THE DYNAMIC ADJUSTMENT PROCESS OF FIRM ENTRY AND EXIT IN MANUFACTURING AND FINANCE, INSURANCE, AND REAL ESTATE*

KENNETH R. TROSKE
U.S. Bureau of the Census, Center for Economic Studies

ABSTRACT

This article examines the dynamic adjustment process of firm entry and exit in manufacturing and finance, insurance, and real estate (FIRE). The object is to extend our knowledge of firm dynamics to include firm exit as well as nonmanufacturing firms. This interindustry comparison of firm dynamics uses a unique longitudinal firm-level data set containing over 13,000 firms. I report three main findings. First, in both industries firm entry is characterized by a decline in the first two moments of the growth rate distribution and by a rise in the first two moments of the relative firm size distribution as firms age. Second, in both industries firm exit is characterized by falling mean growth rates and mean relative firm size for a number of periods prior to exit. Third, relative to FIRE, firm entry and exit in manufacturing is a longer process and involves larger adjustments in relative firm size.

I. INTRODUCTION

ECONOMISTS have long realized that the dynamic process of firm entry and exit has important implications for the overall performance of markets. Theoretical papers examining possible barriers to entry, the contestable market hypothesis, and sunk cost investment and hysteresis, along with the multitude of empirical papers engendered by these theories, attest to the importance economists place on the entry and exit of firms. While there has been a number of important empirical examinations of firm and plant dynamics, all have focused exclusively on the dynamic adjustment process of firm entry and almost all have focused exclusively on manufacturing firms.[1]

* This work is based on my doctoral dissertation, and as such special thanks go to my advisors Robert Topel, Steve Davis, and Sherwin Rosen for their valuable assistance. Thanks also go to William Carrington, Mark Doms, Timothy Dunne, John Haltiwanger, Ron Jarmin, Brad Jensen, Shannon Mudd, Mark Roberts, SuZanne Troske, an anonymous referee, and seminar participants at the Center for Economic Studies, the University of Maryland, and the University of Pennsylvania. Any remaining errors are the property of the author. Any opinions, findings, or conclusions expressed herein are those of the author and do not in any way reflect the views of the U.S. Bureau of the Census.

[1] See John R. Baldwin & Paul K. Gorecki, Structural Changes and the Adjustment Process: Perspectives on Firm Growth and Worker Turnover (1990); Steve J. Davis & John Haltiwanger, Gross Job Creation, Gross Job Destruction and Employment Reallocation, 107 Q.

[*Journal of Law and Economics,* vol. XXXIX (October 1996)]
 0022-2186/96/3902-0011$01.50

This is unfortunate for two reasons. First, firm exit is as important in determining overall market performance as firm entry. In the contestable market hypothesis, a firm's ability to exit a market is just as important as a firm's ability to enter the market in determining whether a market is contestable. Second, there are a number of reasons to suspect that the dynamic process of firm entry and exit differs between manufacturing and service firms. Service firms in general contain fewer employees, invest in less capital, and are more likely to fail.[2] As the nonmanufacturing sector of the economy grows, it becomes increasingly important to understand the dynamic behavior of these firms as well.

This article partially fills this gap in the literature by examining the dynamic process of firm entry and exit in manufacturing and finance, insurance, and real estate (FIRE). The results from this analysis will be used in four ways: first, to illustrate the dynamic process of firm entry and exit in these sectors; second, to examine cross-industry differences in the dynamic adjustment process of firm entry and exit; third, to assess the ability of dynamic models of firm entry and growth to capture the time-series aspects of firm entry;[3] and fourth, to serve as a guide for how these models could be modified to incorporate both the dynamic process of firm exit and cross-industry differences in the entry and exit process.

J. Econ 810–63 (1992); Timothy Dunne, Mark Roberts, & Larry Samuelson, Patterns of Firm Entry and Exit in U.S. Manufacturing Industries, 19 RAND J. Econ. 495–515 (1988); Timothy Dunne, Mark Roberts, & Larry Samuelson, Firm Entry and Post-entry Performance in the U.S. Chemical Industries, 32 J. Law & Econ. S233–S271 (1989); Timothy Dunne, Mark Roberts, & Larry Samuelson, The Growth and Failure of U.S. Manufacturing Plants, 104 Q. J. Econ. 671–98 (1989); David S. Evans, The Relationship between Firm Growth, Size and Age: Estimates for 100 Manufacturing Industries, 35 J. Indus. Econ. 567–82 (1987); David S. Evans, Tests of Alternative Theories of Firm Growth, 95 J. Pol. Econ. 657–74 (1987); Bronwyn Hall, The Relationship between Firm Size and Growth in the U.S. Manufacturing Sector, 35 J. Indus. Econ. 583–606 (1987); and Ariel Pakes & Richard Ericson, Empirical Implications of Alternative Models of Firm Dynamics, (Working Paper No. 2893, National Bureau of Economic Research 1989). Pakes and Ericson's is the only work which examines the dynamic behavior of nonmanufacturing firms.

[2] The average firm size in 1987 was 20 employees in retail trade, 12 employees in services, and 74 employees in manufacturing. U.S. Department of Commerce, Bureau of the Census, 1987 Enterprise Statistics: Company Summary (1989). The estimated average capital stock in a firm in 1987 was $3.1 million in manufacturing, $1.1 million in FIRE, $.2 million in retail trade, and $.1 million in the services. U.S. Department of Commerce, Bureau of Economic Analysis, Fixed Reproducible Tangible Wealth in the United States, 1925–1989 (1993). Pakes and Ericson show that 40 percent of retail trade firms, 45 percent of eating and drinking firms, and 24 percent of manufacturing firms fail between 1978 and 1986. Pakes & Ericson, *supra* note 1.

[3] Avinash Dixit, Entry and Exit Decisions under Uncertainty, 97 J. Pol. Econ. 620–38 (1989); Richard Ericson & Ariel Pakes, Markov-Perfect Industry Dynamics: A Framework for Empirical Work, 62 Rev. Econ. Stud. 53–82 (1995); Boyan Jovanovic, Selection and the Evolution of Industry, 50 Econometrica 649–70 (1982); Robert Pindyck, Irreversible Investment, Capacity Choice, and the Value of the Firm, 78 Am. Econ. Rev. 969–95 (1988).

This interindustry comparison of firm dynamics is facilitated by the use of a unique firm-level longitudinal database. This database contains observations on over 13,000 manufacturing and FIRE firms operating in the state of Wisconsin between 1978 and 1987. While not without limitations, these data are unique in that they provide panel information on firms in multiple industries. It is this latter feature that allows research on both time-series and cross-sectoral aspects of firm entry and exit.

This article reports three main findings. First, in both industries firm entry is characterized by a decline in the first two moments of the growth rate distribution and by a rise in the first two moments of the relative firm size distribution as firms age. Second, in both industries firm exit is characterized by falling mean growth and mean relative size. Third, relative to FIRE, firm entry and exit in manufacturing is characterized by a longer process and involves larger adjustments in size.

While the observed dynamics of firm entry conform to the predictions of all of the models of firm dynamics, none accounts for the cross-industry differences in the entry and exit process.[4] Further, none explicitly models the process of firm exit. Therefore, I conclude this article with some suggestions for how these models might be modified to capture the observed time-series and cross-sectional aspects of firm entry and exit.

The rest of the article is as follows. The next section contains a brief discussion of previous theoretical and empirical work on the dynamic adjustment process of firm entry. Section III contains a discussion of the data and measurement issues. Section IV presents the empirical findings. Section V concludes.

II. Previous Theoretical and Empirical Findings regarding the Dynamic Adjustment Process of Firm Entry and Exit

A. *Theoretical Models*

The dynamic cost-of-adjustment model is one of the earliest models to incorporate firm entry. In this model, the per-period marginal cost of investment rises with the level of investment, making it optimal for firms to spread out large investments over a number of periods. This model implies that an entering firm should experience high initial growth as it begins investing in capital, but that this growth should fall as the firm completes its investment.

[4] This claim is somewhat unfair. All of these models are industry-specific models of firm dynamics, and therefore none explicitly tries to account for cross-industry differences in firm dynamics.

Another dynamic model of firm entry is the Jovanovic model.[5] In this model, firms enter an industry endowed with an underlying parameter θ, which measures the firm's ability to produce output in the industry and is initially unknown to the firm. The θ parameter acts as a cost shifter. Firms with a high θ have high costs and, therefore, low profits. Firms' costs also have a stochastic element, so firms discover the true value of their θ over time only by producing, observing their resulting costs, and updating their expectations of θ. If a firm discovers it has a high θ (it is an inefficient producer of output) it shrinks in size and eventually exits the industry. Conversely, if a firm discovers it is endowed with a low θ, it expands and remains in the industry. Given this structure, the Jovanovic model predicts that the first two moments of the growth rate distribution for a cohort of firms should decline as the cohort ages, while the first moment of the firm size distribution should rise as the cohort ages.[6]

Both the dynamic cost-of-adjustment model and the Jovanovic model imply that once entry is complete firms should experience identical growth. The Ericson and Pakes model incorporates heterogeneous growth among firms after entry.[7] In the Ericson and Pakes model, firms enter the market with an underlying parameter θ, which, as in the Jovanovic model, is a measure of the firm's ability to produce output. However, in the Ericson-Pakes model, firms know their underlying θ and can also invest to improve θ. Ericson and Pakes show that their model implies, first, that the firm size distribution of a cohort of entering firms shifts to the right with age and, second, that the effect of a firm's initial size on its current size should decrease over time (firms should experience declining state dependence).

Recent theoretical models concerned with sunk cost investment and hysteresis also have implications for the dynamic adjustment process of firm entry and exit.[8] These models emphasize that when the future is uncertain there is a value to the option of waiting before making sunk cost investment in capital. Dixit shows that one implication of these models is that firms will wait longer before entering a market and, once in the market, will wait longer prior to exiting.[9] Pindyck shows that firms will make smaller invest-

[5] Jovanovic, *supra* note 3.

[6] These predictions of the Jovanovic model hold only when certain assumptions concerning the firm's updating rule are made. See Dunne, Roberts, & Samuelson, The Growth and Failure of Manufacturing Plants, *supra* note 1, and Pakes & Ericson, *supra* note 1, for a further discussion of these assumptions.

[7] Ericson & Pakes, *supra* note 3.

[8] See the papers by Avinash Dixit, Investment and Hysteresis, 6 J. Econ. Persp. 107–32 (1992); and Robert Pindyck, Irreversibility, Uncertainty and Investment, 29 J. Econ. Lit. 1110–48 (1991), for a general overview of these models.

[9] Dixit, *supra* note 3.

ments in capacity than they would in an identical environment without the uncertainty or when the investment is not sunk.[10]

B. *Previous Empirical Studies*

Previous empirical work on the dynamic adjustment process of entry and exit have been primarily concerned with examining the predictions of the Jovanovic model.[11] Dunne, Roberts, and Samuelson, Evans, and Hall all examine the entry process of manufacturing *firms* and all find a negative relationship between firm age and growth.[12] In addition, Evans finds that the variance of firm growth declines with age, while Dunne, Roberts, and Samuelson find that the average relative size of entering firms rises with firm age.[13]

Baldwin and Gorecki, Davis and Haltiwanger, and Dunne, Roberts, and Samuelson examine the entry process for manufacturing *plants,* and all find that the mean of the plant growth rate distribution falls with plant age.[14] Dunne, Roberts, and Samuelson also find that the variance of the plant growth rate distribution falls with age.

Pakes and Ericson examine the entry process of manufacturing and retail trade firms and find that, in both industries, the firm size distribution shifts to the right as a cohort of firms age.[15] Pakes and Ericson also find that the firm size distribution of entering retail trade firms resembles the size distribution of incumbent firms much sooner than the size distribution of entering manufacturing firms. Based on this evidence, Pakes and Ericson conclude that the dynamic adjustment process at entry is shorter for retail trade firms than for manufacturing firms.

III. Data and Measurement Issues

A. *The Data*

The data used in this study are administrative data originally collected by the state of Wisconsin for the state's unemployment insurance (UI) pro-

[10] Pindyck, *supra* note 3.

[11] Jovanovic, *supra* note 3.

[12] Dunne, Roberts, & Samuelson, Patterns of Firm Entry, *supra* note 1; Dunne, Roberts, & Samuelson, Firm Entry and Post-entry Performance, *supra* note 1; Evans, The Relationship between Firm Growth, *supra* note 1; Evans, Tests of Alternative Theories of Firm Growth, *supra* note 1; Hall, *supra* note 1.

[13] Evans, The Relationship between Firm Growth, *supra* note 1; Evans, Tests of Alternative Theories of Firm Growth, *supra* note 1; Dunne, Roberts, & Samuelson, Patterns of Firm Entry, *supra* note 1.

[14] Baldwin & Gorecki, *supra* note 1; Davis & Haltiwanger, *supra* note 1; Dunne, Roberts, & Samuelson, The Growth and Failure of U.S. Manufacturing Plants, *supra* note 1.

[15] Pakes & Ericson, *supra* note 1.

gram. Every business operating in the state is required, by law, to report its employment if the business has ever employed a worker for more than 20 weeks, or if it has ever paid more than $1,500.00 in wages in a quarter. Records in these data consist of a UI account number, the location of the reporting unit filing the report, the date the reporting unit first began filing a report under its current UI account, the date the reporting unit officially closed, the reporting unit's industry classification, any transfer of legal responsibility for the UI tax, and the reporting unit's monthly employment as of the twelfth of each month.[16] The data cover the period from the first quarter of 1978 to the first quarter of 1987.

A subsample of firms with a plurality of their employment in either manufacturing or FIRE was selected from the overall business population of the state. The decision to focus on a subset of the data was made to keep the sample size reasonable.[17] The manufacturing sector was chosen because almost all previous studies of the dynamic entry and exit process have focused on manufacturing firms or plants. FIRE was chosen, first, because it is a service industry and, second, because it is the second largest industry in Wisconsin in terms of total value of output (manufacturing is the largest).

One key issue in studying the dynamic process of entry and exit is identifying a consistent unit of analysis. The state of Wisconsin allows a firm that operates separate establishments in the state to choose the level of aggregation used when filing its employment reports. A firm can file one report for the entire firm, one report for each separate establishment, or one report for almost any combination of establishments it desires. Further, the firm can choose to change the level of aggregation at any time. In the original data each separate report filed by a firm appears as a separate record. However, each separate record filed by a subunit of a multiestablishment firm is assigned a unique firm-level identifier.[18] Using this identifier, all records filed by subunits of a firm in a given year have been summed together to form one record per firm per year, ensuring that each observation in the data refers to the same entity, a firm-year.[19]

A second issue in studying firm entry and exit involves distinguishing

[16] I use the term "reporting unit" because firms are allowed to aggregate their employment when filing UI reports, making it unclear whether a report is being filed by an individual establishment or by a collection of establishments owned by the same firm. See the discussion later in the section.

[17] The entire data set consists of over four million firm-year observations.

[18] This identifier is *not* the Federal Employer Identification Number (FEIN), which is also available for each reporting unit. This identifier is a 10-digit number, with the first six digits being unique to each reporting unit that is owned by the same legal entity.

[19] The Standard Industrial Classification (SIC) code assigned to a firm that operates multiple plants in different industries is the SIC code that contains the plurality of employment.

TABLE 1

THE PROBABILITY OF A FIRM BEING INVOLVED IN A TRANSFER (IN %)

	Manufacturing	FIRE
Overall	20.55	15.77
Size class:		
1	9.01	6.35
2	19.47	12.09
3	22.37	18.06
4	31.41	30.64
Entering firms	7.14	4.18
Exiting firms	1.73	1.13
N	12,523	12,097

changes in firm ownership from firm entry and exit. In these data, when a new firm is created through the purchase of an existing firm, the UI account number of the acquiring firm is entered in the record of the acquired firm.[20] This information allows records to be linked across ownership transfer and ensures that the transfer of ownership does not appear as the exit of the acquired firm and the entry of the acquiring firm.[21]

One concern with linking firms across ownership transfers is whether the probability of a firm experiencing an organizational change varies systematically with industry, size, or age. If there are any systematic differences in this probability it could mask cross-industry differences in the dynamics of entry and exit. For example, it could be that successful manufacturing firms are those that enter, produce for a few periods without experiencing any change in size, and are then acquired by an existing firm. In contrast, successful FIRE firms may be those that enter the industry, remain independent, and grow until they resembles existing firms. Table 1 investigates this possibility by presenting the overall probability of a manufacturing firm and FIRE firm being involved in a transfer, with this probability broken out by size class, and by whether the firm entered or exited the market in the pe-

[20] The reader should note that creating firm-level records helps minimize the problem of ownership transfer. It is only when an entire firm is transferred that it is necessary to link records. When a plant from one multiplant firm is sold to a second multiplant firm, this shows up in the data as the contraction of the first firm and the expansion of the second.

[21] The acquiring firm does have the option of choosing whether to have its new account linked to the old account. However, when the acquiring account is not linked to the acquired account, a code is entered in the acquiring account's record indicating that the creation of the new account was the result of an ownership transfer. This ensures that the new account is not counted as a birth. This happens so seldom that it does not appear to bias any of the reported results.

riod covered by the data.[22] This table shows that manufacturing firms and large firms are more likely to be involved in a transfer. However, Table 1 also shows that very few entering or exiting firms in either industry are involved in a transfer of ownership. Therefore, it does not appear that linking firms across ownership transfer masks any systematic cross-industry differences in the dynamics of entry and exit.

One final point concerning the data is worth noting. Given that these data are drawn from Wisconsin's UI database, firm entry and exit is more precisely the entry or exit of a firm from the state. While this does limit the analysis to studying the part of a firm operating in a single state, it also ensures that the analysis is focused on a localized market.[23] Therefore, there is much less room for regional differences in growth or regulation to bias the results. Further, a comparison of the time-series behavior of various aggregate variables, such as unemployment, inflation, and total output, at the state and national levels reveals that the growth of the Wisconsin economy is similar to the growth of the U.S. economy over the relevant period. This suggests that the findings from these data should be fairly robust.[24]

B. Measurement Issues

In studying the dynamic adjustment process of firm entry and exit, it is necessary to construct measures of firm entry, exit, size, and growth. The first two of these tasks is straightforward. The state of Wisconsin records the date a firm was first required to file a UI report and the last date of positive employment for the firm prior to exiting the market.[25] The former date is used to measure the date of firm entry into the market, while the latter is used to measure the date of firm exit. With regard to the latter date, once a firm enters the UI system, it is required to file a UI report every quarter until it has 8 consecutive quarters of zero payroll, after which the

[22] Firm size is defined as the yearly employment of the firm averaged over all years for which the firm appears in the data. The size classes are the quartiles of this size distribution.

[23] Data from the 1982 Census of Manufactures show that 98 percent of all manufacturing firms operate in a single state (source: author's calculations). While this number would obviously be much lower if it were weighted by employment, it does demonstrate that for an overwhelming majority of *firms,* the entire firm will be contained in the state.

[24] Kenneth R. Troske, The Growth and Survival of Firms and Changes in the Firm Size Distribution in Industries (unpublished Ph.D. dissertation, Univ. Chicago, Dep't Economics 1992).

[25] Wisconsin first began recording information on firm entry in 1967, so it should be possible to know the age of every firm that entered after 1967. However, for over 20 percent of firms with a nonmissing date of first entry, the entry year is 1972. Since it seems implausible that this many firms began operating in the state in this year, I use only firms with nonmissing dates of entry after 1972 in the entry analysis.

account is considered closed. The date of exit is then recorded as the last month of positive employment prior to having 8 consecutive quarters of zero payroll.[26]

Firm size is measured as the total employment in a firm in period *t*.[27] Since firms are required to report monthly employment, *t* could conceivably be a month. However, given the enormous computer resources this would require, and to ensure that my findings are comparable to previous findings, *t* is chosen as a year and firm size is measured as the sum of total monthly employment in firm *i* in industry *j* in year *t*, divided by the number of months the firm has positive employment in year *t*. Call this measure Emp_{ijt}.[28]

While Emp_{ijt} does measure the absolute size of a firm, when making cross-sectional and time-series comparisons it is important to have a measure of size that controls for possible cross-sectional and secular differences in optimal firm size. For example, the average size of a manufacturing firm in these data is 75 employees, while the average size of a FIRE firm is 11 employees. Obviously, a FIRE firm that enters with 10 employees is much different than a manufacturing firm that enters with 10 employees. To correct for this I employ a relative measure of size. Letting Emp_{jt} represent the average size of a firm in the two-digit industry *j* at time *t*, then

$$Z_{ijt} = \frac{\text{Emp}_{ijt}}{\text{Emp}_{ij}} \tag{1}$$

measures the size of a firm relative to the average size of a firm in industry *j* in year *t*.

[26] When creating firm-level observations for multiestablishment firms, the earliest date of entry is used to date the firm's entry into the market, and the latest date of exit is used as the firm's exit date. Thus, a firm is not considered closed until every plant the firm owns ceases operation.

[27] One obvious limitation of these data is that employment is the only measure of firm size. The growth of an input can be a misleading measure of total firm growth if a technological change occurs that enables a firm to produce greater output with the same input. However, Dunne, Roberts, & Samuelson; Evans; and Hall all show that their results are robust to the choice of total value of shipments, total value of physical assets, and total employment as a measure of firm size. Further, Evans shows that all three of these measures of firm size are highly correlated. Dunne, Roberts, & Samuelson, Firm Entry and Post-entry Performance, *supra* note 1; Dunne, Roberts, & Samuelson, The Growth and Failure of U.S. Manufacturing Plants, *supra* note 1; Evans, The Relationship between Firm Growth, *supra* note 1; Evans, Tests of Alternative Theories, *supra* note 1; Hall, *supra* note 1.

[28] The reader should note that using this measure of employment eliminates firms that enter and exit in the same year from the data. Thus, I miss any cross-industry differences in high-frequency entry and exit.

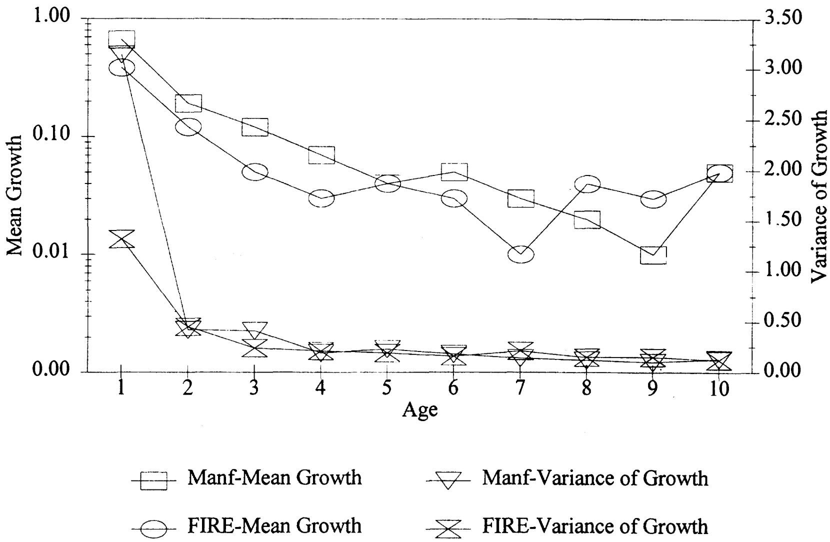

FIGURE 1.—Mean and variance of firm growth by age

Finally, if we let $\Delta \text{Emp}_{ijt} = \text{Emp}_{ijt} - \text{Emp}_{ijt-1}$ then the growth of firm i in industry j in year t is measured as

$$G_{ijt} = \frac{\Delta \text{Emp}_{ijt}}{\text{Emp}_{ijt-1}}. \tag{2}$$

The G_{ijt} distribution is bounded between -1 and ∞, with $G_{ijt} = \infty$ in the year of entry. Observations in the year of entry are excluded from the analyses (where $G_{ijt} = \infty$).[29]

IV. Empirical Analysis

A. *The Dynamic Adjustment Process of Firm Entry*

To begin analyzing the dynamic adjustment process of firm entry and exit, Figure 1 plots the first two moments of the growth rate distribution,

[29] An alternative growth rate measure is

$$g_{ijt} = \frac{\Delta \text{Emp}_{ijt}}{(\text{Emp}_{ijt} + \text{Emp}_{ijt-1}) \times 0.5}.$$

All of the empirical analysis in this article was performed using both G_{ijt} and g_{ijt}. Since the results are qualitatively identical using either measure and since most previous researchers have used G_{ijt}, I only present the results based on G_{ijt}.

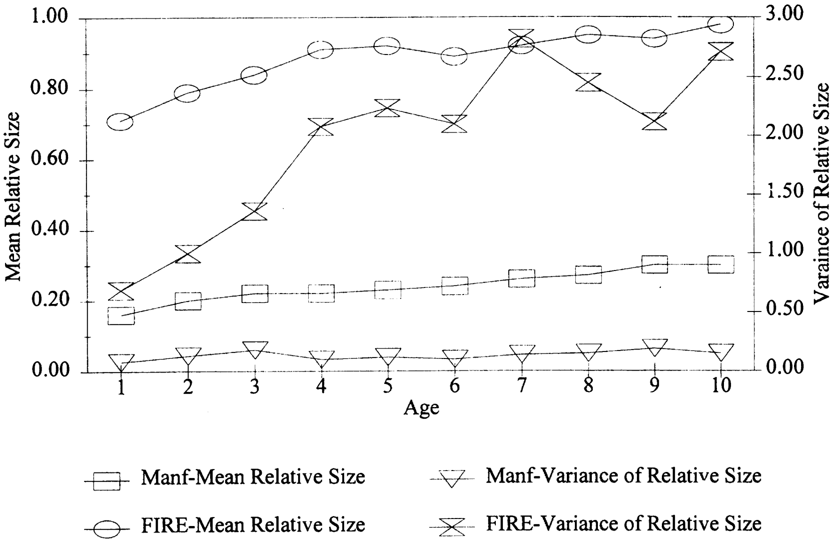

FIGURE 2.—Mean and variance of relative firm size by age

G_{ijt}, by age for manufacturing and FIRE firms.[30] Figure 2 presents the identical plots for the relative firm size distribution, Z_{ijt}. In Figure 1 the mean of the growth rate distribution is measured on the left axis and the variance of the growth rate distribution is measured on the right axis. In Figure 2 the mean of the relative size distribution is measured on the left axis and the variance of this distribution is measured on the right axis. In Figure 1 the left axis measures growth using a logarithmic scale for purely expository purposes. To focus on the dynamic entry process only nonfailing firm-year observations are used to construct these distributions (where $G_{ijt} > -1$).[31]

Figure 1 shows that both moments of the growth rate distribution fall with firm age. In manufacturing, average firm growth falls by 99 percent between ages 1 and 9, while the variance of the growth rate distribution falls by 96 percent between ages 1 and 10. In FIRE, average firm growth declines by 93 percent between ages 1 and 7, while the variance of the

[30] The reader should note that these figures do not represent movements in the growth or relative size of a cohort of firms. The age 2 growth rate in Figure 1 is the average growth of all age 2 firms in the data, regardless of when a firm entered the market.

[31] Including the failing firm-year observations shifts down both the mean and variance lines without any substantial change in the slope.

growth rate distribution falls by 92 percent between ages 1 and 10.[32] In both industries firms experience rapid growth initially, but firm growth rates fall quickly as firms age. It appears from the movements in the variance that for firms in both manufacturing and FIRE, the idiosyncratic component of firm growth declines in importance as firms age.[33]

Figure 2 shows that the first two moments of the relative firm size distribution rise with firm age in both industries. In manufacturing, average relative firm size doubles between ages 1 and 9, while the variance of the relative firm size distribution increases by 280 percent over the same ages. In FIRE, average relative firm size increases by 48 percent between ages 1 and 9, while the variance of the relative firm size distribution increases by over 600 percent between these same ages. While most firms increase in relative size with age in these industries, it appears that a few firms experience dramatic changes in relative size.

Comparing the first two moments of the growth rate distributions for manufacturing and FIRE shows that entering firms in these industries experience very similar patterns of growth. In both industries, mean firm growth falls steadily for the first few years after entry and then turns up slightly at age 10. In both industries the variance in firm growth falls continually throughout the period. In addition, both the level and the magnitude of these changes are quite similar.

In contrast, comparing the relative firm size distribution for manufacturing and FIRE firms, it appears that the entry process is very different for firms in these two industries. Figure 2 shows that, relative to manufacturing firms, FIRE firms enter the market at a much larger size and experience a much smaller change in size in the first 10 years. The relative size of age 1 FIRE firms is almost 3 times larger than the relative size of age 1 manufacturing firms. As was mentioned above, the relative size of manufacturing firms doubles between ages 1 and 9, while the relative size of FIRE firms increases by 48 percent between these same ages. These changes in the rela-

[32] The way I am measuring age could produce the large drop in growth seen between ages 1 and 2 and may hide cross-industry differences in the age-growth relationship. I consider firms that enter (exit) a market in January of a given year to be the same age as firms that enter (exit) in December of the same year. If firm size is positively correlated with firm age (as it appears to be), this will bias upward the age 1 growth rate and bias downward the age 2 growth rate, thus overstating the difference in the two rates of growth. In addition, if there are systematic cross-industry differences in when firms enter (exit) the market, then this may hide cross-industry differences in the dynamic entry (exit) process. To check for the former problem, I have repeated the entire analysis using only firms that enter (exit) the market in the first (last) 3 months of the year. The results are qualitatively identical to those reported in the article. To check on the second problem, I have examined the month of entry (exit) for manufacturing and FIRE firms and find no systematic differences.

[33] This fall in variance is primarily due to movements in the right tail of the distribution.

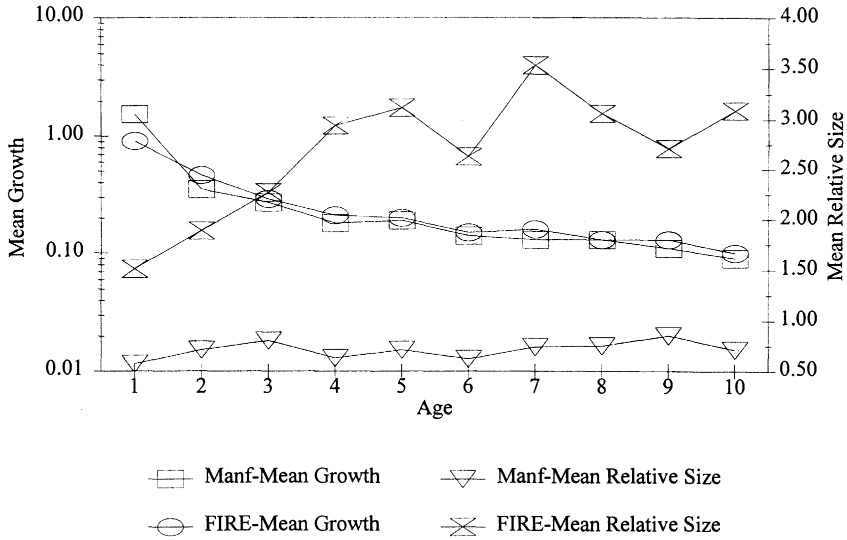

FIGURE 3.—Mean of firm growth and relative size by age (employment weighted)

tive size distributions suggests that for FIRE firms the dynamic adjustment process after entry occurs more quickly and is accompanied by a smaller change in relative size than for manufacturing firms.

One possible explanation for the cross-industry differences in the entry process may be differences in the number and growth of large entrants. It may be that large entering manufacturing firms exhibit similar patterns of growth as large entering FIRE firms but that there are relatively fewer large entering manufacturing firms. To investigate this hypothesis, Figure 3 graphs the mean of the growth rate distribution and the mean of the relative size distribution for manufacturing and FIRE firms weighted by employment. The mean of the growth rate distribution is measured on the left axis, while the mean of the relative firm size distribution is measured on the right axis. A logarithmic scale is again used on the left axis for expository purposes.

Figure 3 again shows very little cross-industry difference in the age-growth relationship. The weighted age 1 growth rate of manufacturing firms is somewhat larger than the weighted age 1 growth rate of FIRE firms. However, by age 3, firms in both industries average very similar growth rates and continue to average similar growth rates through age 10. Interestingly, comparing Figures 1 and 3 shows that large firms in both industries average much higher growth than small firms over the first 10 years of existence.

Comparing the movements in the relative size distributions in Figure 3 shows that large manufacturing firms experience very little change in relative size after entry, while large FIRE firms experience extremely large changes in relative size after entry. The weighted mean of relative size in manufacturing increases by 40 percent over the first 10 years after entry, while the weighted mean of relative size in FIRE doubles over this same period. Comparing the movements in relative size in Figures 2 and 3 suggests that much of the cross-industry difference in the dynamic entry process is the result of differences in the behavior of small entering firms. It appears that small manufacturing firms experience a much longer period of adjustment after entry than small FIRE firms.

To further examine the dynamic adjustment process at entry, I present basic regressions which show the changes in firm growth and relative size immediately after entry controlling for other firm characteristics, such as industry or year of entry, that may affect the entry process. The basic equations are

$$G_{ijt} = \beta' x_{ijt} + u_{it} \tag{3}$$

and

$$\ln(Z_{ijt}) = \beta' y_{ijt} + u_{it}, \tag{4}$$

where G_{ijt} is the measure of firm growth given in equation (2), $\ln(Z_{ijt})$ is the log of relative firm size (Z_{ijt} is given in eq. [1]), and x_{ijt} and y_{ijt} are vectors of firm and industry characteristics. Table A1 in the Appendix provides a list of the variables contained in x_{ijt} and y_{ijt}.

Tables 2 and 3 present the results from estimating equations (3) and (4), respectively, where x_{ijt} and y_{ijt} include firm age. To impose as few restrictions as possible on the relationship between firm age and growth and firm size and growth, age enters both of these regressions as a series of dummy variables. Firms older than age 10 are the excluded group.

Relative size (Z_{ijt}) is included in x_{ijt} because the Jovanovic model implies that firm growth should be a function of both size and age and also because previous research has found a statistically significant relationship between firm growth and size.[34] Interactions between age and size are included to control for any nonlinearities in the relationship between age and size, and growth. Year and two-digit industry dummies are included in both sets of

[34] Jovanovic, *supra* note 3. Dunne, Roberts, & Samuelson, Patterns of Firm Entry, *supra* note 1; Dunne, Roberts, & Samuelson, Firm Entry and Post-entry Performance, *supra* note 1; Evans, The Relationship between Firm Size, *supra* note 1; Evans, Test of Alternative Theories, *supra* note 1.

regressions to control for sectoral and secular effects.[35] The urban variable is included to control for regional differences in growth. Interactions between age and year are included in both sets of regressions to control for possible cohort effects. In an effort to impose as few restrictions as possible on any cross-industry differences in the relationship between age and growth, separate regressions are run for manufacturing and FIRE.[36]

In Tables 2 and 3, column 1 is referred to as the All Firms regression, and all firm-year observations in the data are included in the regression. Column 2 is referred to as the Continuing Firms regression, and only nonfailing firm-year observations are included in the regression (where $G_{ijt} > -1$). Column 3 is referred to as the Weighted regression, and all nonfailing firm-year observations, weighted by the firm's employment in year *t*, are included in the regression.

The coefficients on the age dummies in Table 2 show that in both industries firm growth initially declines with age but then begins to rise slightly between ages 3 and 5. This is similar to the pattern seen in Figure 1. The regressions also show that a majority of the decline in growth occurs between ages 1 and 2. It appears from Table 2 that firms in both industries have a small initial presence in the market in the year of entry and then expand quite rapidly between the year of entry and age 1. Then, having reached some optimal starting size, their rate of expansion slows and changes very little with age. This pattern holds for the All Firms, Continuing Firms, and Weighted regressions in both industries. In fact, the Weighted regressions show that larger firms are larger because they experience much higher initial growth. One possible explanation for this pattern is that firms in both industries initially employ a "start-up" crew to set up the new plant or office. Once this start-up phase is complete, the firm hires an entire workforce and begins operation. After this initial expansion, the growth of the firm slows and is primarily affected by market factors.

The coefficients on the age dummies in Table 3 show that in both industries the relative size of entering firms rises monotonically with age. This is similar to the pattern seen in Figure 2. Even after controlling for year, industry, and cohort effects, it still appears that relative firm size rises steadily after entry.

[35] See Table A2 in the appendix for a complete list and description of the two-digit industries contained in manufacturing and FIRE. The excluded year in these regressions is 1986. Industry 39 is the excluded industry in the manufacturing regressions, and industry 67 is the excluded industry in the FIRE regressions.

[36] Due to the presence of heteroskedasticity in the data, all *t*-statistics reported in the article are constructed using White standard errors, which correct for general forms of heteroskedasticity. Halbert White, A Heteroskedastic-Consistent Covariance Matrix Estimator and Direct Test for Heteroskedasticity, 48 Econometrica 817–38 (1980).

TABLE 2

REGRESSION OF FIRM GROWTH, G_{ijt}, IMMEDIATELY AFTER ENTRY

	MANUFACTURING			FIRE		
VARIABLE	All Firms (1)	Continuing Firms (2)	Weighted (3)	All Firms (1)	Continuing Firms (2)	Weighted (3)
Intercept	−.1105*	−.0061	.3371	−.0670	.0253	.1332
	(3.494)	(.100)	(.180)	(1.625)	(.653)	(1.221)
Age1	.3914*	.4251*	.9273*	.1047	.1424*	.6667*
	(5.782)	(6.324)	(4.354)	(2.351)	(3.363)	(5.494)
Age2	−.0961	−.0315	−.2226	−.0952	−.0536	.1319
	(1.405)	(.459)	(.846)	(1.971)	(1.135)	(.813)
Age3	−.1269	−.0815	−.2346	−.1388*	−.100	−.0335
	(1.980)	(1.270)	(1.004)	(3.077)	(2.273)	(.230)
Age4	−.1301	−.1069	−.2617	−.1211*	−.0952	−.1045
	(2.221)	(1.834)	(1.260)	(2.848)	(2.299)	(.765)
Age5	−.1275*	−.1114	−.2073	−.0920*	−.0743	−.1062
	(2.338)	(2.053)	(1.059)	(2.339)	(1.943)	(.807)
Age6	−.1170*	−.1062	−.2261	−.0641	−.0598	−.0939
	(2.354)	(2.158)	(1.350)	(1.783)	(1.735)	(.829)
Age7	−.1051*	−.1068*	−.2167	−.0463	−.0556	−.0540
	(2.358)	(2.432)	(1.437)	(1.375)	(1.720)	(.526)

Age8	−.0915	−.1009*	−.1662	−.0298	−.0250	−.0685
	(2.295)	(2.583)	(1.339)	(.988)	(.889)	(.829)
Age9	−.1166*	−.1086*	−.1889	−.0035	−.0182	−.0507
	(3.218)	(3.129)	(1.935)	(.122)	(.694)	(.672)
Age10	−.0827	−.0567	−.1584	.0281	.0282	.0264
	(2.308)	(1.692)	(2.019)	(1.022)	(1.160)	(.517)
Relsize	.9012*	.6575*	−.0815	.2839*	.2400*	.1443*
	(8.290)	(6.469)	(1.084)	(8.883)	(7.472)	(4.082)
Relsize2	−.2041*	−.1264	.0940	−.0153*	−.0117*	−.0063*
	(3.282)	(2.126)	(1.350)	(9.488)	(7.785)	(3.508)
Relsize3	.0124	.0073	−.0070	.0003*	.0003*	.0001*
	(2.551)	(1.574)	(1.279)	(7.074)	(6.187)	(3.313)
Urban	−.0066	−.0079	−.0676	.0006	.0084	.0672
	(.475)	(.572)	(1.727)	(.063)	(.947)	(1.657)
Age*Size	−.0496*	−.04412	−.0163	−.0167*	−.0166*	−.0079*
	(2.845)	(2.635)	(.633)	(4.312)	(4.332)	(3.041)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Age*Year	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	.086	.085	.152	.062	.059	.081
N	16,803	15,663	15,663	18,069	16,946	16,946

NOTE.—t-statistics are in parentheses.
* Significantly different from zero at the 1% level.

TABLE 3

REGRESSION OF LOG RELATIVE FIRM SIZE, $\ln(Z_{ijt})$, IMMEDIATELY AFTER ENTRY

	MANUFACTURING			FIRE		
VARIABLE	All Firms (1)	Continuing Firms (2)	Weighted (3)	All Firms (1)	Continuing Firms (2)	Weighted (3)
Intercept	−1.511*	−1.458*	−.492*	−.905*	−.888*	.485
	(19.195)	(18.141)	(5.759)	(−15.876)	(15.101)	(1.980)
Age1	−.717*	−.725*	−.493*	−.305*	−.302*	−.742*
	(4.339)	(8.654)	(2.821)	(4.641)	(4.467)	(2.859)
Age2	−.548*	−.537*	−.294	−.222*	−.213*	−.516
	(6.984)	(6.740)	(1.856)	(3.535)	(3.296)	(2.110)
Age3	−.431*	−.426*	−.178	−.175*	−.170*	−.336
	(5.703)	(5.564)	(1.052)	(2.911)	(2.743)	(1.432)
Age4	−.368*	−.372*	−.203	−.133	−.130	−.154
	(5.036)	(5.024)	(1.371)	(2.296)	(2.176)	(.688)
Age5	−.349*	−.346*	−.133	−.128	−.124	−.081
	(4.893)	(4.791)	(.909)	(2.282)	(2.159)	(.371)

Age6	−.260*	−.271*	−.171	−.103	−.113	−.119
	(3.730)	(3.842)	(1.215)	(1.894)	(2.032)	(.558)
Age7	−.219*	−.223*	−.096	−.105	−.107	.061
	(3.150)	(3.178)	(.671)	(1.964)	(1.959)	(.278)
Age8	−.159	−.175*	−.033	−.089	−.077	.187
	(2.259)	(2.472)	(.232)	(1.659)	(1.394)	(.815)
Age9	−.108	−.102	.090	−.041	−.036	.225
	(1.482)	(1.392)	(.659)	(.729)	(.628)	(.942)
Age10	−.063	−.043	−.005	−.005	.001	.027
	(.832)	(.561)	(.037)	(.093)	(.012)	(.120)
Urban	−.017	−.025	−.192*	.145*	.149*	.378*
	(.977)	(1.416)	(4.566)	(12.323)	(12.240)	(7.825)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Age*Year	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	.179	.180	.164	.356	.353	.316
N	16,624	15,663	15,663	17,912	16,946	16,946

NOTE.—*t*-statistics are in parentheses.
* Significantly different from zero at the 1% level.

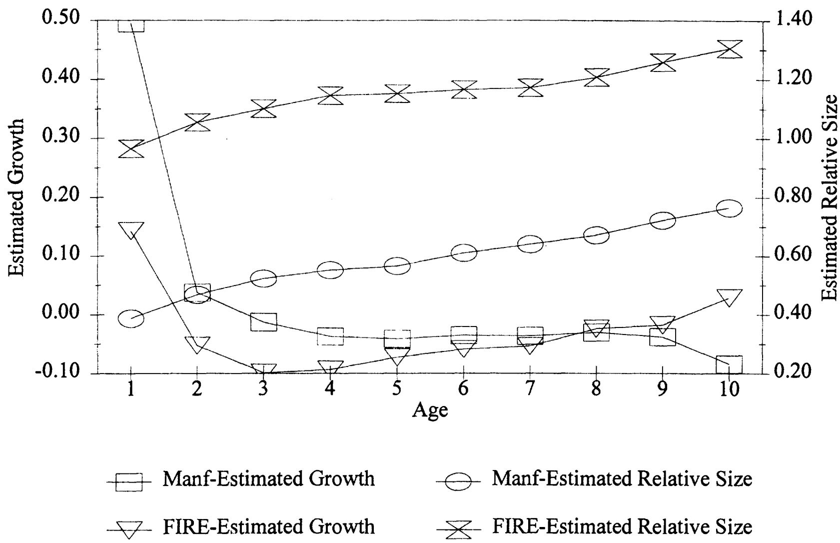

FIGURE 4.—Estimated relationship between firm growth and relative size by age (continuing firms).

To aid in evaluating cross-industry differences in the estimated relationship between firm age and growth, and firm age and size, Figure 4 graphs these estimated relationships from the Continuing Firms regressions (cols. 2) for firms in the average two-digit industry in manufacturing and FIRE. Growth is measured on the left axis, and relative size is measured on the right axis.

Similar to Figure 1, Figure 4 and Table 2 show that there is very little cross-industry difference in the pattern of firm growth after entry. While the estimated initial growth of manufacturing firms is larger than the initial growth of FIRE firms, Table 2 shows that for firms in both industries only the age 1 growth rate is significantly higher than the growth of the excluded firms. Further, the results from a pooled regression run on Continuing Firms in both industries show that only the growth of age 1 manufacturing firms is significantly larger than the growth of FIRE firms.[37] It appears that after age 1 firms in both industries experience similar growth.

Similar to Figure 2, Figure 4 and Table 3 show that, relative to FIRE firms, manufacturing firms enter the industry at a much smaller relative size and experience significantly larger changes in relative size over the sample

[37] An appendix containing the results from this regression is available from the author.

period. Figure 4 shows that the relative size of age 1 FIRE firms is much larger than the relative size of age 1 manufacturing firms and remains so through age 10. Table 3 shows that in FIRE there is no significant difference in the relative size of age 4 firms and the relative size of the excluded firms, while in manufacturing the size of 7-year-old firms is still significantly smaller than the size of the excluded firms.

By examining only the growth of firms it appears that the dynamic adjustment process after entry is similar in these industries. Firms in both manufacturing and FIRE experience large rates of growth at age 1, but then average firm growth slows quite dramatically and remains fairly constant between ages 2 and 11. In contrast, looking at the relative size of firms shows that, relative to FIRE firms, manufacturing firms enter the market at a much smaller size, experience more periods of significant change in size, and take many more periods to reach the size of the average firm in the industry.

The findings that the first two moments of the growth rate distribution fall with firm age, while the mean of the firm size distribution rises with age, are consistent with the predictions of the cost-of-adjustment, Jovanovic, and Ericson and Pakes models of firm entry.[38] In addition, these findings are similar to the Dunne, Roberts, and Samuelson; Evans; Hall; and Pakes and Ericson findings.[39]

More interesting, the observed cross-industry differences in the entry process are similar to the results of Pakes and Ericson, who examine the retail trade and manufacturing sectors. Both here and in the Pakes and Ericson study firms in the service industries (retail trade and FIRE) experience fewer periods of significant changes in size, and a smaller overall adjustment in size, after entry. It appears that, relative to manufacturing, entry occurs much faster for service firms.

There are a number of possible explanations for the cross-industry differences in firm entry. In terms of the cost-of-adjustment model, manufacturing firms may invest in larger amounts of capital and therefore spread out their investment over a longer period. From the standpoint of the Jovanovic model, the cross-industry difference in the rate of entry may indicate that manufacturing firms require more periods to form a precise estimate of θ.[40]

[38] Jovanovic, *supra* note 3; Ericson & Pakes, *supra* note 3.

[39] Dunne, Roberts, & Samuelson, Patterns of Firm Exit, *supra* note 1; Dunne, Roberts, & Samuelson, Firm Entry and Post-entry Performance, *supra* note 1; Evans, The Relationship between Firm Growth, *supra* note 1; Evans, Tests of Alternative Theories of Firm Growth, *supra* note 1; Hall, *supra* note 1; Pakes & Ericson, *supra* note 1.

[40] Jovanovic, *supra* note 3. It should be noted that this hypothesis is not supported by an analysis of firm survival in these two industries. In both industries, the conditional probability of firm exit initially rises, peaks around age 3, and declines steadily thereafter (see Troske,

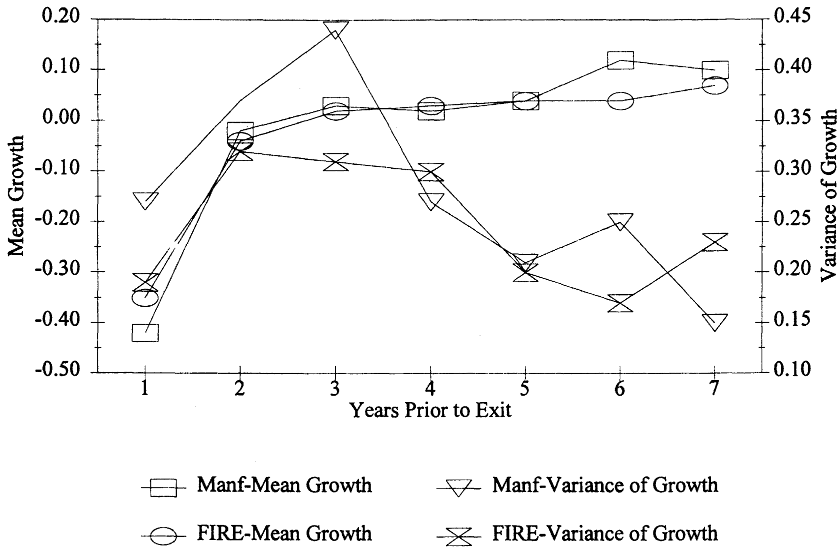

FIGURE 5.—Mean and variance of firm growth by years prior to exit

Alternatively, if learning occurs at the same speed in both industries, cross-industry differences in the entry process may indicate that FIRE firms fit the constructs of the Jovanovic model, while the behavior of manufacturing firms may be best described by an alternative model of firm growth such as the Ericson and Pakes model.[41]

B. The Dynamic Adjustment Process of Firm Exit

To begin exploring the dynamic adjustment process prior to firm exit, Figure 5 plots the first two moments of the firm growth rate distribution, G_{ijt}, by years prior to exit for manufacturing and FIRE firms. Figure 6 presents the identical plots for the relative firm size distributions, Z_{ijt}. Mean growth and mean relative firm size are measured on the left axis of their respective figures, while the variances of these distributions are measured on the right axis.

Figures 5 and 6 show that, while the first moments of the growth rate and relative firm size distributions decline prior to exit for both manufactur-

supra note 24). If manufacturing firms do require longer to form a precise estimate of θ, then their survival function should be much different from the survival function of FIRE firms.

[41] Ericson & Pakes, *supra* note 3. See Pakes & Ericson, *supra* note 1, for evidence in support of this hypothesis and a further discussion of this issue.

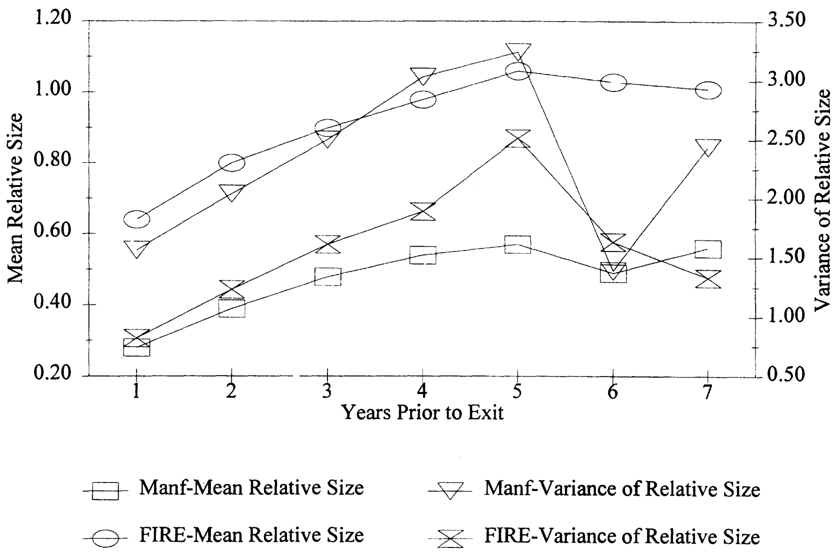

FIGURE 6.—Mean and variance of relative firm size by year prior to exit

ing and FIRE firms, there seems to be no systematic relationship between the second moments of these distributions and years prior to exit. One possible explanation for this pattern is that there is an increasing amount of heterogeneity among firms exiting the market. The distribution of exiting firms includes both firms who have been producing output for a number of years as well as firms who have just entered the market. As years prior to exit falls, this latter type of firm will make up a larger percentage of the distribution. Since these firms are recent entrants to the market, they will exhibit the large initial growth and small initial size of new entrants. This in turn will tend to increase the variance of the growth rate and relative firm size distributions.

To control for this, Figure 7 plots the means of the G_{ijt} and the Z_{ijt} distributions immediately prior to exit for manufacturing and FIRE firms that are at least 5 years old at exit. Examining the means of the growth rate distributions in this figure shows that exiting firms in both industries experience very similar rates of growth prior to exit. In both industries firms experience a fairly steady decline in the mean rate of growth starting 6 years prior to exit, with the biggest drop in growth starting 3 years prior to exit.[42]

[42] See note 32 *supra* for the possible effects of measurement error in the way I measure years prior to exit.

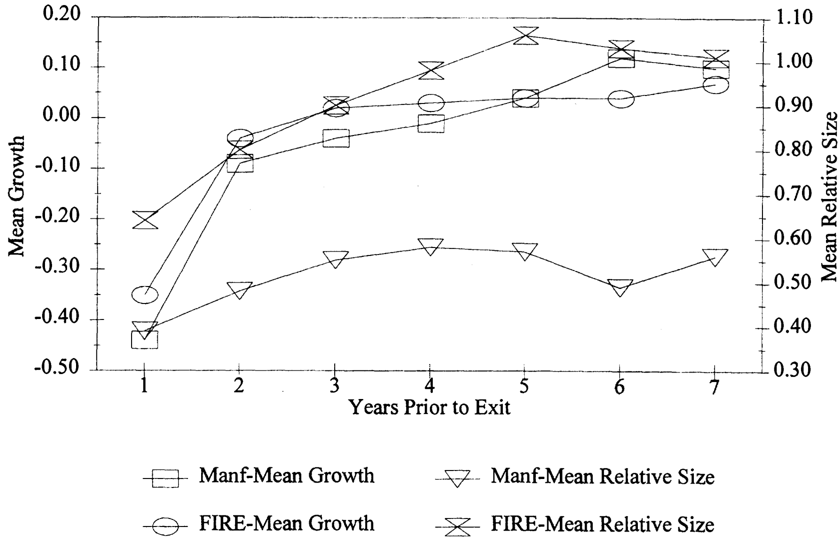

FIGURE 7.—Mean firm growth and relative size by years prior to exit (old firms)

Comparing changes in the average relative size of manufacturing and FIRE firms shows that firms in these industries experience very similar changes in relative size prior to exit. In both industries average relative size begins a monotonic decline 5 years prior to exit. In addition, firms in both industries experience an approximately equal percentage fall in relative size prior to exit. In manufacturing, the average relative firm size declines by 50 percent in the 5 years prior to exit, while in FIRE the average relative firm size falls by 45 percent in the 8 years prior to exit.

Again, to further examine the dynamic adjustment process of firm exit in these industries, I present some basic regressions of firm growth and relative size immediately prior to exit. Tables 4 and 5 present the results from estimating equations (3) and (4), respectively. The variable ExitAge measures the number of years prior to exit and enters the estimation equations as a series of dummy variables. ExitAge = 8 is the excluded group. Again, relative size is included in x_{ijt} to control for the effect of firm size on firm growth. Year and two-digit industry dummies are included to control for year and industry effects, while interactions between ExitAge and relative size and ExitAge and Year are included to control for any nonlinearities in these relationships.[43]

[43] Again 1986 is the excluded year, industry 39 is the excluded manufacturing industry, and industry 67 is the excluded FIRE industry.

TABLE 4

REGRESSION OF FIRM GROWTH, G_{ijt}, IMMEDIATELY PRIOR TO EXIT

VARIABLE	MANUFACTURING All Firms (1)	MANUFACTURING Old Firms (2)	FIRE All Firms (1)	FIRE Old Firms (2)
Intercept	.310*	.306*	.281*	.311*
	(5.322)	(3.918)	(4.670)	(4.917)
ExitAge1	−.428*	−.482*	−.395*	−.411*
	(6.373)	(7.691)	(9.031)	(9.025)
ExitAge2	−.042	−.171*	−.066	−.103*
	(.694)	(3.277)	(1.646)	(2.527)
ExitAge3	.030	−.108*	−.006	−.047
	(.483)	(2.311)	(.161)	(1.276)
ExitAge4	−.018	−.079	.001	−.017
	(.377)	(1.845)	(.030)	(.499)
ExitAge5	−.039	−.070	.001	.008
	(.885)	(1.664)	(.029)	(.205)
ExitAge6	.044	.027	−.005	−.008
	(.983)	(.632)	(.162)	(.266)
ExitAge7	−.019	−.021	−.003	.001
	(.470)	(.539)	(.079)	(.032)
Relsize	.001	.003	.022*	.017*
	(.328)	(1.801)	(5.642)	(4.742)
Urban	−.019	−.003	−.019	−.024
	(1.185)	(.266)	(1.875)	(2.214)
ExitAge*Relsize	−.00001	−.00001	−.0002*	−.0002*
	(1.588)	(2.335)	(4.818)	(3.837)
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
ExitAge*Year	Yes	Yes	Yes	Yes
Adjusted R^2	.064	.080	.092	.085
N	8,555	6,881	8,846	7,051

NOTE.—t-statistics are in parentheses.
* Significantly different from zero at the 1% level.

Column 1 in Tables 3 and 4 is referred to as the All Firm regression, and all firm-year observations for exiting firms are included. Column 2 presents the results from the Old Firm regressions, where only observations from firms older than 5 years at exit are included. Because of the problems seen in figures 4 and 5, I will focus on the results for Old Firms.

Similar to Figure 7, Table 4 shows that firm exit in manufacturing and FIRE is characterized by declining average growth for a number of periods prior to exit. The Old Firms regressions in table 4 show that manufacturing firm growth begins a monotonic decline 5 years prior to exit, while FIRE firm growth begins a monotonic decline 4 years prior to exit.

Table 4 also shows that firms exit the market in much the same manner

TABLE 5

REGRESSION OF LOG RELATIVE FIRM SIZE, $\ln(Z_{ijt})$, IMMEDIATELY PRIOR TO EXIT

	MANUFACTURING		FIRE	
VARIABLE	All Firms (1)	Old Firms (2)	All Firms (1)	Old Firms (2)
Intercept	−.829*	−.690*	−1.013*	−1.086*
	(5.206)	(3.742)	(9.850)	(9.525)
ExitAge1	−1.008*	−.812*	−.426*	−.371*
	(7.765)	(5.653)	(5.425)	(4.218)
ExitAge2	−.635*	−.492*	−.272*	−.248*
	(5.369)	(3.834)	(3.799)	(3.184)
ExitAge3	−.454*	−.345*	−.177*	−.151
	(4.050)	(2.878)	(2.596)	(2.083)
ExitAge4	−.330*	−.266*	−.108	−.095
	(3.053)	(2.363)	(1.638)	(1.385)
ExitAge5	−.170	−.181	−.080	−.074
	(1.598)	(1.673)	(1.220)	(1.102)
ExitAge6	−.146	−.145	−.059	−.065
	(1.355)	(1.333)	(.906)	(.987)
ExitAge7	−.104	−.098	−.037	−.042
	(.946)	(.889)	(.550)	(.613)
Urban	.079	.012	.095*	.081*
	(2.478)	(.341)	(5.500)	(4.047)
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
ExitAge*Year	Yes	Yes	Yes	Yes
Adjusted R^2	.118	.093	.293	.258
N	8,668	6,944	8,846	7,051

NOTE.—t-statistics are in parentheses.
* Significantly different from zero at the 1% level.

as they entered. While firms in both industries experience declining growth rates prior to exit, the largest drop in average growth occurs 1 year prior to exit. One possible explanation for this sudden decline in growth prior to exit is that firms exiting a market make one last attempt to succeed by slashing costs. This shows up as a large fall in employment. If this attempt succeeds, the firm continues operating (and does not enter this regression); if it fails, then the firm exits the market in the next period.

The coefficients on the ExitAge dummies in Table 5 show that the relative size of firms in both industries declines monotonically over the 8 years prior to exit. This pattern holds for both the All Firms regressions and the Old Firms regressions. This falling relative size is similar to the pattern seen in Figure 7 and suggests that firm exit is characterized by a slow steady fall in size prior to exit.

To again aid in comparing the dynamic pattern of firm exit across manu-

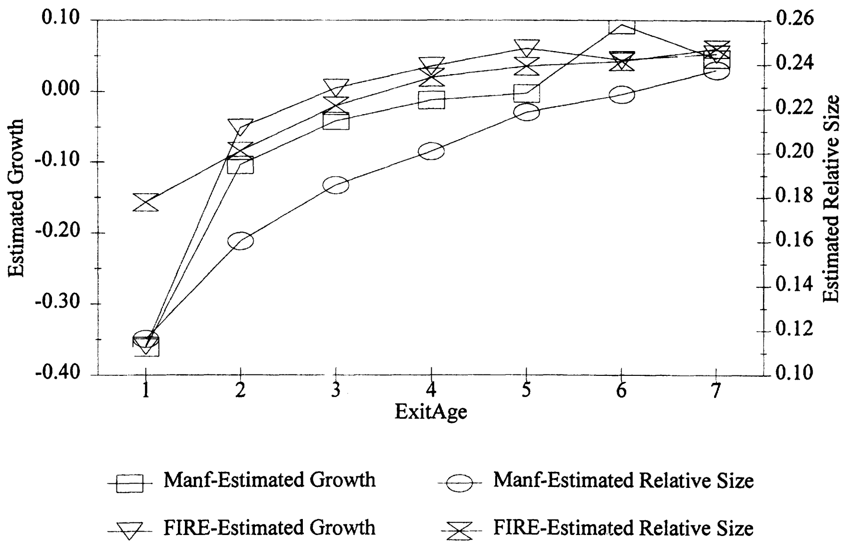

FIGURE 8.—Estimated relationship between firm growth and relative size by years prior to exit (old firms).

facturing and FIRE, Figure 8 graphs the estimated relationship between average growth and relative size and ExitAge for firms in the average two-digit industry in manufacturing and FIRE. The growth rate is measured on the left axis, and relative firm size is measured on the right axis.

Figure 8, in conjunction with Table 4, shows that firm growth prior to exit is similar for firms in these two industries. Figure 8 shows that the growth of firms in both industries begins to fall 4–5 years prior to exit. The Old Firms regressions in Table 4 show that in manufacturing only the growth of firms within 3 years of exit is significantly lower than the growth of firms 8 years prior to exit, while in FIRE only the growth of firms within 2 years of exit is significantly lower than the growth of firms 8 years prior to exit. Again, just examining the growth of firms suggests that the dynamic adjustment process of firm exit is similar in these industries.

Figure 8, in conjunction with Table 5, shows that old FIRE firms and old manufacturing firms experience very different changes in relative size prior to exiting the market. While the relative size of firms in both industries falls prior to exit, Figure 8 shows that old manufacturing firms undergo a larger fall in relative size prior to exit and exit at a much smaller relative size. Table 5 confirms this. Looking at the Old Firms regressions in Table 5 shows that the size of manufacturing firms 4 years prior to exit is significantly smaller than the size of manufacturing firms 8 years prior to exit. In

FIRE, it is not until 2 years prior to exit that the relative size of firms is significantly smaller than the relative size of firms 8 years prior to exit. Figure 8 shows that while manufacturing and FIRE firms are approximately the same relative size 7 years prior to exit, manufacturing firms are half as small as FIRE firms in the year prior to exit.

Similar to firm entry, when examining the growth rates of exiting firms, it appears that the dynamic adjustment process is similar in manufacturing and FIRE. However, examining changes in the relative size of exiting firms shows that the adjustment process in manufacturing is much more severe, and of a longer duration, than the adjustment process prior to exit in FIRE.

V. Conclusion

This article shows that for both manufacturing and FIRE, firm entry is characterized by a fall in the first two moments of the growth rate distribution and a rise in the first two moments of the relative firm size distribution for a number of periods after entry. Further, exit in both industries is characterized by falling average growth and relative size for a number of periods prior to exit. Finally, this article shows that the dynamic adjustment process of firm entry and exit is much more severe and prolonged in manufacturing than in FIRE.

A number of possible explanations for the observed cross-industry differences in the entry process were offered in the previous sections. Unfortunately, all of these explanations are based on theories that focus on the adjustment process at firm entry.[44] No theory models the dynamic adjustment process at firm exit, nor do any account for the cross-industry differences in entry and exit. The empirical results presented here suggest that existing dynamic models of firm behavior need to be modified to incorporate both the dynamics of firm exit, as well as cross-sectional differences in firm entry and exit. One possible way to modify existing models would be to combine aspects of the sunk cost investment model with the Jovanovic model.[45] For example, assume that firms are endowed with an underlying parameter θ, which acts as an idiosyncratic cost shifter and is initially unknown to the firm. Let the firm's per-period costs contain a random component so that firms must produce for a number of periods before obtaining a precise estimate of θ. Further assume that, in order to operate efficiently in a market,

[44] If one hypothesizes that there are adjustment costs to both investing and disinvesting, then the dynamic cost of adjustment model would imply that firms should decline in size prior to exiting the market.

[45] Jovanovic, *supra* note 3.

firms must invest in a fixed amount of sunk capital, but that firms can produce output with a smaller amount of this capital (just not at minimum average cost). Finally, assume that manufacturing firms must invest in a larger amount of sunk cost capital than FIRE firms. As was mentioned earlier, Pindyck shows that when firms must invest in sunk cost capital in the face of uncertainty, there is a positive value associated with the option of waiting to invest.[46] This implies that firms will invest in a smaller amount of capacity than they would in the absence of the uncertainty. The fact that manufacturing firms must invest in larger amounts of sunk cost capital than FIRE firms makes the value of waiting to invest larger, and therefore the process of entry will be longer for manufacturing firms. Intuitively, manufacturing firms will do more "testing of the waters" prior to completely plunging into a market. Empirically this will appear as manufacturing firms entering at a smaller relative size and experiencing more periods of significant increases in size, compared with FIRE firms.

Conversely, when exiting the market, manufacturing firms will have larger stocks of sunk cost capital than FIRE firms. This makes the value of waiting to exit larger for manufacturing firms and will produce a more prolonged and severe exit process.[47] While this is extremely tentative, this brief discussion shows how existing models could be combined to create a more complete model of firm dynamics.

APPENDIX

TABLE A1

Definition of Variables

Variable	Definition
Age1–Age10	Dummy variables for firm age
ExitAge1–ExitAge7	Dummy variable for years prior to exit
Relsize	Relative size of the firm
Relsize2	Relative size of the firm squared
Relsize3	Relative size of the firm cubed
Urban	Dummy variable = 1 if the firm is located in an urban area
Industry dummies	Dummy variable for the firm's two-digit industry
Year dummies	Dummy variable for the year of operation
Agesize	Interaction of Age variable and Relsize
Age*Year	Interaction of Age variable and Year dummies
ExitAge*Relsize	Interaction of ExitAge variable and Relsize
ExitAge*Year	Interaction of ExitAge variable and Year dummies

[46] Pindyck, *supra* note 3.

[47] Dixit, *supra* note 3; Dixit, *supra* note 8; Richard Baldwin & Paul Krugman, Persistent Trade Effects of Large Exchange Rate Shocks, 104 Q. J. Econ. 635–54 (1989).

TABLE A2

DESCRIPTION OF THE TWO-DIGIT INDUSTRIES IN MANUFACTURING AND FIRE

Industry	Description
A. Manufacturing:	
20	Food and kindred products
22	Textile mill products
23	Apparel and other finished products
24	Lumber and wood products
24	Furniture and fixtures
26	Paper and allied products
27	Printing, publishing, and allied industries
28	Chemicals and allied products
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastic products
31	Leather and leather products
32	Stone, clay, glass, and concrete products
33	Primary metals industries
34	Fabricated metal products
35	Industrial and commercial machinery and computer equipment
36	Electronic and other electrical equipment and components
37	Transportation equipment
38	Instruments/clocks/optical goods
39	Miscellaneous manufacturing
B. FIRE:	
60	Depository institutions
61	Nondepository credit institutions
62	Security and commodity brokers
63	Insurance carriers
64	Insurance agents, brokers, and service
65	Real estate
67	Holding and other investment offices

BIBLIOGRAPHY

Baldwin, John R., and Gorecki, Paul K. *Structural Change and the Adjustment Process: Perspectives on Firm Growth and Worker Turnover.* Ottawa: Economic Council of Canada, 1990.

Baldwin, Richard, and Krugman, Paul. ''Persistent Trade Effects of Large Exchange Rate Shocks.'' *Quarterly Journal of Economics* 104, no. 4 (1989): 635–54.

Davis, Steve J., and Haltiwanger, John. ''Gross Job Creation, Gross Job Destruction and Employment Reallocation.'' *Quarterly Journal of Economics* 107 (1992): 810–63.

Dixit, Avinash. ''Entry and Exit Decisions under Uncertainty.'' *Journal of Political Economy* 97 (1989): 620–38.

Dixit, Avinash. ''Investment and Hysteresis.'' *Journal of Economic Perspectives* 6 (1992): 107–32.

Dunne, Timothy; Roberts, Mark; and Samuelson, Larry. ''Patterns of Firm Entry and Exit in U.S. Manufacturing Industries.'' *RAND Journal of Economics* 19 (1988): 495–515.

Dunne, Timothy; Roberts, Mark; and Samuelson, Larry. ''Firm Entry and Post-entry Performance in the U.S. Chemical Industries.'' *Journal of Law and Economics* 32 (1989): S233–S271.

Dunne, Timothy; Roberts, Mark; and Samuelson, Larry. ''The Growth and Failure of U.S. Manufacturing Plants.'' *Quarterly Journal of Economics* 104 (1989): 671–98.

Dunne, Timothy; Roberts, Mark; and Samuelson, Larry. ''Plant Turnover and Gross Employment Flows in the U.S. Manufacturing Sector.'' *Journal of Labor Economics* 7 (1989): 48–71.

Ericson, Richard, and Pakes, Ariel. ''Markov-Perfect Industry Dynamics: A Framework for Empirical Work.'' *Review of Economic Studies* 62 (1995): 53–82.

Evans, David S. ''The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries.'' *Journal of Industrial Economics* 35 (1987): 567–82.

Evans, David S. ''Tests of Alternative Theories of Firm Growth.'' *Journal of Political Economy* 95 (1987): 657–74.

Hall, Bronwyn. ''The Relationship between Firm Size and Firm Growth in the U.S. Manufacturing Sector.'' *Journal of Industrial Economics* 35 (1987): 583–606.

Jovanovic, Boyan. ''Selection and the Evolution of Industry.'' *Econometrica* 50 (1982): 649–70.

Pakes, Ariel, and Ericson, Richard. ''Empirical Implications of Alternative Models of Firm Dynamics.'' Working Paper no. 2893. Cambridge, Mass.: National Bureau of Economic Research, 1989.

Pindyck, Robert. ''Irreversibility, Uncertainty, and Investment.'' *Journal of Economic Literature* 29 (1991): 1110–48.

Pindyck, Robert. ''Irreversible Investment, Capacity Choice, and the Value of the Firm.'' *American Economic Review* 78 (1988): 969–85.

Troske, Kenneth. *The Growth and Survival of Firms and Changes in the Firm Size Distribution in Industries.* Unpublished Ph.D. dissertation, University of Chicago, Department of Economics, 1992.

U.S. Department of Commerce. Bureau of the Census. *1987 Enterprise Statistics: Company Summary.* Washington, D.C.: U.S. Government Printing Office, 1989.

U.S. Department of Commerce. Bureau of Economic Analysis. *Fixed Reproducible Tangible Wealth in the United States, 1925–1989.* Washington, D.C.: U.S. Government Printing Office, 1989.

White, Halbert. ''A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity.'' *Econometrica* 48 (1980): 817–38.