find that the marginal effect of US multinational ownership is to *increase* the probability of exit by 4.5 percentage points (column VII). In addition, almost every multinational is also a multi-plant firm. Adding the multinational and multi-plant effects, we find that the average plant owned by a US multinational has a shutdown probability

[14] Our findings confirm and extend the results on multinational characteristics in Doms and Jensen (1998).

that is more than 10 percentage points (or over 40 percent) higher than a stand-alone domestic plant with similar features.

This finding on the effects of multinational ownership matches the notion of 'footloose' capital proposed by Rodrik (1997). The foreign assets of the multinational firm may increase their flexibility and thus raise the probability that they will close one of their domestic plants. This also matches the evidence of Brainard and Riker (1997a,b) and Braconier and Ekholm (2000) that multinationals have, in effect, an increased elasticity of labor demand due to their ability to shift production across locations within the firm.

Ownership changes at the plant show a similar pattern. Plants that have experienced a change in ownership in the previous five-year period have characteristics that decrease their probability of death. This suggests that ownership changes typically occur at 'good' plants. However, controlling for plant attributes, we find that 'takeover' targets are *more likely* to fail than plants with unchanged ownership. The effect of an ownership change is quite large, 5.4 percentage points (column VII). With our data we cannot distinguish the source of this negative effect. One possibility is that the dramatically higher probability of shutting down is related to an unexpectedly poor match between the plant and the acquiring firm. Alternatively, the firm may have acquired the plant in order to shut it down, i.e. a planned rationalization of capacity.

Plant and Industry

In this section, we briefly summarize the results on the plant and industry controls. As expected, the probability of plant shutdown remains significantly decreasing in plant age, plant size, and plant productivity. As expected, higher industry entry costs also decrease the probability of failure. Increasing plant size by one standard deviation reduces the probability of shutdown by 4.8 percentage points, and a comparable increase in age is associated with a 3.3 percentage point drop.[16] The probability of death falls 1.7 percentage points for a one standard deviation increase in productivity.

Even controlling for age, size, and productivity, we find significant roles for plant factor intensity in the shutdown decision. Both capital- and skill-intensive plants are less likely to die. The

[15] There remains the possibility that our specification does not include all the relevant plant characteristics, i.e. that the increased probability of shutdown is driven by an attribute found predominantly in the plants of multi-plant firms but not available in our dataset.

[16] Using the coefficients from column VII in table 7, the change in probability is calculated with all variables at their sample means, increasing only the relevant variable.

capital-labor ratio, production worker wage, and nonproduction worker wage are all significantly negatively associated with plant failure.

Both unconditionally and conditionally, plants that produce more products have lower probabilities of failure. Multiple product facilities have shutdown probabilities 4.3 percentage points lower than single-product plants. Exporting by the plant remains strongly positively associated with plant survival. Conditional on all the other variables, the probability of death at exporters is 6.8 percentage points lower than at nonexporters. The sign of the export variable is unchanged from the unconditional regressions reported above. This result on exporting matches the predictions of the selection and survival models of Melitz (2003) and Bernard et al. (2003) and suggests either that exporting has a direct positive effect on survival or that exporting is correlated with other unobserved characteristics of the plant that increase survival.

VI. CONCLUSION

This paper has examined the role of firms in the decision to close a plant. We have asked whether multi-plant and multinational firms differ in their decision to close a plant from stand-alone or domestic firms.

We find that the nature of the firm plays a crucial role in plant shutdowns. Plants that are part of a larger firm are unconditionally far less likely to shut down than a single-plant firm. Similarly, plants owned by US multinationals are less likely to close. Finally, plants that have changed ownership also die less often.

However, we also show that plants owned by a multi-plant firm or a US multinational have a range of good characteristics, which make them more likely to survive. These plants are larger, older, more productive, more likely to export, employ more capital and more skilled workers, and operate in industries with lower shutdown probabilities. Once we condition on this array of good plant characteristics we find that multi-plant firms are actually *more* likely to close a plant. This is particularly true if the plant is different from the rest of the firm in terms of its factor intensities in production.

We also find strong evidence that ownership by a US multinational significantly *increases* the shutdown probability of a domestic plant conditional on plant characteristics. Even controlling for the fact that almost every US multinational is also a multi-plant firm, we find that the conditional closure probability is higher at these plants. Finally, conditioning on the plant's qualities, we find that a new owner is significantly more likely to close a recent acquisition.

We also extend the current literature on plant attributes and plant failure. While size, age and productivity improve plant survival, so too do the capital and skill intensities of the plant. In addition,

we find that exporters and multi-product plants are much more likely to survive over a five-year interval than nonexporters or single-product establishments.

Our results have implications for future research in a number of areas. Additional theoretical and empirical work is needed to develop a deeper understanding of the nature of the shutdown decision in multi-unit firms, especially those that cross borders. The rapid growth in multinational activity around the world and in the US economy over the past decade only increases the importance of understanding decision making in these firms. Models with heterogeneous firms have become increasingly important in areas such as industrial organization and international trade. Dynamic firm-based models of productivity growth and survival must be augmented to recognize the multi-plant, multi-product, multi-market nature of the firm, especially given their importance in the overall economy and in manufacturing. Our findings suggest that multi-unit, multinational firms have greater flexibility in adjusting to changing market conditions than do single-plant, domestic firms. Decisions about labor market adjustments at these firms (both at the extensive and intensive margins) will likely differ from those at purely domestic firms.

DATA APPENDIX

The data in this paper come from the Longitudinal Research Database (LRD) of the Bureau of the Census. We use data from the Censuses of Manufactures (CM) starting in 1987 and continuing through 1997. The sampling unit for the Census is a manufacturing establishment, or plant, and the sampling frame in each Census year includes detailed information on inputs, output, and ownership on all establishments.

Variables

Size: Log of plant total employment.

Age: The difference between the current year and the first recorded Census year for the plant, starting with the 1963 Census. Plants that are in their first Census year are given an age of zero.

Productivity: We estimate a simple five input production function in logs allowing the coefficients to vary across industries and years,

$$\ln Y_{pit} = (c_{i'})^0 + \sum_j (\beta_{ij})^j \ln (X_{ipt})^j + e_{ipt} \qquad (4)$$

where Y is gross output of the plant in year *t* and the five inputs are the number of production and non-production workers at the plant, the book value of machinery and equipment, the book value of buildings and structures, and the value of purchased inputs and energy. We use e_{ipt} as our measure of plant total factor productivity. By construction the measure is mean zero for each industry in each period. We recognize that this measure may have problems with comovement of markups and productivity, or the comovements of variable inputs and productivity. Using a productivity measure based on industry cost shares did not change the results.

Capital Intensity: The log of the capital-labor ratio, where capital is the book value of machinery, equipment, buildings, and structures.

Production Wage: Log of the average wage paid to production workers at the plant.

Nonproduction Wage: Log of the average wage paid to production workers at the plant.

Export: An indicator variable that is one when the plant exports and zero otherwise.

Products: The number of products produced at the plant where a product is defined as a five digit 1987 SIC product-class. The probits include a dummy variable for plants that produce multiple products.

Entry Costs: Recent equilibrium models of industries with heterogeneous firms predict that, in

steady state, entry and entry rates will covary exactly as sunk entry costs change. If all our industries were in steady state, we could use the industry entry rate to proxy for industry sunk costs in our plant shutdown equation. In practice, of course, some industries are growing and others are declining leading to important differences in the two margins. We use the comovement of the two rates across industries to develop an entry cost measure.[17] Our measure of industry entry costs is based on the minimum of the entry and exit rates in a five-year interval,

$$EC_{it} = 1 - \{\min[\text{entryrate}_{it}, \text{exitrate}_{it}]\}$$

Contracting industries by definition will have higher exit rates than entry rates. However, a contracting industry with low entry costs will have a higher entry rate. Conversely, an expanding industry with relatively low entry costs will have fewer plant deaths and a lower exit rate.

[17] We thank Marc Melitz for suggesting this measure. Our measure is similar to one calculated by Dunne and Roberts (1991), who find their measure of producer volatility is both more pronounced and more persistent than entry, exit or net entry, suggesting it is a good proxy for sunk costs.

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Table 1 Output, employment, and job destruction between 1992 and 1997

	Number of plants	Employment, 1992	Output, 1992	Change in employment, 1992 to 1997
Plants with net job creation	156,270	6,858,402	1,286	2,955,873
Plants with net job destruction	214,720	10,127,455	1,719	–4,909,186
Survivors	84,995	7,263,745	1,314	–2,045,476
Deaths	129,725	2,863,710	405	–2,863,710

Note: Output is given in billions of 1987 dollars.

Source: Longitudinal Research Database, Bureau of the Census; calculations by the authors.

Table 2 Output and employment by firm type (percent)

	Plants	Firms	Output	Employment
Single-plant firms	61	83	12	22
Multi-plant firms	39	17	88	78
Non-US multinationals	94	99	66	74
US multinationals	6	1	34	26
Multi-plant firms (not US multinationals)	32	16	53	52

Note: Numbers indicate the fraction of the category accounted for by that type of firm.

Table 3 Means of characteristics for surviving and closing plants

	Plant type	
	Survivors	Deaths
Firm characteristics		
Multi-plant	0.401	0.359
Multinational	0.070	0.050
Takeover	0.097	0.085
Dissimilarity[a]	0.472	0.532
Plant characteristics		
Size (log employment)	3.661	3.185
Age	13.260	9.510
Capital Intensity (log K/L)	3.185	2.888
Nonproduction wage (log)	3.284	3.154
Production wage (log)	2.857	2.733
Total factor productivity (log)	0.010	–0.028
Multi-product plant	0.676	0.547
Exporter	0.221	0.121
Industry		
Entry cost	0.681	0.645
Number of plants	172,536	63,556

a. Dissimilarity measures the difference in cost shares between the plant and the firm and is calculated only for plants that are part of a multi-plant firm.

Note: All means for survivors are significantly different from those for deaths at the 1 percent level.

Table 4 Univariate probits of plant death on characteristics

	(I)	(II)
Firm characteristics		
Multi-plant	–0.0345 ***	0.0033
	(0.0019)	(0.0022)
Multinational	–0.0645 ***	–0.0449 ***
	(0.0035)	(0.0038)
Takeover	–0.0277 ***	–0.0049
	(0.0030)	(0.0032)
Plant characteristics		
Size (log employment)	–0.0561 ***	–0.0677 ***
	(0.0007)	(0.0009)
Age	–0.0072 ***	–0.0061 ***
	(0.0001)	(0.0001)
Capital intensity (log K/L)	–0.0494 ***	–0.0282 ***
	(0.0009)	(0.0011)
Nonproduction wage (log)	–0.0908 ***	–0.0805 ***
	(0.0018)	(0.0019)
Production wage (log)	–0.1224 ***	–0.0952 ***
	(0.0021)	(0.0024)
Total factor productivity (log)	–0.0762 ***	–0.0771 ***
	(0.0031)	(0.0031)
Multi-product plant	–0.1155 ***	–0.0910 ***
	(0.0020)	(0.0021)
Exporter	–0.1260 ***	–0.1267 ***
	(0.0021)	(0.0023)
Industry and region		
Entry cost	–0.8207 ***	
	(0.0101)	
Combined		
Multi-plant	–0.1061 ***	–0.0380 ***
	(0.0039)	(0.0059)
Dissimilarity	0.1510 ***	0.0537 ***
	(0.0072)	(0.0136)
Industry fixed effects (SIC4)	No	Yes
Observations	236,092	236,092

*** indicates the coefficient is significant at the 1 percent level.

Note: The combined probit includes both the multi-plant dummy and the dissimilarity measure. The coefficients give the marginal effect of changing the independent variable evaluated at the mean. Column I includes time dummies but not industry fixed effects. Column 2 includes both time dummies and SIC4 industry fixed effects. Standard errors have been corrected for clustering at the plant level.

Table 5 Plant characteristics by firm type

	Single-plant firms	Multi-plant firms	Non-US multinationals	US multinationals
Size (log employment)	3.04	4.30	3.43	5.02
Age	10.70	14.69	11.95	16.64
Capital intensity (log K/L)	2.83	3.53	3.05	3.94
Production wage (log)	2.77	2.91	2.81	3.05
Nonproduction wage (log)	3.20	3.33	3.24	3.44
Total factor productivity (log)	–0.02	0.02	0.00	0.06
Exporter (percent of plants)	13	29	17	50
Observations	144,150	91,942	220,879	15,213

Note: Numbers represent the mean across plants within the category for 1987 and 1992. All the single-plant and multi-plant means are significantly different at the 1 percent level. Similarly all the multinational and nonmultinational means are significantly different at the 1 percent level.

Table 6 Correlation of plant characteristics

	US MNC	Multi-plant	Size	Age	Capital	Production wage	Nonproduction wage	TFP
Multi-plant	0.33							
Size (log employment)	0.29	0.46						
Age	0.11	0.19	0.36					
Capital intensity (log K/L)	0.20	0.32	0.16	0.17				
Production wage (log)	0.13	0.15	0.08	0.16	0.49			
Nonproduction wage (log)	0.10	0.12	0.20	0.15	0.30	0.43		
Total factor productivity (log)	0.05	0.06	0.01	0.02	–0.01	0.24	0.22	
Exporter	0.20	0.20	0.36	0.18	0.14	0.13	0.16	0.05
Multi-plant	0.27							
Size (log employment)	0.24	0.38						
Age	0.09	0.12	0.33					
Capital intensity (log K/L)	0.15	0.21	0.15	0.11				
Production wage (log)	0.05	0.07	0.16	0.12	0.27			
Nonproduction wage (log)	0.10	0.11	0.11	0.14	0.37	0.37		
Total factor productivity (log)	0.05	0.07	0.01	0.02	–0.01	0.24	0.28	
Exporter	0.14	0.13	0.28	0.15	0.09	0.08	0.07	0.06

MNC = multinational corporation
TFP = total factor productivity

Note: Numbers are the pairwise correlation coefficients of the plant characteristics. The top panel reports unconditional correlations; the bottom panel reports correlations conditioning on SIC4 industry fixed effects. All correlations with multinational status and multi-plant status are significant at the 1 percent level.

Table 7 Multivariate probits of plant death on characteristics

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Firm characteristics							
Multi-plant	0.079 ***	0.030 ***	0.092 ***	0.047 ***	0.050 ***	0.050 ***	0.042 ***
	(0.002)	(0.008)	(0.002)	(0.008)	(0.007)	(0.008)	(0.007)
Dissimilarity		0.060 ***		0.053 ***	0.041 ***	0.041 ***	0.032 ***
		(0.020)		(0.018)	(0.017)	(0.017)	(0.015)
Stand-alone							0.049 ***
							(0.005)
Multinational	0.040 ***	0.056 ***	0.036 ***	0.051 ***	0.042 ***	0.043 ***	0.045 ***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Takeover	0.049 ***	0.057 ***	0.048 ***	0.057 ***	0.055 ***	0.055 ***	0.054 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Plant characteristics							
Size (log employment)	–0.043 ***	–0.040 ***	–0.043 ***	–0.039 ***	–0.053 ***	–0.053 ***	–0.053 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age	–0.004 ***	–0.004 ***	–0.004 ***	–0.004 ***	–0.004 ***	–0.004 ***	–0.004 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital intensity (log K/L)	–0.023 ***	–0.021 ***	–0.012 ***	–0.010 ***	–0.005 ***	–0.005 ***	–0.005 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Nonproduction wage (log)	–0.028 ***	–0.031 ***	–0.027 ***	–0.029 ***	–0.039 ***	–0.038 ***	–0.039 ***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Production wage (log)	–0.061 ***	–0.061 ***	–0.051 ***	-0.052 ***	–0.055 ***	–0.055 ***	–0.054 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Total factor productivity (log)	–0.056 ***	–0.048 ***	–0.060 ***	–0.053 ***	–0.048 ***	–0.048 ***	–0.048 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Multi-product plant	–0.058 ***	–0.057 ***	–0.051 ***	–0.050 ***	–0.043 ***	–0.043 ***	–0.043 ***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Exporter	-0.056 ***	–0.058 ***	–0.052 ***	–0.054 ***	–0.068 ***		–0.068 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Industry characteristics							
Entry cost			–0.484 ***	–0.473 ***			–0.506 ***
			(0.012)	(0.012)		(0.045)	(0.045)
Industry fixed effects	No	No	No	No	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*** indicates the coefficient is significant at the 1 percent level.

Notes: The coefficients give the marginal effect of changing the independent variable. Industry dummies are calculated at the four-digit SIC level. Region dummies correspond to Labor Market Areas. All specifications have 236,092 observations. Standard errors are adjusted for clustering at the plant level.