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Firm Performance and Evolution: Empirical Regularities in the U.S. Microdata

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Abstract[1]

This paper presents a view of firm performance, industry evolution, and economic growth that contrasts with the traditional representative firm model. The paper reviews recent empirical work, primarily studies using the Longitudinal Research Database (LRD), that explicitly focuses on individual business units. The major empirical regularity in the studies is that heterogeneity is pervasive -- it is found across and within all sectors and across all plant characteristics. Further, firms are not only different in the cross-section. They enter at different times, make different choices, and react differently to economic shocks. Thus, to understand economic performance and competition, one must move beyond representative firm models. Competition must be understood as a process in which some firms

[1]The research program of the Center for Economic Studies (CES) produces a wide range of theoretical and empirical economic analyses that serve to improve the statistical programs of the U.S. Bureau of the Census. Many of these analysis take the form of CES research papers. The papers are intended to make the results of CES research available to economists and other interested parties in order to encourage discussion and obtain suggestions for revision before publication. The papers are unofficial and have not undergone the review accorded official Census Bureau publications. The opinions and conclusions expressed in the papers are those of the authors and do not necessarily represent those of the U.S. Bureau of the Census. Republication in whole or part must be cleared with the authors. All papers are screened to ensure that they do not disclose confidential information. Persons who wish to obtain a copy of the paper, submit comments about the paper, or obtain general information about the series should contact Sang V. Nguyen, Editor, *Discussion Papers*, U.S. Bureau of the Census, Center for Economic Studies, Room 211, Washington Plaza II, Washington, D.C. 20233, (301-457-1882) or INTERNET address snguyen@census.gov.

choose correctly and grow while other firms choose poorly and die; the growth of the successful firms at the expense of less successful rivals drives economic growth.

Introduction

The main purpose of this paper is to explore what we know and how we think about firm performance, firm and industry evolution, and economic growth. To this end, we report empirical findings from a new literature that explicitly focuses on individual business units. This literature has been spurred by recent theoretical developments and, perhaps more importantly, the development of longitudinal microdata that track individual plants over time. In contrast to traditional empirical studies of competition and economic growth that examine aggregate economic variables such as industry or regional productivity, this new work concentrates on differences in the behavior of firms and their business units. The results emerging from these analyses confirm the importance of microeconomic approaches to economic research and place the firm at the center of economic growth.

The idea that differences in firms are important to understanding economic growth and the performance of capitalist economies is not new to economists. Schumpeter (1942) describes the process by which competition produces economic growth and improvements in living standards as one of "creative destruction." Firms constantly search for new products and new ways of doing things to try to gain competitive advantage.

> "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates" (page 83).

Viewed from this perspective, firms are, to put it colloquially, where the action is. Economic growth is not evenly spread across firms. Some firms make correct choices. These firms prosper and grow. Other firms make mistakes. These firms contract and die. Economic growth is the outcome of successful firms replacing less successful firms. It is the growth of successful firms, and the decline of less successful firms, that raises overall productivity.

While Schumpeter's view of the competitive process is compelling, it has not been the primary foundation for empirical research in economics. Academic research has been structured around the "representative firm" model. In this model, firms in the same industry use the same production processes, produce identical products, and face identical costs. Thus, all firms react similarly to shocks and the "industry" becomes the effective unit of analysis. Using this model has meant that research in industrial organization and economic growth, both theoretical and empirical, has usually focused on explaining differences in "industry" performance, not the determinants of "firm" performance and success.[2]

Two related impediments account for the paucity of micro approaches to the study of competition and economic growth. First, the lack of statistics at the business unit or plant level has made research in the area difficult. Most governmental statistics are provided at aggregate levels broader than firms or plants.[3] Government

[2] This is in sharp contrast to the business literature that focuses on case studies of particular business units and the operation of firms.

[3] Even when microdata on firms is publicly available, it usually is for large, multi-unit firms operating in many industries. Use of firm-level data under these circumstances leads to serious aggregation biases in

data are disseminated in aggregative formats to protect the confidentiality of the data. New programs for data access that provide researchers the means to analyze the microdata and protect respondent confidentiality have been important to the development of the new empirical literature (See McGuckin 1992, 1995; McGuckin and Reznek 1993, 1996).

Second, it is only recently that computer resources have been capable of handling the extensive data and mathematical calculations required for more microeconomic approaches. Both of these previous limitations influenced the direction of economic research toward the representative firm model.[4]

With new empirical research possibilities, the past 15-20 years have seen a number of new models in the economic literature describing firm behavior and the associated industry dynamics. A common feature of these models is that uncertainty and limited information cause firms to take different approaches to common problems, thereby generating heterogeneity among firms, even within the same industry or product grouping. These theoretical developments, coupled with new databases and powerful computers, have led to a flood of empirical studies of firm behavior and performance. Generally speaking, the empirical relationships confirm the relevance of the new theoretical approaches. The real world appears much closer to that described by Schumpeter than to the one that exists in most economic models; the behavior of firms within industries differs dramatically.

Heterogeneity in the distribution of business units is pervasive along a wide variety of dimensions. Even within the same geographic areas and the same four-digit industries and five-digit product classes, as defined by the Standard Industrial Classification (SIC), firms differ dramatically. Heterogeneity is observed across time as well as in the cross-section (Davis, Haltiwanger, and Schuh 1996). Not only does the growth process differ across firms, it is characterized by large, discrete movements rather than smooth or continuous changes even for those firms in continuous operation (Doms and Dunne 1994; Power 1995). During any time interval, observed changes are "lumpy" and uneven, some business units open and some grow, while others shrink and die.

Taken together, this evidence rejects representative firm models and empirical analyses based on industry-level observations. Economic performance and competition cannot be understood in terms of differences in the behavior of an "average" firm in an industry-level analysis.[5] In fact, most of the observed variation in the data is <u>within</u> industries.[6] Moreover, the vast majority of this variation is <u>not</u> associated with traditional observables such as location, industry, size, age, or capital. Rather, this variation is associated with unobserved firm- or business unit-specific factors, many of which appear to be long-lived attributes of the business unit.

We begin the paper with a brief discussion of the new modeling approaches used to explore firm performance and associated industry dynamics. This section is brief,

the study of business behavior. See McGuckin and Nguyen (1995).

[4] A related factor is that most economists simply did not think that the biases inherent in misspecified industry- and economy-wide models were very large. Of course, in the absence of access to the microdata, there was simply no other alternative than to use the aggregative data.

[5] For the representative firm model to fail, the functions that aggregate individual firm responses into aggregate variables need to be non-linear. As indicated, this condition is satisfied both in the cross-section and over time.

[6] Davis, Haltiwanger, and Schuh (1996) is the most comprehensive source in terms of the number of factors examined. Extensive heterogeneity is not restricted to the U.S. (In addition to the above cited book see Baldwin, Dunne, and Haltiwanger 1994, which compares job flows in the U.S. and Canada).

introduced simply to provide context for the main body of the paper. The primary focus of the paper is to describe empirical regularities emerging from the new research with microdata.

We review the empirical literature and describe the emerging empirical regularities that inform our understanding of firm performance and evolution. We make no attempt to be comprehensive in the studies we cover. References are primarily to studies using the Longitudinal Research Database (LRD), an extensive database of longitudinal plant-level data covering the inputs and outputs of virtually every manufacturing plant in the U.S. since 1963.[7] This database has supported a large volume and wide range of policy and academic research over the last seven or eight years.[8] The discussion of empirical regularities is organized in terms of a simple empirical model that categorizes the factors that determine a plant's behavior into those 1) specific to the plant, 2) associated with the firm that owns or manages it, and 3) related to the industry or products that comprise its output.

After describing the empirical regularities in the cross-section, we move to a more dynamic picture of firm performance,[9] reviewing the literature on how firm characteristics change over time and providing some new evidence on how persistent firm performance is across time.

We then describe how understanding the underlying firm-level dynamics is critical to understanding industry performance and structure. Firm dynamics, the growth of successful firms and the demise of unsuccessful firms, determine observable industry characteristics. Further, the underlying heterogeneity of firms affects how the aggregate economy responds to exogenous shocks. While a clearer picture of firm performance and evolution and how these affect aggregate performance is emerging, more work is needed. We suggest areas for future research in our conclusion.

Beyond the Representative Firm, Theoretical Background

Competition is a dynamic process involving many dimensions. Modeling it in ways that allow individual firms to differ is necessarily abstract and complex. The criticism of the representative firm approach has a long history. Nelson and Winter (1982) succinctly stated the case for developing explicit models of firm behavior:

> "... it [is] inevitable that models built according to the orthodox blueprints miss completely or deal awkwardly with these [a large degree of uncertainty and limited information available to firms trying to decide what is their best strategy] features of economic change" (page 400).

Firms operating in an uncertain world with limited information choose to produce different products and employ different production methods. In turn, these different choices generate heterogeneity among firms, even among firms classified within the same industry. Firms are different -- they enter at different times, have different investment patterns, possess different information, use different production technologies, pay different wages, and so on -- and this causes them to react differently to changes in their environment. Thus firms adjust

[7] The LRD is housed at CES, an economic research unit of the U.S. Census Bureau.

[8] See McGuckin and Pascoe (1988) for a description of the LRD. Research with the LRD is described in McGuckin (1995), McGuckin and Reznek (1993), and the annual reports of the CES.

[9] While there have been some panel studies, most of the work to data has been cross-sectional, with the longitudinal data primarily used to construct specific measures of change at the plant level.

to economic shocks differently, implying that change is idiosyncratic or firm-specific.

Nelson and Winter were not alone in their attempt to develop new approaches to modeling firm behavior. Jovanovic (1982) and Pakes and Ericson (1989) also developed models of firm performance and behavior that captured the uncertainty and limited information that characterizes firm decision making. In contrast to Nelson and Winter, these authors did not abandon the use of models with long-run equilibrium properties. The equilibrium models feature firms that learn (either actively or passively) about their relative efficiency, their product quality, and/or the profitability of their research and development (R&D) as part of ongoing operations, usually within a specific industry.[10] As the firms learn about themselves, they make decisions about whether to continue in operation or to close. The models predict systematic differences in firm growth, generate testable predictions about the distribution of size, age, and growth rates of firms within particular industries. The steady state distribution of firms is characterized by heterogenous firms (firms with different sizes and ages) in which change has a large idiosyncratic (firm-specific) component. Thus, the models provide a framework for structuring empirical analysis of firm and market behavior that allows for 1) intra-industry heterogeneity and 2) idiosyncratic (firm-specific) sources of change.

A key issue that the new models highlight is that with heterogenous firms and idiosyncratic sources of growth, selection mechanisms are very important. That is, the factors that determine which firms survive and grow and which fail and die are important to both firm competition and growth and industry evolution. Firms that are relatively productive will choose to continue in the industry and will grow. Firms that are less productive will lose market share and eventually go out of business. For an excellent example of empirical work using this modeling approach, see Olley and Pakes (1996). As we discuss in more detail below, just what factors determine firm success and failure remains an important open question.

Empirical Regularities

Our stated goal is to review what we know and how we think about firm performance and evolution. Recent theoretical developments suggest that given the degree of uncertainty in the environment and the lack of information about the "right" way to do something, there is likely to be considerable firm-level heterogeneity. This heterogeneity is the result of experimentation by different firms. Further, the theoretical literature posits that this heterogeneity will affect firm-level dynamics and, ultimately, industry and aggregate performance. What does the empirical literature have to say about this view of the world?

The empirical literature has seen extensions that parallel those in theoretical literature. While this research area is still fairly young, a number of empirical regularities have emerged. Of particular interest, the new empirical work confirms the importance of the theoretical approaches outlined above. For example, the most compelling empirical regularity confronting researchers is the tremendous amount of diversity in firm and plant characteristics and behavior. Even within industries, firms have very different attributes along many observable dimensions such as size, age, wages, productivity, job creation and destruction, investment patterns, and productivity growth. In fact, within-industry differences among firms along practically every dimension show greater variability than the variability of the average of the same variable between industries (Davis, Haltiwanger, and Schuh 1996).[11]

[10] In the models, the firm's initial position is based on a random draw from a distribution of efficiencies.

[11] While some of the heterogeneity within industries may result from poorly defined SICs, this source of

While there is tremendous heterogeneity in plant characteristics and plant performance, researchers are identifying relationships between theses characteristics and performance. It is useful to think of this variation in plant performance as attributable to four sources: 1) plant-specific factors, 2) characteristics associated with the firm that owns the plant, 3) factors associated with the industry in which the plant produces, and 4) a stochastic error component.[12] This framework provides a convenient way to categorize the empirical evidence, most of which relies on the plant as the unit of analysis.[13] While the allocation of variables to a particular category is difficult and sometimes arbitrary, from the broad perspective adopted here, such concerns can probably be ignored.

It is also useful to distinguish between observable and unobservable variables within each source. Typical variables in the observable category for plant-specific factors include age, size, and location, all variables that have been extensively studied.[14] Unobservable variables include many things that are important determinants of behavior and are now beginning to be studied by economists. Prime examples are employment practices, managerial skills, and business unit organization and knowledge.[15] These factors have been the subject of both case studies and special surveys. What is new is that with the advent of broad-based, longitudinal data they are now becoming a subject for more generalized economic research. The new longitudinal microdata have begun to allow researchers to control for previously omitted unobservable characteristics.

Plant Effects

We begin our discussion of plant effects by focusing on size and age.[16] We have chosen to treat size and age separately from other observable plant characteristics because they are by far the most studied. In many respects, these characteristics also offer the most severe problems of interpretation.

Size and Age

As business unit and firm microdata have become available, studies of the relationships between firm (and plant) growth, survival, and mortality and their differences by size and age have been a main focus of empirical efforts. Most of the early work with the microdata focused on policy issues, using sophisticated econometric techniques to sort out the influences of various sources of measurement error (transitory stochastic influences reflected in base year observations, regression to the mean problems, and arbitrary size classifications). Evans (1987a, 1987b), Hall

error is unlikely to eliminate the heterogeneity since it is observed in virtually all industries and even in product class groupings.

[12] We ignore interaction effects for the purposes of this discussion, but they might be significant in the data.

[13] McGuckin (1992) argues that the plant is the preferred unit of analysis in most applications. McGuckin and Nguyen (1995) show that for analysis of ownership change, the use of the firm as the unit of analysis leads to aggregation biases that are not present when the plant is the unit of analysis.

[14] In principle, we also could include "industry" in the list of observable plant characteristics. However, it is useful to distinguish this variable separately since industry has, until recently, been the main unit of observation in empirical work.

[15] These idiosyncratic or unobservable factors generally include human and organizational capital. See Gort, Grawbowski, and McGuckin (1985) for a discussion of the differences between the two types of capital.

[16] Unless explicitly noted, the results described throughout this section are independent of the particular business unit behavior or performance measure used as the dependent or the "to be explained" variable.

(1987), and Dunne, Roberts, and Samuelson (1989) are important examples of this work in the industrial organization tradition, while Brown and Medoff (1990), and Davis, Haltiwanger, and Schuh (1996) provide insights on size-growth relationships from the labor perspective. There is also substantial work from other countries, (e.g., Canada, France, Holland, Australia, and Germany) on the relationship of size and job creation and destruction. While the precise relationships differ among countries, this literature has made great strides in showing the potential pitfalls in drawing conclusions based on faulty statistical designs.

The focus on age and size distributions can be attributable in part to the relative availability of measures identifying the size and age of a business unit and firm. But the focus on these variables also reflects the importance of the size distribution in industrial organization analyses, particularly in the antitrust and oligopoly areas and the popularity of industrial policy focused on "small" business. Much of the work reflects attempts to identify the role of small business in job creation and economic growth and has been driven by policy concerns. This is a major reason for the focus on statistical issues in the literature.

The relationship of a plant's age to performance is similar to the effect of a plant's size on performance. This is not unexpected because both variables are intimately related to the competitive process. The more a firm grows (the bigger it is) the more likely it is to survive another period (the older it is). But, while size and age are correlated, age has an independent effect on performance. For example, Bates and Nucci (1990) find that the probability of firm failure is inversely related with age, even after controlling for the size of the business.

This is not the place to undertake a detailed discussion of size and age. Numerous empirical studies suggest that plants of different sizes have significantly different characteristics and performance. Bigger plants tend to be more capital intensive, more productive, more likely to adopt technological innovations, more likely to export, and pay higher wages. Because size is correlated with all of these other characteristics, it is important to control for size in studies examining plant performance. While it is clear that size and age are important observables that need to be controlled for in empirical models of business behavior, in many respects they raise serious difficulties for empirical researchers. Size and age are outcomes of the competitive process, and to include them in estimating equations designed to explain firm performance begs the question of what factors determine whether firms succeed or fail. Moreover, when the empirical focus is on size and age, the workings of the firm tend to be obscured and the firm is treated as a "black box."

Standard Control Variables

Aside from age and size there are a wide range of observable factors that are regularly introduced as explanatory variables in regressions using plant performance as the dependent variable. Virtually every study with the LRD includes regional dummy variables as controls and they are generally significant.

Ownership status is another important variable utilized in empirical studies of plant performance. In empirical studies, plants are often divided into two classes, single-unit and multi-unit plants, for estimating purposes. Single-unit plants belong to firms that have no other operations distinct from the single plant. Multi-unit plants, in contrast, are plants that are owned by firms with other establishments. Typically, multi-unit plants pay higher wages than single-unit plants. Further, multi-unit plants tend to be bigger, more productive (McGuckin, Streitwieser, and Doms 1996), and more likely to export (Bernard and Jensen 1995). While virtually every study of plant performance controls for this aspect of the structure of the firm, it is difficult to determine the exact source of the positive relationship found. A positive relationship is likely associated with a positive firm effect -- large successful firms are most likely to be multi-unit. It is also the result of measurement error in the plant's performance measure because inputs supplied by the firm are included in the single unit's costs, but not in the multi-unit's.

Capital intensity -- assets per employee -- is another plant characteristic that is positively associated with plant performance. Capital intensity is also associated with plant size. Bigger plants are more capital intensive. But, researchers find that capital intensity is positively associated with plant survival and wages even after controlling for other observable plant characteristics such as size (see, for example, Dunne and Roberts 1990).

Other Variables

Researchers have been able to merge data from other sources (for example, Special Census Bureau Surveys) to the basic LRD data to create new datasets with additional variables. Such datasets have been invaluable in extending the list of factors that have been empirically linked to business unit performance. Importantly, they tend to bring the detail of the case study approach to the more general setting of the typical economic study. They accomplish this by developing econometric experimental models that exploit general databases with probabilistic designs, like the LRD, to control for selection and other biases inherent in studies relying on particular cases or limited survey information. See Jarmin (1995) for a more complete description of this approach in the context of evaluating a particular government program.

One survey that has been particularly fruitful in this regard is the Survey of Manufacturing Technology (SMT). The SMT is a plant-level survey covering four two-digit manufacturing industries (SICs 34-38). It develops information on the use of 17 relatively recent advanced computer-based technologies. Examples of such technology include robotics and Computer-Added Design (CAD). Dunne (1991) and Dunne and Schmitz (1992) explore the relationship between plant characteristics, wages, and technology adoption using a 1988 version of the survey. In addition, McGuckin, Streitwieser, and Doms (1996), Doms, Dunne, and Troske (1996), and Dunne and Troske (1996), use the 1988 SMT, in conjunction with a newer version of it conducted in 1993, to examine the effects of technology adoption on business unit performance.

These studies suggest that larger plants, multi-unit plants, plants engaged in defense-related production, and plants owned by firms with high R&D to sales ratios are more likely to adopt advanced technologies. More technology-intensive plants pay higher wages, are more productive, and are more likely to survive than non-adopters.

R&D is also important to plant and firm performance. Lichtenberg and Siegel (1989) find that there is a positive association between firm R&D expenditures and plant total factor productivity.

Bernard and Jensen (1995) find that plants that manufacture for export tend to be larger, more productive, more capital intensive, and pay more than plants that do not export. Further, Bernard and Jensen (1996a) find that because these plants are more non-production worker intensive than other non-exporters and have grown as a share of total manufacturing employment, these plants have contributed significantly to the increase in the wage gap between production and non-production workers.

Another in this general line of studies is based on a new database linking workers to the plants that employ them. The database, termed the Worker-Employee Characteristics Database (WECD), contains detailed information on various personal characteristics of the worker, (e.g., age, sex, education, etc.). The use of this information has substantially improved the explained variation in a number of studies of business unit performance. See Troske (1995).

A Note on Evidence From an Earlier Period

Most of the work cited so far is based on data from the 1963-1993 period. But some historical work with recently uncovered economic census data provides a similar picture of business success to that found in the LRD. Bresnahan and Raff (1991) observe substantial differences in productivity among automotive plants during the 1930s, a time when mass production technology was replacing craft production. The heterogeneity they find is strongly associated with the technology in use at the plant, with plants using mass production techniques showing significantly higher productivity. Today, the "Toyota system" -- craft or custom production through management practices emphasizing flexibility in produced products -- appears to represent a return to the pre-depression era of made-to-order vehicles, but is now supported by new computer-based technologies that allow for efficient adoption of human and organization methods unavailable in the earlier period.[17]

Firm Effects

Several studies point to the importance of firm effects in explaining business unit behavior. For example, Baily, Hulten, and Campbell (1992) find that plants' productivity has an associated "firm" effect. As another example, Streitwieser, (1991) finds that plants classified in the same industry, on the basis of their primary product, differ substantially in their mix of secondary products. Exploiting the fact that many of the plants in the sample are part of multi-unit firms, she finds evidence that these differences in the secondary products produced by manufacturing plants are explained by a plant's ownership structure.[18] Another aspect of ownership status is whether a plant is owned by a multinational firm. Doms and Jensen (1995) find that plants owned by foreign firms and plants owned by U.S. firms with foreign assets are bigger, more productive, and pay higher wages. In terms of explained variance, however, these studies and others introducing a firm fixed-effect into a cross-section performance regression, find that "firm" effects are small relative to plant-specific factors.

Unfortunately, it is impossible to sort out the precise role of firm and plant-specific effects on plant behavior without much more sophisticated empirical designs than those available at this time. One problem in studying firm effects is that they are only separately identified in a cross-section analysis for firms composed of multiple plants. This limits sample sizes in many instances. However, it is possible to get some idea about their relative importance by comparing plant performance before and after a firm-level change. One of the most important such changes is an ownership change.[19] There is solid evidence that ownership change is associated with significant improvements in business unit performance. Mergers, divestitures, leveraged buyouts, etc. generate changes in the composition of the firm that affect behavior. For example, a series of studies have consistently identified ownership change as an event that increases business unit productivity

[17] Bresnahan and Raff (1991) find that differences in price-cost margins between business units were not tied to the type of technology used. They appeared more closely aligned with localized competition in product space. In today's world, global competition probably leaves little room for localized rents.

[18] The product structures of plants change, often dramatically, over time. See McGuckin and Peck (1992).

[19] Many earlier studies (see Mueller 1993 for a review) suggest that mergers have neutral or negative effects on acquiring firm's performance. These studies, for the most part, use data from samples composed of large multi-unit firms. Recent work by McGuckin and Nguyen (1996) indicates that such studies are subject to significant aggregation bias that tends to obscure the positive impacts of merger.

(see, for examples, Lichtenberg and Siegel 1992, Long and Ravenscraft 1993a, and McGuckin and Nguyen 1995).

Studies of job change and investment at the level of the business unit are also consistent with significant firm effects. Both job changes (Davis, Haltiwanger, and Schuh 1996) and investment (Doms and Dunne 1994) are characterized by large lumpy changes. For example, most jobs are created at plants that scale back dramatically. Job change is concentrated in plants increasing or decreasing their workforces by 25 percent or more. A very similar picture emerges for capital -- adjustments of over 37 percent in one year and more than 50 percent over two years. Thus, jobs typically are gained or lost and new capital acquisition are concentrated in particular plants. The data show that these large changes are not systematic across plants, even those classified in the same industry.[20] Since dramatic changes in operations such as these are often concentrated in times when ownership is changing, this evidence is consistent with significant firm effects. While this evidence is indirect, McGuckin, Nguyen, and Reznek (1995) provide direct evidence that ownership change is related to employment growth.

Industry Effects

Until recently, much of the empirical literature attempted to explain differences in industry-level variables where industry is defined in terms of the SIC system usually at the three- or four-digit level of detail. This literatures is reviewed very well by Schmalensee in the *Handbook of Industrial Organization* (1989). While the economic meaning of industry-level cross-section regression studies of performance measures (such as profitability and price-cost margins) is murky, such studies do suggest that factors that vary across industries are significant in business performance. For example, Dunne and Roberts (1991) conclude a recent study of exit and entry with three observations:

1. Entry and exit rates vary by industry, both in gross and net terms.
2. These rates are stable across time for individual industries and an industry's relative position in the distribution of entry and exit rates is persistent over time.
3. Consistent with the first two points, positive correlations between industry entry and exit rates are observed at each point in time.

These findings suggest that industry classification is a meaningful concept in the sense that it explains firm behavior.

This conclusion is supported by various studies incorporating industry effects into empirical models of firm behavior. Industry is important in explaining differences in firm behavior in every recent study using the LRD (see, for examples, Bernard and Jensen 1995, Doms and Jensen 1995, McGuckin, Streitwieser, and Doms 1996, Davis, Haltiwanger, and Schuh 1996, and Doms, Dunne, and Troske 1996). Moreover, this is not a recent finding or one limited to the LRD database. Gort, Arora, and McGuckin (1972) find significant industry effects in a fixed effects specification for firm diversification levels measured using Dun and Bradstreet data from the 1960s. Similarly, Cohen and Levin (1989) summarize numerous studies and conclude that "industry" effects explain a significant portion of firm R&D. Schmalensee (1985) in an influential contribution found that industry effects were more important than business unit and firm effects in explaining profitability using Federal Trade Commission

[20] Most of the job changes described are persistent. On average, 71 percent of all the jobs created last at least one year. 56 percent last for 2 years. Job destructions are even more persistent -- 82 percent are not regained in one year, and 74 percent are still lost 2 years later. This suggests that growth or decline in plants is permanent. So these effects involve real restructuring and change -- not transitory movements.

line of business data. Later studies by Kessides (1987) and, in a broader treatment of the issue, Rumelt (1991) show that while industry effects are significant in explaining profitability, the importance of the industry effect is dramatically reduced from that suggested in Schmalensee's work.

Recent studies with the LRD, such as those cited above, while not directly replicating the earlier studies, find that industry is a significant source of "explained" variation, but overall it explains very little of the observed variation in plant performance measures along a variety of dimensions. This is consistent with the Rumelt (1991) study that found that plant-specific factors are the more significant determinants of profitability. This means that the source of most of the observed variance in plant behavior is plant- or firm-specific effects.

Other Factors Determining Success

The empirical work discussed above identifies a wide range of characteristics associated with successful performance. Moreover, the results are generally both economically and statistically significant. However, while the relationships are significant, the unexplained residuals associated with them are large (i.e., the explanatory power of the empirical models is strikingly low). The percentage of explained variance tends to be on the order of between 10 percent and 30 percent. Similar levels of explained variation are found for regressions that use change measures -- job creation, productivity growth, investment, for examples -- as the performance variable. Thus, most of the variance in the data is unexplained and, therefore, idiosyncratic to the business unit.

This suggests that unobserved business unit characteristics like management practices, production process, and so forth, play a large role in performance differences. In turn, the important determinants of plant performance are now beginning to be studied by economists. Many of these, for example, differences in plant technologies (process and products) and managerial skills and practices, have been the provence of the case study or business school approach. However, with the new longitudinal databases covering large sectors of the economy (e.g., manufacturing) it is possible to study within plant factors systematically. In attempts to explain more of the variation in performance, researchers have moved to supplement data in the LRD with other ancillary, special surveys. As illustrated by the research with the SMT, described above, this is where much of the current research activity with the LRD is concentrated.

Persistence

We observe considerable variation in business units in the cross-section. We also observe entry, exit, plants growing, and plants shrinking over time. This leads to the question: How stable are intra-industry distributions of plant characteristics over time? The evidence on persistence is relatively new, but a picture of how the distribution of plants evolves over time is beginning to emerge.

For example, while there is strong evidence that reallocations of resources from low to high productivity plants are the most important factor in the growth of productivity in the economy, there also appears to be substantial persistence in plant productivities (see Baily, Hulten, and Campbell 1992, Bartelsman and Dhrymes 1992, and Dwyer 1995a). The finding of significant persistence in plant productivity performance across time suggests that permanent characteristics of the business unit account for its superior performance. Recent work by Dwyer (1995b) offers strong support for the existence of such permanent characteristics. He estimates that the persistent effects have a half-life of 10-20 years in the textile industry and explain nearly one-half the observed variation in productivity.

Other work also suggests that long-lived characteristics are important determinants of performance. In a very comprehensive study of 13 homogeneous products, Roberts and Supina (1994) find "clear patterns of price dispersion among producers with the amount of dispersion varying substantially across products but relatively little over time for a given product." Moreover, they find substantial persistence in the pricing of individual plants compared to what one would expect from random movements. Thus, they conclude that plants have stable permanent differences in costs that are reflected in their product prices, even within narrowly defined product groupings.

The work cited so far on persistence in the productivity distribution -- the most general measure of plant efficiency -- is usually based on specific industries and time periods. Therefore, it made sense to derive some simple descriptive statistics on persistence across the entire manufacturing sector. For this purpose, we selected from the LRD all plants producing in 1992 (over 350,000) and from this group of plants we identified all those that were operating in 1987. This gave us a sample that included all plants operating in 1992 that were five or more years old. We then classified each of these plants according to its primary four-digit Standard Industrial Classification (SIC) code. There were 458 four-digit industries in manufacturing in 1992.

For each industry, we regressed the plant's relative labor productivity (total shipments/total employment for the plant divided by the average labor productivity for the four-digit industry in which the plant was classified) in 1992 on the similar value for 1987.[21] This yielded 458 regression coefficients, each showing the average relationship between productivity in 1992 and productivity five years earlier for a four-digit industry.

The results of these calculations are displayed in Table 1 and are grouped by the 20 two-digit manufacturing sectors. Plants in industries with a higher coefficient show greater persistence in the sense that their position in the productivity distribution in 1992 is positively correlated with that in 1987. Table 1 shows that the average (unweighted) industry had a regression coefficient of .54 with a variance of .08. But the range was quite wide -- from about .75 for food and tobacco to less than .40 for transportation, furniture, and miscellaneous manufacturing.

Since this work is preliminary, we don't want to dwell on it except to note that in all industries, the estimated coefficients are consistent with substantial persistence in the productivity distribution over the five-year interval.

But, the regressions also suggest that transitory factors are important. A plant's productivity in 1992 is positively related to its productivity five years earlier, but the correlation is far from perfect. Thus, in addition to persistence, there appears to be a good deal of regression to the mean in the data. Because of this, some form of a random shock/measurement error model of productivity dynamics is also working. Dwyer (1995b) offers some support for this view.

Taken together, the evidence suggests that a model combining persistence with random shocks, both common and idiosyncratic, is likely to be necessary if we are to explain productivity dynamics. Such dynamic structural models need to be developed and estimated. Analyses examining the relationships of multiple dimensions of performance are a natural extension of the new empirical literature.

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[21] We also carried out the exercise for plants producing in 1982 and 1987, as well as in 1992. This allowed us to use the average labor productivity in 1982 and 1987 as the base year value. By doing this, we are able to, partially at least, control for transitory factors that would be average out due to regression to the mean. The results are broadly consistent with those reported here.

Industry Dynamics

While models and empirical work combining the elements of firm-level heterogeneity, firm-level persistence, and firm, sectoral, and aggregate random shocks are relatively new, evidence is emerging suggesting that this is a fruitful way to think about firm and industry evolution. Researchers are beginning to uncover empirical evidence of the aggregate effect of plant- and firm-level changes.

As noted above, Davis, Haltiwanger, and Schuh (1996) find the magnitudes of gross employment changes -- both job creations and job destructions -- are substantial. On average, 1 in 10 manufacturing jobs are lost in an average year, and 1 in 9 are gained. This means that 19 percent -- almost 20 percent of all jobs in manufacturing -- are reallocated among plants each year.[22] Clearly, these figures suggest that change -- growth and decline -- is a dominant characteristic of the economy.

Davis, Haltiwanger, and Schuh also find large gross changes in employment at individual plants in every manufacturing industry during the 1972-1988 period they studied. Regardless of whether an industry showed increase, decrease, or no change in its net employment, the authors observe some plants increasing, some plants decreasing, and some plants not changing their employment. And a similar pattern of large, idiosyncratic changes is observed for capital (see Doms and Dunne 1994 and Power 1995).

How does the heterogeneity among plants, observed for both levels and changes, affect competition and economic growth? If we observe an industry at two points in time we can categorize the firms into three categories, stayers -- those operating at both the beginning and the end of the period -- entrants, and exits. Davis, Haltiwanger, and Schuh (1996) find that a considerable portion of this reallocation of employment involves plants that operate continuously; annually, only 15 percent of job creation and 22 percent of job destruction are associated with entry and exit, respectively. Even over five-year intervals, entry and exit are not the prime vehicles for expansion and contraction of jobs or output.

The story for productivity is similar. In an important empirical study, Baily, Hulten, and Campbell (1992) investigate the role of plant-level productivity in industry productivity dynamics. Somewhat surprisingly, in light of the large turnover of plants through entry and exit in most industries,[23] the Baily, Hulten, and Campbell study finds that entry and exit are relatively unimportant in aggregate productivity growth, even over the full 15-year period they study. Roughly two-thirds of the aggregate productivity growth is attributable to gains in market shares by the most efficient producers and declines in market share by the least efficient.[24] This basic finding -- that the most productive business units grow faster and are less likely to exit -- has been confirmed by a host of studies with the LRD (see Dhrymes 1989, Bartelsman and Dhrymes 1992, Olley and Pakes 1996, Dwyer 1995 (a and b), and Roberts and Supina

[22] Net changes in jobs -- about 1 percent per year -- are small relative to gross.

[23] Entry and exit are relatively larger in terms of number of business units -- 35 to 40 percent over the typical 5-year period.

[24] There are reasons to believe that the entry/exit effects are minimized in their empirical decomposition and that some of the plant-specific growth reflects growth by entrants subsequent to their entry. The problem is that low productivity firms exit and the entrants that replace them also typically exhibit below average productivity at the time of entry. But surviving entrants grow very quickly and improve productivity, reaching average levels in 5 to 10 years. Thus, a good deal of the "plant" growth effect observed by the authors -- about one-third of aggregate productivity growth -- may be associated with subsequent growth by entrants. Alexander (1994) makes this point on page 8.

1994). In turn, there is convincing support for the proposition that economic growth is achieved via a competitive selection process in which the most efficient firms survive.

Caballero, Engel, and Haltiwanger (1995) suggest that understanding the distribution of plant attributes is important to understanding how an industry or sector will respond to a random shock. They examine the response of plant-level investment to changes in tax policy. They find that aggregate investment behavior depends on plant-level adjustments to capital. This, in turn, depends on the distribution of plant characteristics and past plant decisions. This research begins
to integrate aspects of plant heterogeneity, persistence, and random shocks into a model of how plants and industries evolve.

As another example, consider the problem of evaluating product choice and energy usage decisions in reaction to a change in energy prices. This kind of problem arises in assessments of economic or environmental policies such as the imposition of an energy tax. In the absence of a model and data at the plant level, an analysis completely describing the effects of the policy change is not possible. In this application, the responses of small, high-millage cars makers and low-mileage care producers will differ. Also, poor people who cannot afford to shift to new, high-mileage cars will bear a significant burden of the tax. They will continue to use their high-mileage cars longer than high-income drivers (income effect). Aside from equity issues, this will affect the dynamic adjustments and delay increases in the miles per gallon of the average car on the road. Pakes (1990) explicitly models the role of plant and firm differences in his analysis of the effect on the auto industry of changes in energy costs.

Concluding Observations

Heterogeneity is a fact of life among firms and their business units. It is the most pervasive attribute of the data and is found across all sectors no matter how the sector is defined -- by industry, region, size, etc. Once you group business units on one variable, they vary on virtually all others. For example, the various studies find significant differences in the product structure, productivity, productivity growth rates, investment, export activity, merger, organization, technology, age, mark-up differences, R&D, ability to assimilate new technologies, rate of learning by doing, job creation, job destruction, environmental emissions, capital intensity, etc. among business units classified in the same industry.

Firms are not only different in the cross-section. They enter at different times and make different choices about the products they produce and the technologies they use. In turn, their different circumstances mean that they react differently, even to common external shocks. Heterogeneity is observed across time as well as in the cross-section. During any time interval, observed changes among firms in the same industry are uneven and idiosyncratic as some open and some grow, while others shrink and die.

Thus, to understand economic performance and competition, one must move beyond representative firm models. Since most of the observed variation in the data is within industries, economic change cannot be understood in terms of the behavior of an "average" firm in an industry-level analysis.

The empirical evidence supports the view that some firms will succeed (that is, survive and grow) and some firms will fail (lose market share and go out of business). Thus, competition can be characterized as a process in which successful firms grow and lead industry growth at the expense of less efficient rivals.

But what factors distinguish successful firms from unsuccessful ones? While the empirical evidence has identified a wide variety of factors associated with successful firms, the evidence is not clear on what lies behind the observed relationships. For example, the evidence that adoption of advanced technology is positively related to performance is overwhelming. But does this positive association reflect the impact of the technology on the efficiency (competitiveness) of the adopting firm, or is it primarily a manifestation of well-managed efficient firms being more likely to adopt advanced technologies?

The problem is that much of the research discussed above has used models that explore pair-wise correlations among variables. While establishing correlation is an important first step, the results should not be interpreted as causal relationships between business unit characteristics. The observed correlations can reflect a positive relationship between performance and technology adoption because both of these variables are positively correlated with a third, unobserved factor.

This is a real possibility. The vast majority of variation in firm performance is not associated with traditional observables such as location, industry, size, age, or capital. Rather, this variation is associated with unobserved factors specific to the firm or business unit, many of which appear to be permanent attributes of the business unit. One such attribute is the managerial capital of the firm, another is the skills of its workforce.

The most important area for research is the development and estimation of models that disentangle the causes and effects of firm growth.[25] A logical next step in this line of research is to flesh out a more complete picture of the relationships between plant characteristics and plant performance. Causal models would allow us to move beyond more simple correlations to answer such specific questions as: Do plants that have higher wages grow? Or is it that successful plants grow, and then later pay higher wages? What is the relationship of exporting and success? Do exporters become successful firms or do successful firms become exporters? How long does it take before strong productivity growth yields improved business outcomes, and what is the strength of that relationship? Answers to these and similar questions can, in turn, help identify firms that show particular potential for success.

[25] Bernard and Jensen (1996b,c) begin to disentangle the relationship between plant characteristics, performance, and exporting in a dynamic model. They find that better plants do become exporters and there is some evidence of gains from exporting -- thus underlining the need for more sophisticated modeling approaches.

TABLE 1
THE RELATIONSHIP BETWEEN PLANT PRODUCTIVITY IN 1987 AND 1992*

SIC	Number of Four-Digit Industries	Mean Slope	Mean Slope Variance
All Industries	458	0.55	0.08177
20 Food	48	0.61	0.05927
21 Tobacco	4	0.75	.015413
22 Textiles	23	0.54	0.12979
23 Apparel	31	0.57	0.17257
24 Lumber & Wood	17	0.61	0.03069
25 Furniture	13	0.34	0.03788
26 Paper	17	0.66	0.06059
27 Print.& Publ.	14	0.50	0.04253
28 Chemicals	29	0.74	0.08271
29 Petroleum	5	0.68	0.02594
30 Rubber	15	0.51	0.03139
31 Leather	11	0.65	0.15078
32 Stone & Clay	26	0.44	0.04737
33 Primary Metal	26	0.56	0.09480
34 Fab. Metal	38	0.49	0.03913
35 Machinery	51	0.57	0.10563
36 Electronics	37	0.56	0.14573
37 Transportation	18	0.37	0.20866
38 Instruments	17	0.48	0.03910
39 Miscellaneous	18	0.36	0.02993

*The mean slope in the 2-digit industry is obtained by regressing $\ln P_{92} = a + b (\ln P_{87})$ for each 4-digit manufacturing industry. P = relative productivity.

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