THE TIME-SERIES PATTERN OF FIRM GROWTH IN TWO INDUSTRIES

By

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Abstract

Using a unique firm-level longitudinal data set that covers both the manufacturing and finance, insurance and real estate (FIRE) industries, this paper examines the time-series pattern of firm growth both immediately after entry and immediately prior to exit, and compares these patterns across the two industries. While previous research has examined the post-entry time-series behavior of firms, this research has focused exclusively on manufacturing firms. Examining the behavior of nonmanufacturing firms is important for two reasons. First, since the relative importance of the manufacturing industry has been declining recently, the behavior of manufacturing firms may be much different than the behavior of firms in an expanding industry, such as FIRE. Thus, comparing the growth of firms in a nonmanufacturing industry, with the growth of manufacturing firms provides more general knowledge about firm behavior. Second, since any good theory of firm dynamics should explain cross-industry differences in firm behavior, cross-industry differences in behavior must be documented before models of this type can be developed. The main finding of this paper are: (1) relative to FIRE firms, manufacturing firms experience more periods of above average growth immediately after entry; (2) relative to FIRE firms, manufacturing firms experience more periods of below average growth immediately prior to exit; and (3) relative to the growth of manufacturing firms, the growth of the typical FIRE firm is much more responsive to transitory shocks.

Keywords:cross-industry, FIRE, firm growth, manufacturing

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A. *Introduction*

How firms enter and exit the market can have a profound impact on the dynamic behavior of the economy. Entering and expanding firms demand resources that must flow from either firms in the same industry, or from firms in other sectors of the economy. Exiting and contracting firms free resources that must flow to their next highest valued use, again be it in the same industry, or other sectors of the economy. Further, cross-industry differences in the pattern of firm entry and exit can produce aggregate changes in the dynamic behavior of the economy as one sector becomes more important relative to other sectors. Unfortunately, the manner in which firms enter and exit the market remains a mystery.

The paper performs two tasks in this context. First, I document empirical regularities in the time-series pattern of firm growth both immediately after entry and immediately prior to exit. Second, I compare the pattern of firm growth across two industries in order to highlight the firm-level differences that lead to the different observed pattern of industry wide growth.

This interindustry comparison is facilitated by my use of a unique firm-level longitudinal data set that covers both the manufacturing and finance, insurance, and real estate (FIRE) industries. While not without limitations, these data are unique in that they provide information about firms operating in more than one industry. It is this latter feature that allows research on both the time-series and cross-industry growth of firms.

Several recent studies have examined the time-series behavior of firms immediately after entry (Davis and Haltiwanger 1992; Dunne, Roberts and Samuelson 1989; Evans 1987a, 1987b; and Hall 1987). However, data limitations have forced these studies to focus exclusively on the growth of manufacturing firms. This may paint a misleading picture of firm behavior. Although manufacturing has traditionally been the most important industry in the economy, its relative importance has been declining in recent years. Thus, studying firms in an alternative industry, such as FIRE which has grown in relative importance in recent years, provides more general knowledge about the time-series behavior of firms in both a growing and declining industry.

Cross-industry studies of firm behavior are also important for developing general theories of firm dynamics. Any good theory of firm dynamics should be able to explain cross-industry differences in firm behavior. There are many reasons to think that the behavior of manufacturing firms differs significantly from the behavior of firms in other industries. Manufacturing firms tend to be larger, are more capital intensive, and manufacturing as a whole is more procylical than most other industries. Thus, before a complete dynamic model of firm behavior can be developed, cross-industry differences in firm behavior must be documented.

One study that does examine the behavior of nonmanufacturing firms is the study by Pakes and Ericson (1989). This work examines the behavior of both manufacturing and retail trade firms. The difference between the present work and the Pakes and Ericson work is that Pakes and Ericson are primarily interested in testing the nonparametric differences between their model of industry and growth and the Jovanovic (1982) model of industry growth. In contrast, this paper is primarily concerned with documenting cross-industry empirical regularities and differences in the time-series pattern of firm growth.

The Jovanovic (1982) model of industry growth provides the theoretical basis for the empirical investigation. While this model clearly does not incorporate all of the relevant factors affecting firm growth, nor does it allow for cross-industry differences in firm behavior, it is simple and does model firm growth as a function of firm age. Therefore, reduced form equations from this model are used as a starting point for the empirical investigation which follows. However, this investigation should not be viewed as a structural test of the Jovanovic model.

This paper reports four main findings. First, in both manufacturing and

FIRE, post-entry firm growth declines steadily, and subsequently levels off, as firms age. Second, in both industries, firm growth declines steadily prior to exit. Third, relative to FIRE firms, manufacturing firms experience more periods of above-average growth after entry, and more periods of below-average growth prior to exit. Fourth, while measures of long-run and short-run industry growth have approximately equal impact on the growth of FIRE firms, the growth of manufacturing firms is only affected by short-run changes in industry size. Long-run industry growth has no measurable impact on the growth of any particular manufacturing firm.

A possible explanation for these facts is that firms in manufacturing and FIRE differ in the amount of sunk cost capital needed in production. If producing output in manufacturing requires firms to undertake a large investment industry specific capital, and firms in both industries face initial uncertainty about their ability to produce output, manufacturing firms should take longer to invest in the necessary capital. This implies that manufacturing firms will take longer to enter a market completely and will experience more periods of above-average post-entry growth. Further, because its capital is worthless outside the industry, a manufacturing firm should be willing to experience more periods of below average growth prior to exiting the market. Finally, if it is necessary to undertake large sunk cost investment prior to production, firms will be unwilling to enter the market in response to short-run changes in demand. Therefore, short-run changes will be met exclusively by existing firms.

The rest of the paper proceeds as follows. Section B briefly lays out the Jovanonvic model of firm behavior, and derives reduced form equations from this model. Section C describes the data and develops measures of firm and industry size and growth. Section D presents the results from the empirical investigation of firm growth. Section E presents conclusions.

B. *The Jovanovic Model of Firm Growth*

The theoretical basis for the empirical investigation in Section D is the Jovanovic model that relates firm growth to firm age. The basic hypothesis is that firms differ in their ability to produce output and, initially, are uncertain whether they are good or bad producers of output in the industry. The firm's problem is further complicated by independent, random, cost shocks which occur every period. This assures that a firm cannot discover its underlying ability in a single period, but instead must produce output for a number of periods before ascertaining whether it is a efficient or inefficient producer of output in the industry.

Briefly, let a random firm's costs be given by $c(q_t).(N+,_t)$, where q_t is the firm's total output in period t, and . is a cost shifter which is a function of N, a measure of the firm's underlying ability to produce output, and $,_t$, a random normal i.i.d disturbance. To preclude extremely large or negative costs, assume $\lim_{z6-4}.(z)="_1>0$ and $\lim_{z64}.(z)="_2<4$. Prior to entry the firm draws N randomly from a known normal distribution with a mean $\bar{N}$ and a variance F_N. Let the firm's period t expectation of its ability be given by N^*_t. Prior to entry $N^*_t=\bar{N}$. Each period, after producing and observing the resulting costs, the firm updates N^*_t using Bayes' rule.

Firms operate in a perfectly competitive industry with a known time path of prices $\{p_t\}$. Each period all firms, and potential entrants to the industry, make all entry, exit, and production decisions based on N^*_t. Jovanovic shows that per period output is a declining function of N^*_t: $q_t=q(N^*_t)$, $q_N(N^*_t)<0$.

Let n be the number of periods the firm has produced output (firm age), and q^*_{t+1} be the expected output in period t+1 based on period t expectations. As firms age and produce output, they gain an ever more accurate estimation of N. Thus, the expected change in N^*_t between period t and t+1 falls, as does the expected change between q_t and q_{t+1}. Since expected firm growth, g, is simply a linear transformation of q_t and q^*_{t+1}, the expected growth of a firm falls with age. Thus, the Jovanovic model implies that expected firm growth is a declining function of firm age: $g=g(N_t^*(n))$, $g_n<0$.

C. *The Data and Empirical Measures*

1. The Data

The data used in this study were collected by the state of Wisconsin's Department of Industry, Labor, and Human Relations, for use in the operation of the state's unemployment insurance (UI) program. Every firm operating in the state is required, by law, to file a report if it has ever employed a worker for more than twenty weeks or if it has ever paid more than $1500.00 in wages in a quarter. Once a firm enters the UI system it must file a report every quarter of its existence regardless of its employment. Records consist of the firm's UI account number, the location of the firm, the date the firm began filing reports under its current UI account number, the date it was removed from the UI system, its SIC classification, any transfer of legal responsibility for the UI tax, and the firm's monthly employment as of the twelfth of each month. The data cover the period from the first quarter 1977 to the first quarter 1987.

The main advantage of these data is that they contain both manufacturing and nonmanufacturing firms. This allows a comparison of firm behavior across industries. Not only does a more complete understanding of firm behavior arise from such a comparison, but differences in behavior, and the reasons for these differences, draw our attention to what factors are most important in affecting firm growth.[1]

The main disadvantage of these data is that they do not contain a complete description of the firm. Total employment is the only measure of

[1] For a more complete discussion of how the final data set used in this analysis is constructed, problems with the data, and additional advantages and disadvantages of the data, the reader is referred to appendix B in Troske (1992).

firm size available in these data. The growth of an input can be a misleading measure of total firm growth if a technological change occurs which enables a firm to produce greater output with the same input. However, the work of Evans (1987a, 1987b), Hall (1987), and Dunne, Roberts, and Samuelson (1988, 1989a, 1989b) indicate that this may not be a serious problem. These authors, who all study firm growth, produce robust results using total value of shipments, total value of physical assets, and total employment, as measures of firms size. Further, Evans (1987a) shows that all three of these measures of firm size are highly correlated. Thus, only having total employment as a measure of firm size should not seriously hamper this study.

2. Measurement Issues

In order to analyze firm behavior, appropriate measures of both firm and industry size and growth need to be constructed. These measures should meet a number of criteria. First, measures of size and growth should take advantage of the high-frequency of reporting of these data, but should also reflect desired long-run changes in firm size and not short-run disequilibrium conditions or seasonal fluctuations. Second, the measures should incorporate entering and exiting firms into the analysis. Third, the measures should allow a comparison of firm behavior both across industries and time. Finally, the measures should capture the behavior of the "typical" firm in a class of firms, using standard statistical techniques.

With these criteria in mind let Emp_{ijt} be the average employment in firm i in industry j in year t, and Emp_{jt} be the average yearly employment in industry i in year t. Given these measures of employment let

$$z_{ijt}=(Emp_{ijt-1}+Emp_{ijt})*0.5 \tag{1}$$

be the measure of firm size in industry j in period t, with industry size measured as

$z_{jt}=(Emp_{jt-1}+Emp_{jt})*0.5.$

Using z_{ijt} as a measure of firm size, although appropriate for intra-industry comparisons of firm size, can be misleading when making inter-industry comparisons. Especially when comparing firms across industries with vastly different size distributions. To facilitate the comparison of firm size across industries, I also construct the following relative measure of firm size:

$$s_{ijt}=\frac{z_{ijt}}{\overline{z}_{jt}} \qquad (2)$$

where $\overline{z}_{jt}$ is the period t average firm size in a firm's two digit industry j, $\overline{z}_{jt} = \Sigma_{i=1}^{n} z_{ijt}/n$.

Let $\Delta Emp_{ijt}=Emp_{ijt}-Emp_{ijt-1}$ be the change in firm i's employment between t-1 and t. The growth of firm i in industry j in period t is measured as:

$$g_{ijt}=\frac{\Delta Emp_{ijt}}{z_{ijt}}, \qquad (3)$$

with industry growth measured in an analogous fashion.[2,3] This growth measure

[2] This growth rate measure is a specific example of the class of growth rate measures known as mean value functions. For a complete discussion of these growth measure see Lorenzen (1990) and the reference therein.

[3] Traditional studies of firm growth (See Dunne, Roberts and Samuelson 1989b; Evans 1987a, 1987b; and Hall 1987) measure growth as:

$$G_{ijt}=\frac{\Delta Emp_{ijt}}{Emp_{ijt-1}}.$$

There are a number of advantages with using g_{ijt}, as opposed to G_{ijt}, to measure the relative change in firm size. First, g_{ijt} is not limited to years in which the firm reports employment in consecutive years and therefore is defined for both firm birth and firm death. G_{ijt} is undefined for firm birth (G_{ijt} = -1 when a firm dies). Thus g_{ijt} meets the first measurement criteria. Second, G_{ijt} is not symmetric, i.e., $|(Emp_{ijt}-Emp_{ijt-1})/Emp_{it-1}| \neq |(Emp_{ijt-1}-Emp_{ijt})/Emp_{ijt}|$ so the choice of a base period will drastically alter measured growth. Finally, computing firm growth rates using G_{ijt} produces a growth rate distribution that is highly skewed, with the moments of this distribution being extremely sensitive to small changes in the tails of the distribution. Thus G_{ijt} does not accurately reflect the growth of the "typical" firm in an industry. For these reasons the growth rate g_{ijt} is preferred to the growth rate G_{ijt}. For a lies in the closed interval [-2,2] with deaths (births) corresponding to the left (right) endpoint.

These measures of firm and industry size and take advantage of the high frequency of observation in the data by incorporating both entering and exiting firms into the analysis.

D. *Empirical Analysis*

1. Exploratory Analysis

a. The Pattern of Firm Growth Immediately After Entry

To begin examining the relationship between firm age and firm size and growth, table 1 presents the mean of the relative firm size distribution by age, while table 2 does the same for the firm growth rate distribution. Firm size is measured using the relative size measure s_{ijt} (equation 1) in table 1.[4] Table 2 presents both unweighted (the Unwgt column) and weighted (the Wgt column) mean growth. Weighted growth is obtained by multiplying firm growth by firm employment.

In tables 1 and 2 the "All Firms" columns indicate that all firm-year observations in a given age cell are used to construct the given distributions. The "Continuing Firms" columns indicate only nonfailing, firm-year observations in a given age cell are used to construct the distributions (i.e., only firm-year observations where g_{ijt}…-2.00), while the "Successful Firms"
columns indicate only firm-year observations for firms that survive for more than five years are used to construct the distributions. Finally, the "Unsuccessful Firms" columns indicate that only nonfailing firm-year observations for firms that exit the market within five years are used to

comparison of these two growth measures and an empirical investigation that uses the g_{ijt} measure, see the work by Davis and Haltiwanger (1992).

[4] Recall that s_{ijt} is a relative measure of firm size, therefore both industry and year effects are controlled for in table 1.

construct the distributions.[5]

Table 1 shows that, with the exception of Unsuccessful Firms, the distribution of relative firm size shifts out and expands as firms age. This is true for all types of firms in both industries. In manufacturing, age zero Continuing Firms are, on average, 15% as large as the average firm in its two-digit industry. The average ten year old Continuing Firm is 31% as large as the average firm in its two-digit industry. In FIRE, entering Continuing Firms are on average 44% as large as the average firm in their two-digit industry and are 66% as large by age ten. Although not reported, the standard deviation of the s_{ijt} distribution also increases for Continuing Firms in both industries between birth and age ten. Age seems to have an impact on the relative size distribution in both industries.[6] Firm size both rises and becomes more varied as firms age.[7]

Two possible ways exist for the relative average size of Continuing Firms to grow with age: (1) through the exit of small firms from the industry

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[5] In tables 1-3 the asterisk (*) indicates a significant difference in the mean of two distributions. The t-statistic for a difference between the mean of two independent normal distributions with different variances is given by:

$$t=\frac{(\bar{x}_1-\bar{x}_2)}{\sqrt{(s_1^2/n_1)+(s_2^2/n_2)}}$$

where $\bar{x}_1$ and $\bar{x}_2$ are the sample means, s_1^2 and s_2^2 are the sample variances, and n_1 and n_2 are the sample sizes. The degrees of freedom for this statistic is given by:

$$df=\frac{(s_1^2/n_1+s_2^2/n_2)^2}{\frac{(s_1/n_1)^2}{(n_1-1)}+\frac{(s_2/n_2)^2}{(n_2-1)}}.$$

[6] The way in which I have constructed all of these tables may hide possible year and cohort effects. For example, it is possible for a cohort of firms entering in 1977 to behave differently than a cohort of firms entering in 1983 (especially given the major recession that occurs in the middle of these data). Obviously in cross tabulations such as these it is difficult to control for these effects. However to attempt to determine whether the results found in tables 1,2 and 3 are affected by age and year effects I have estimated all of the tables for groups of firms that entered or exited the industry within a given five year span. In no instance were any of the results qualitatively different from the results that are reported in the text.

[7] It is possible that the observed rise in the relative size of young firms in the first ten years of life is due to a fall in the absolute size of older firms in the industry and not due to the growth of young firms. Examining the distribution of absolute firm size by age shows that this is not the case. See Troske (1992).

or (2) through the growth of Continuing Firms remaining in the industry. The change in the average relative size of Successful Firms, those firms who exist in the market for at least five years, shows that a large part of this growth in the average relative size of Continuing Firms is accounted for by the growth in the average relative size of nonexiting firms. This is especially true in manufacturing. In manufacturing, while Continuing Firms experience a 47% increase in average relative size by age 4, Successful Firms experience a 90% increase in average relative size by age four, growing from 0.11 to 0.21. In FIRE, while Continuing Firms experience a 52% rise in mean relative size by age four, Successful Firms mean relative size grows from 0.51 to 0.69 between ages one and four, an increase of 35%.

Table 2 shows that both weighted and unweighted growth falls with firm age.[8] In manufacturing, the average unweighted growth of Continuing Firms falls from 0.22 to -0.02 between ages one and five while the average weighted growth falls from 0.49 to 0.11 over the same ages. In FIRE, firm growth also falls with age. Weighted growth for FIRE firms drops from 0.11 to 0.00 between ages one and five and weighted growth falls from 0.43 to 0.10 over these same ages.[9]

The finding that growth falls quite quickly with age is similar to the findings of Davis and Haltiwanger (1992), Dunne, Roberts, and Samuelson (1989b) and Baldwin and Gorecki (1990). Davis and Haltiwanger, using plant-level manufacturing data, and measuring firm growth using the g_{ijt} growth

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[8] The weighted growth of firms will capture the growth of *employment* among these firms while the unweighted growth will capture the growth of *firms*.

[9] It is possible that the way I measure firm size may produce the observed fall in post-entry firm growth. For example, if a firm enters the market in December of a given year with 100 employees and remains at 100 employees forever, I would measure firm size as 8.33 employees at age zero and 100 at age one and would measure age 1 growth as 1.69 when in fact no growth has occurred in the firm. To check for the possibility of this affecting my results I have repeated all of the analysis reported measuring firm size by averaging only over months with positive employment. Thus, in the example above, the entering firm would have 100 employees at both age 0 and 1 and would have an age 1 growth of 0. The reported results are the same regardless of the size measure used. These two measures are identical because, for administrative reasons, records never have partial year observations. Entering firms always enter in January and exiting firms always exit in December.

measure, find positive average growth for the first three years of a plant's existence, but then find negative growth for all subsequent years. Dunne, Roberts and Samuleson and Baldwin and Gorecki, both using data on manufacturing plants, find that the share of total industry employment contained in an entering cohort of firms rises for five years after entry, but declines steadily thereafter. Dunne, Roberts, and Samuelson show that this fall in the share of employment occurs when the growth of employment from successful firms stops compensating for the loss of employment from failing firms. Table 2 shows that for manufacturing, the positive growth of expanding firms slows faster than the negative growth of failing firms, so average growth for an entire cohort becomes negative by age five.

Even though the firm size and growth distributions vary with age in both industries, the range over which age plays a role differs across industries. In table 1 the rise in the average relative size of manufacturing firms continues at a significant rate throughout the first ten years of existence, while in FIRE, the increase in the average size of firms is concentrated in the first four years of existence. In manufacturing, the average relative sizes of All Firms and Continuing Firms three years old and older are significantly larger than the average relative size of one year old firms. Further, for All Firms and Continuing Firms the average relative sizes of zero and one year old firms are significantly smaller than the average relative size of four year old firms, while the average relative sizes of nine and ten year old firms are significantly larger than the average size of four year old firms. In FIRE, the average relative sizes of All Firms and Continuing Firms two years old and older are significantly larger than the average relative size of one year old firms, but only the average sizes of zero and one year old firms are significantly different than the average size of four year old firms. No firms of any age are ever significantly larger than four year old firms in FIRE.

In table 2, in manufacturing, the unweighted mean growth rate for

Continuing Firms of every age is significantly smaller than the mean growth rate for one year old firms.[10] In addition, the unweighted mean growth of eight, nine, and ten year old Continuing Firms is significantly smaller than the mean growth of four year old firms. In FIRE, at every age, Continuing Firms experience significantly lower average growth than one year old firms, but only one, two and five year old firms exhibit significantly different average growth than four year old firms. Whatever drives the growth of firms early in life continues for over ten years in manufacturing, but ceases after four to five years in FIRE.

The finding that firm age affects the firm size distribution for a longer period in manufacturing than in FIRE is similar to the findings in Pakes and Ericson (1989). Using data on firms in the manufacturing and retail trade sectors, the authors compare changes in the firm size distribution that occurs as firms age. They find that the firm size distribution for a cohort of firms entering the retail trade sector is similar to the firm size distribution for the entire industry by age eight, but the firm size distribution of age eight manufacturing firms is still much smaller than the firm size distribution of all firms in the industry. The maturation process seems to take much longer in manufacturing than in either FIRE or retail trade.

One possible explanation for why age plays a more prominent role in manufacturing than in FIRE may be that FIRE firms are able to enter the industry at a much larger relative size than manufacturing firms. Table 1 shows that the relative size of FIRE firms is much larger throughout the first ten years of life than the relative size manufacturing firms. The average relative size of an entering FIRE firm is 0.44, and is 0.66 by age ten. The average relative size of an entering manufacturing firm is only 0.15, and

[10] I focus on the unweighted growth of firms here because this reflects the growth of firms and not of employment.

grows to be only 0.33 by age ten.

One possible reason that FIRE firms can enter at relatively larger sizes is that large, sunk, capital investments are a more important component in production for manufacturing firms than for FIRE firms. If this is the case, and firms face initial uncertainty about how successful they will be in an industry, then entering manufacturing firms will invest completely in the industry only when they become fairly confident that they will be successful. Thus, manufacturing firms more often "test the waters" before completely plunging into the market. They will spread out their investment in capital equipment over a longer period of time, and the successful firms will experience more periods of above average post-entry growth. This is only one possible explanation for the observed cross-industry differences, but one that may be helpful when studying the results from the rest of the analysis.

b. The Pattern of Firm Growth Immediately Prior to Exit

Tables 1 and 2 examine the time series pattern of firm size and growth after entry for manufacturing and FIRE firms and shows that age affects firm size and growth for longer in manufacturing than in FIRE. Another interesting exercise is to compare the time series patterns of firm size and growth prior to exit for manufacturing and for FIRE. How firms grow prior to exit, and whether there are any differences in the pattern of growth, provides further evidence on cross-industry differences in firm structure that may account for the different patterns of growth.

Table 3 presents evidence on the manner in which firms exit the market by presenting the mean relative firm size and firm growth rate distributions, by Years Before Exit. Firm size is again measured using the relative size measure s_{ijt} (equation 1).[11] In these tables the columns labeled "All Firms", indicates the all firm-year observations are used, "Old Firms" indicates that

[11] Again, using s_{ijt} to measure size will effectively control for year and two-digit industry effects.

only firm-year observations for firms older than five years are used, and "Young Firms" indicates that only firm-year observations for firms five years old and younger are used.[12]

Table 3 shows that firms in both manufacturing and FIRE experience a substantial decline in average size prior to exiting the market. In manufacturing, All Firms experience an 83% fall in average relative firm size in the nine years prior to exit, while in FIRE All Firms experience a 75% fall over the same period. In addition, although not reported, as firms exit the industry the distribution of firm size shrinks. This is the opposite pattern found for entering firms in table 1. In table 1, as firms age they become less homogeneous, while in table 3, as firms exit an industry they become more homogeneous.[13]

The results in table 3 again suggest that age plays a much more important role in manufacturing than in FIRE. In manufacturing, in the four years prior to exit, and in the year of exit, there are significant differences between the relative size of Old Firms and Young Firms. For FIRE, significant differences exist only between the average relative size of Old Firms and Young Firms in the year of, and the two years prior to, exit.

Table 3 suggests that the exit process is much more long-term and gradual for manufacturing firms than it is for FIRE firms. In table 3, nine years prior to exit the average manufacturing and FIRE firms are about the same size relative to the average firm in their respective industries, 107% as large for manufacturing firms and 118% as large for FIRE firms. However, two years prior to exit, manufacturing firms are on average only 40% as large as the average firm in their industry, while FIRE firms are on average 60% as large. In manufacturing the average growth for All Firms declines

[12] Please see footnote 6 for a discussion of why year and cohort effects may be covered up in these tables

[13] The same caveat applies to these tables as applied earlier; these results could be produced by the manner in which I construct annual employment in the firm. See footnote 9 for a discussion of this issue, and what tests I perform to show why this is not a problem.

monotonically from eight years prior to exit, becoming negative five years prior to exit. The average growth of All Firms in manufacturing eight and nine years prior to exit is significantly larger than the average growth of All Firms four years prior to exit, while the average growth of All Firms one and two years prior to exit is significantly smaller than the average growth of All Firms four years prior to exit. In contrast, in FIRE the average growth of All Firms begins a monotonic decline only three to four years prior to exit. Only the average growth of All Firms in FIRE one and two years prior to exit is significantly different from the average growth of All Firms four years prior to exit. In FIRE, firms four years prior to exit average the same growth as firms seven, eight and nine years prior to exit. All of these facts taken together suggest lagged growth is much worse for predicting firm exit in FIRE than in manufacturing.

The results from table 3 can be viewed in light of the findings in tables 1 and 2 which showed that the maturation process takes longer for manufacturing firms than for FIRE firms. Again, one possible reason for the differences in size is that manufacturing firms have much larger capital stocks than FIRE firms. Further, if these capital stocks have relatively little value outside their current use, then it will be the case that manufacturing firms will be willing to endure more periods of negative growth (hoping that conditions will improve) prior to exiting the market. Thus, these larger capital stocks would produce a much longer, drawn out exit process for manufacturing firms than for FIRE firms. Again, this is one possible explanation for the different behavior exhibited by manufacturing and by FIRE firms, but one that should be kept in mind when considering the results discussed in the next section.

2. Regression Analysis

a. Regression of Firm Growth Immediately After Entry

Given the results in section D.1 a closer look at the relationship between firm age, size and growth seems warranted. The Jovanovic (1982) model presented in section B implies that firm growth is given by:

$$g_{it}=\beta' a_{it}+u_i \tag{4}$$

where a_{it} is a vector of firm characteristics (in particular firm age). Table 4 provides a list of the variables used to estimate equation (4). Tables 5 and 6 present the results from the ordinary least squares estimation of equation (4) for manufacturing and for FIRE, respectively.

The model in section B implies that age should be included in a_{it}. However, the model does not state exactly how age should enter equation (4). I use a cubic function of age in these regressions because this provides the best fit with the data.

The dummy variables Rsize1-Rsize5 are used to control for firm size in these regressions. Size is measured relative to the size of the average firm in a firm's two-digit industry in a given year. This is done to control for cross-industry differences in the firm size distribution. The size variables are constructed by dividing firms into five equal year cells based on their relative size for each two-digit industry. Rsize1=1 are the smallest firms. In all of the regressions Rsize5 (the largest firms) is the excluded group.

These dummy variables will reveal only how average growth varies across size classes. They will not reveal how growth varies with size within a size class. In order to capture this effect, the variables Prsiz1-Prsiz5 are included in these regressions. Prsiz1-Prsiz5 are interactions between the size dummy variables, Rsize1-Rsize5, and the continuous measure of relative firm size, s_{ijt} (Prsiz1=Rsize1*s_{ijt}). Thus, the coefficients on Prsiz1-Prsiz4 show how firm size and growth are related within size classes.[14]

One problem with the Jovanovic model is that it fails to incorporate

[14] This form of a spline is adopted because it provides the best fit with the data.

intra- or inter-industry differences in production technology, and the possible impacts these differences have on the growth of firms. Even if firms faced the same form of uncertainty about their ability to produce in a market, cross-industry differences in the amount of capital necessary to produce output could also be an important determinant of the relationship between firm age and size and firm growth. Unfortunately, it is impossible to directly control for firm-level differences in capital since the data contain no measure of a firm's capital stock. In order to indirectly control for the effect of cross-industry differences in the amount of capital needed for production, separate regressions are run for manufacturing and for FIRE, and two-digit industry dummy variables are included in each regression. While this should help control for some of the cross-industry differences in capital requirements, it is obviously not a perfect control. Thus, when examining these results, the reader should keep in mind the possible effects of any cross-industry differences in production.

To control for economy wide effects that may influence firm growth, year dummies are included in all of the regressions with 1986 being the excluded year.

Age-year interaction dummies also are included in all of the regressions to control for cohort effects. It may be the case that the relationship between age and growth varies with the year of firm entry. For example, the growth of a four year old firm in 1979 may differ from the growth of a four year old firm in 1984 (see footnote 6 for a further discussion of the problems with age-year interactions) because a firm that entered the market in 1974 may have invested in much different capital than a firm that entered in 1980. Age-Size interactions also are included to control for nonlinear interactions of age and size. Again, the behavior of a large age four firm may be much different from the behavior of a large age ten firm. The urban variable is included to control for the effect of being located in a city.

The variables Tran and Postran are included in these regressions to control for unobserved differences in the ability of managers. Work by Holmes and Schmitz (1990) suggests that whether or not a firm is ever transferred should provide information about management quality and therefore about firm growth. In the Holmes-Schmitz framework there are two types of firm owners: owners that are good at starting businesses, and owners that are good managers of operating firms. Both types of owners can start businesses, but firms started by good entrepreneurs should display much larger post-entry growth, and have a much higher probability of being sold. Since that is where her comparative advantage lies, it pays a good entrepreneur to sell the firm and start another firm. Thus, if a firm is ever sold, it should be a signal that the firm was started by an owner who is a good entrepreneur, and therefore should have higher than average growth prior to the sale.

With this model in mind the variables Tran and Postran are included to control for these effects. Tran=1 in every period if the firm is ever transferred, and Postran=1 in every period after transfer. A positive coefficient on the Tran variable indicates that transferred firms grow faster than nontransferred firms, while the sign on Postran indicates whether this faster growth continues after the transfer.

Finally, in order to concentrate on the growth of firms, and not on the entry of firms, only the post-entry growth of firms is analyzed (i.e., only observations where $g_{ijt} < 2.00$).

Table 5 presents the results from the firm growth regression for manufacturing firms, while table 6 presents the results for FIRE firms. In both tables, the dependent variable is firm growth, measured using the g_{ijt} growth rate measure. The t-statistic for each coefficient is given in parenthesis.[15] "All Firms", "Continuing Firms", "Successful Firms", and "Unsuccessful Firms" have the same meaning as in tables 1 and 2.

Tables 5 and 6 support the findings from section D.1 that firm growth is

[15] Due to the presence of heteroskedasticity, all standard errors are White standard errors which are adjusted to correct for general forms of heteroskedasticity (White 1980). The t-statistics reflect this adjustment.

negatively correlated with firm age. The coefficient on Age is negative for all four firm types in both industries. However, the fact that age enters the regression equations as a cubic makes it difficult to see the exact relationship between age and growth from the coefficients on age in tables 5 and 6. To show clearly how growth varies with age and size, figure 1 plots the estimated relationship between age and growth from the All Firms regression for both manufacturing and for FIRE. This graph shows that in both manufacturing and FIRE, firm growth declines initially with age and then levels off (or rises slightly) by age 5. This is the relationship between age and growth that is implied by the Jovanovic (1982) model and is identical to the relationship found by previous researchers. (See Davis and Haltiwanger 1992; Dunne, Roberts, and Samuelson 1989b; and Evans 1987a, 1987b).

Returning to tables 5 and 6, the coefficients on Rsize1-Rsize4 show that firm growth rises with firm size almost universally. For the All Firms and the Continuing Firms regressions in manufacturing and for all four regressions in FIRE the coefficients on Rsize1 and Rsize2 are significantly less than zero. Only in the Unsuccessful Firms regression in manufacturing is there a different pattern. For these firms the regressions show that the growth of Rsize1 and Rsize2 firms is lower than the growth of Rsize5 firms, while the growth of Rsize3 and Rsize4 firms is larger than the growth of Rsize5 firms.

The positive coefficients on the Tran variables in the All Firms regressions in tables 5 and 6 indicate that transferred firms do grow faster than nontransferred firms. However, the negative coefficients on the Postran variables indicate that this faster growth only occurs prior to transfer. To test whether the faster growth completely disappears after a firm is transferred, a Wald test on the hypothesis that *Tran*=*Postran* is run and is not rejected at the .01 significance level for either manufacturing or FIRE. Apparently, the above average pre-transfer growth is completely eliminated in the post-transfer periods. In terms of the Holmes-Schmitz (1990) hypothesis, it seems that the original founder of a successful firm does not transfer her skills and knowledge to the new owner.

A comparison of the age-growth relationship between manufacturing and FIRE in figure 1 supports the finding from section D.1 that the relationship between age and growth is much stronger in manufacturing than in FIRE. To test whether the relationship between age and growth differs between manufacturing and FIRE, a Chow test on the hypothesis that the coefficients on Age, Age^2, and Age^3 are the same in the separate regressions is run and is rejected at the .01 level of significance. Figure 1 shows that in manufacturing, the fall in growth after entry is much greater than the fall in growth after entry for FIRE firms. Further, this figure shows that the growth of FIRE firms seems to flatten out at a much younger age.

This cross-industry difference in the age-growth relationship may be explained by differences in production technologies in these two industries. If producing output in manufacturing requires a much larger sunk cost investment in capital equipment than it does in FIRE, and firms in both industries face initial uncertainty about success in the industry, manufacturing firms would want to spread their investment over a number of periods in an attempt to reduce the amount of uncertainty. If this is true, then age should affect growth for a longer period in manufacturing than in FIRE.

If entering the manufacturing sector does require a larger sunk cost investment than entering the FIRE sector, then a larger percentage of short run changes in demand in manufacturing should be met by existing firms. In fact, it should be the case that in manufacturing a majority of any temporary change in demand should be met by existing firms while permanent changes in demand should be met by the entry and exit of firms. In FIRE no difference should exist in the way short-run and long-run changes in demand are met. In order to explore this hypothesis, the regressions in tables 5 and 6 for Continuing Firms are reestimated, replacing the industry dummies with measures of permanent and temporary changes in demand in these industries.

The variable Lgrow is used to capture long-run changes in demand and is measured as the change in employment in a two-digit industry between the start and end of the data: $Lgrow=(Emp_{i,86}-Emp_{i,78})/Emp_{i,78}$. The variable Sgrow is used to capture short-run changes in demand, and is measured as the difference between the long-run growth of a two-digit industry and the year-to-year growth of the industry: $Sgrow=[(Emp_{i,t+1}-Emp_{i,t})/Emp_{i,t}]-Lgrow$. The coefficient on Lgrow should capture the effect of long-run changes in industry demand on firm growth, while the coefficient on Sgrow should capture the effect of short-run changes in industry demand on firm growth. If it is the case that in manufacturing, existing firms expand to meet short-run changes in demand, while a larger percentage of long-run changes are met by the entry and exit of firms, then the coefficient on Sgrow should be both positive and larger than the coefficient on Lgrow. In FIRE there should be no difference in the coefficients on Sgrow and Lgrow.

Table 7 presents the results for the firm growth regression where the industry dummies used in the previous regressions have been replaced by the variables Lgrow and Sgrow. To isolate the effect of Lgrow and Sgrow on the growth of firms, only nonfailing firm-year observations are used in the regressions.[16]

The coefficients Lgrow and Sgrow show quite clearly that there are dramatic differences across the two industries in how firms respond to long-run and short-run changes in demand. In manufacturing, the coefficient on Lgrow is extremely small (-0.0152) and is not significantly different from zero. The coefficient on Sgrow is much larger (0.2444) and is significantly different from zero. In FIRE, both Lgrow and Sgrow are approximately the same size (Lgrow=0.1070 while Sgrow=0.1398), and both coefficients are significantly different from zero. A Wald test on the hypothesis that Lgrow = Sgrow in these regressions is run and is rejected at the .01 significance

[16] Again the standard errors were estimated using White's (1990) correction for general forms of heteroskedasticity and these corrections are reflected in the t-statistics, which are given in parentheses in the table.

level for manufacturing, but cannot be rejected for FIRE. Further, a Chow test on the hypothesis that the coefficients on Lgrow and Sgrow are the same in the two regressions is performed and is rejected at the .01 significance level. In fact, the results from the pooled regression run to conduct the Chow test (not reported) reveal that the coefficient on Lgrow is significantly smaller, and the coefficient on Sgrow significantly larger, in manufacturing than in FIRE.

The coefficient estimates on Lgrow and Sgrow show that in manufacturing, the growth of firms is positively correlated with temporary changes in demand, but is unaffected by permanent changes in demand. In FIRE, the coefficients on Lgrow and Sgrow show that firm growth is positively and approximately equally correlated with both transitory and permanent changes in demand. These results suggest that in manufacturing, short-run changes in demand are met by existing firms in an industry, but in the long-run, entry and exit occur to meet the changes in demand. In FIRE, both long-run and short-run changes are met by a combination of the expansion and contraction of existing firms, as well as the entry and exit of firms. This difference in behavior fits with the proposed hypothesis that cross-industry differences in firm growth are the result of different levels of sunk cost capital investment necessary for production.

b. Regression of Firm Growth Immediately Prior to Exit

As was mentioned in section D.1, differences across industries in the time series pattern of firm growth prior to exit provide further evidence on the importance of capital in production. To explore further the time series pattern of firm growth prior to exit, table 8 presents the results from an OLS regression of firm growth, on a number of firm- and industry-level characteristics including size and the number of years prior to exit (Eage). To concentrate on the pattern of exit only observations for firms that actually exit the industry are included and observations for the year of entry (where g_{ijt} = 2.00) and for the year of exit (where Eage = 0 and g_{ijt} = -2.00) are excluded.[17]

In table 8, the same size dummies used in the regressions in tables 6 and 7 are included as controls. Again size is measured as relative size. In addition, year and industry dummies are included in the regression along with interaction terms between Eage and year, and Eage and size to control for any nonlinearities in these relationships.[18] "All Firms, "Old Firms", and "Young Firms" have the same meaning as in table 3.

Table 8 shows that for all three types of firms in both manufacturing and FIRE, years prior to exit is positively correlated with growth, and this correlation is significantly different from zero. (The coefficient on Eage in the All Firms regression in manufacturing is 0.7179 and in FIRE is 0.563.) However, because Eage enters as a cubic function in all of these regressions, the exact shape of the relationship between Eage and growth is difficult to discern. To overcome this, figure 2 graphs the estimated relationship between Eage and growth from the All Firms regression for manufacturing and for FIRE.

Figure 2 shows that growth falls quite dramatically as firms exit the market. In both industries, the highest growth occurs ten years prior to exit, then falls fairly steadily till seven years prior to exit, displays a slight rise until four years prior to exit, and then again falls steadily thereafter.[19] In both industries, it seems that firm growth falls fairly steadily as firms exit the industry.

In order to test for cross-industry differences in the relationship between Eage and growth, a pooled regression was run, and a Chow test

[17] For firms that do not exit the market, years prior to exit is undefined, so observations for these firms cannot be included.

[18] Again, because of the presence of heteroskedasticity in the data, all of the standard errors have been estimated using White's (1980) correction for general forms of heteroskedasticity. All t-statistics given in parenthesis in this table reflect the White correction.

[19] The rising growth between seven and five years prior to exit may simply be an artifact of the cubic form of Eage that is used in these regressions.

performed on the hypothesis that the coefficient estimates on Eage, $Eage^2$, and $Eage^3$ are the same in the two industries. The hypothesis is rejected at the .01 significance level and the coefficients from the pooled regression (not reported) indicate that Eage has a much stronger effect in manufacturing than in FIRE. Firm growth shows a much stronger positive relationship with the number of years prior to exit for manufacturing firms than it does for FIRE firms. This finding is similar to the finding in the previous section and adds further support to the hypothesis that it is cross-industry differences in capital requirement that are behind the observed cross-industry differences in firm behavior.

E. *Conclusion*

Using a unique firm-level longitudinal data set containing firms operating in both the manufacturing and the FIRE industries, this study adds to the growing empirical literature on firm behavior by exploring: (1) the time-series pattern of firm size and growth both immediately after entry and immediately prior to exit and (2) cross-industry differences in the time-series pattern of firm growth.

The main findings from this investigation are, first, that firm age is negatively correlated with firm growth, but this correlation holds for more periods in manufacturing than in FIRE. The entry process lasts much longer in manufacturing than in FIRE. Second, the growth of manufacturing firms is positively correlated with measures of short-run industry growth, but is uncorrelated with long-run measures of industry growth, while the growth of FIRE firms is positively, and approximately equally, correlated with both long-run and short-run measures of industry growth. Third, the firm size and firm growth distributions decline as firms exit the market but again, there are more periods of declining growth in manufacturing than in FIRE. The exit process is also much longer in manufacturing than in FIRE.

These findings are important because of what they say about the structure of firms and industries. Cross-industry differences in the time series pattern of growth suggest that the entry and exit of firms is much more important in FIRE than in manufacturing. One explanation for the observed differences is that production in manufacturing requires much larger investment in industry specific capital than does production in FIRE. This, combined with the assumption the firms in both industries face initial uncertainty concerning how successful they will be, would account for the fact that manufacturing firms experience more periods of above average post-entry growth, more periods of below average pre-exit growth, and why entry to manufacturing is much less responsive to transitory shocks than is entry to FIRE.

These findings are also important because of what they say about the changing structure of the economy. If it is the case that the entry and exit of firms is more important in FIRE than in manufacturing, then as the manufacturing sector declines in importance, the birth and death of firms will become more prevalent. This, in turn, suggests that (1) there will be greater turnover of resources, and (2) the capacity of capital and labor to flow quickly between firms and sectors will become more important.

TABLE 1

THE MEAN OF THE RELATIVE SIZE DISTRIBUTION BY AGE

	All Firms		Continuing Firms		Successful Firms		Unsuccessful Firms	
Age	Manf.	FIRE	Manf	FIRE	Manf	FIRE	Manf	FIRE
0‡	0.15**	0.44**	0.15**	0.44*,**	0.11**	0.51**	0.10	0.38
1‡	0.16**	0.48**	0.17**	0.50**	0.12**	0.53**	0.11	0.44
2‡	0.19	0.55*,**	0.21	0.60*	0.16*,**	0.62	0.14**	0.49
3†,‡	0.20*	0.59*	0.22*	0.64*	0.18*	0.66*	0.11	0.48
4†,‡	0.21*	0.63*	0.22*	0.67*	0.21*	0.69*	0.09	0.40
5	0.22*	0.65*	0.23*	0.70*	.	.	.	.
6	0.22*	0.66*	0.23*	0.68*	.	.	.	.
7	0.23*	0.61*	0.24*	0.63*	.	.	.	.
8	0.25*	0.64*	0.26*	0.67*	.	.	.	.
9	0.27*,**	0.65*	0.29*,**	0.68*	.	.	.	.
10	0.30*,**	0.64*	0.31*,**	0.66*	.	.	.	.

Note: "All Firms" refers to all firms in the industry, "Continuing Firms" refers to non-failing observations for firms, "Successful Firms" refers to firms that survive for more than five years, and "Unsuccessful Firms" refers to firms that fail within five years of entry.

Note: "*" indicates that the mean value is significantly different at the 1% level from the mean value of one year old firms, "**" indicates that the mean value is significantly different than the mean value for four year old firms, "‡" indicates that the mean size of Successful Firms in FIRE is significantly different from the mean size of Unsuccessful Firms in FIRE, while "†" indicate that the mean size of Successful Firms in manufacturing is significantly different from the mean size of Unsuccessful Firms in manufacturing.

TABLE 2

THE MEAN OF THE GROWTH RATE DISTRIBUTION BY AGE

Age	All Firms Unwgt	All Firms Wgt	Continuing Firms Unwgt	Continuing Firms Wgt	Successful Firms Unwgt	Successful Firms Wgt	Unsuccessful Firms Unwgt	Unsuccessful Firms Wgt
				Manufacturing				
$1^{\dagger}$	0.06^{**}	0.49^{**}	0.22^{**}	0.49^{**}	0.33^{**}	0.55^{**}	-0.09^{**}	0.47^{**}
$2^{\dagger}$	-0.23^{*}	0.20^{*}	0.05^{*}	0.20^{*}	$0.14^{*,**}$	0.25^{*}	$-0.28^{*,**}$	0.16^{*}
$3^{\dagger,\ddagger}$	-0.20^{*}	0.16^{*}	0.03^{*}	0.16^{*}	0.07^{*}	0.22^{*}	$-0.30^{*,**}$	0.08^{*}
$4^{\dagger}$	-0.18^{*}	0.16^{*}	0.01^{*}	0.16^{*}	0.05^{*}	0.18^{*}	-0.47^{*}	0.09^{*}
5	-0.19^{*}	0.11^{*}	-0.02^{*}	0.11^{*}	.	.	.	.
6	-0.13^{*}	0.09^{*}	-0.01^{*}	0.09^{*}	.	.	.	.
7	$-0.11^{*,**}$	0.08^{*}	-0.00^{*}	0.08^{*}	.	.	.	.
8	-0.15^{*}	$0.07^{*,**}$	$-0.04^{*,**}$	0.07^{*}	.	.	.	.
9	-0.14^{*}	$0.07^{*,**}$	$-0.03^{*,**}$	0.07^{*}	.	.	.	.
10	-0.16^{*}	$0.05^{*,**}$	$-0.05^{*,**}$	$0.05^{*,**}$	.	.	.	.
				FIRE				
$1^{\dagger}$	-0.07	0.43^{**}	0.11^{**}	0.43^{**}	0.18^{**}	0.44^{**}	-0.06^{**}	0.43^{**}
$2^{\dagger}$	-0.27^{*}	$0.20^{*,**}$	$-0.01^{*,**}$	$0.20^{*,**}$	$0.04^{*,**}$	$0.23^{*,**}$	$-0.21^{*,**}$	$0.18^{*,**}$
$3^{\dagger}$	-0.28^{*}	$0.17^{*,**}$	-0.03^{*}	$0.17^{*,**}$	0.00^{*}	0.18^{*}	$-0.26^{*,**}$	0.13^{*}
$4^{\dagger}$	-0.23^{*}	0.12^{*}	-0.03^{*}	0.12^{*}	0.00^{*}	0.13^{*}	-0.39^{*}	0.04^{*}
5	-0.20^{*}	$0.10^{*,**}$	$0.00^{*,**}$	0.10^{*}	.	.	.	.
6	$-0.14^{*,**}$	$0.08^{*,**}$	-0.02^{*}	0.08^{*}	.	.	.	.
7	$-0.13^{*,**}$	$0.11^{*,**}$	-0.03^{*}	0.11^{*}	.	.	.	.
8	$-0.15^{*,**}$	$0.06^{*,**}$	-0.03^{*}	$0.06^{*,**}$	.	.	.	.
9	$-0.18^{*,**}$	$0.04^{*,**}$	-0.03^{*}	$0.04^{*,**}$	.	.	.	.
10	$-0.13^{*,**}$	$0.03^{*,**}$	-0.04^{*}	$0.03^{*,**}$	.	.	.	.

Note: "All Firms" refers to all firms in the industry, "Continuing Firms" refers to non-failing observations for firms, "Successful Firms" refers to firms that survive for more than five years, and "Unsuccessful Firms" refers to firms that fail within five years of entry.

Note: "*" indicates that the mean value is significantly different, at the 1% level, from the mean value of one year old firms, "**" indicates that the mean value is significantly different, at the 1% level, from the mean value for four year old firms. "†" indicates that the unweighted mean size of Successful Firms is significantly different, at the 1% level, from the unweighted mean size of Unsuccessful Firms and "‡" indicates that the weighted mean size of Successful Firms is significantly different, at the 1% level, from the weighted mean size of Unsuccessful Firms.

TABLE 3

THE MEAN OF THE RELATIVE SIZE AND GROWTH RATE DISTRIBUTIONS BY YEARS BEFORE EXIT

	All Firms		Old Firms		Young Firms	
Years Before Exit	Manf	FIRE	Manf	FIRE	Manf	FIRE
			Mean of Relative Size Distribution			
0†,‡	0.18*,**	0.30*,**	0.28**	0.34*,**	0.06*,**	0.27*,**
1†,‡	0.29**	0.43**	0.43	0.49**	0.10	0.35**
2†,‡	0.40	0.60*,**	0.52	0.64*,**	0.14*	0.50*,**
3†	0.48*	0.71*	0.57	0.74*	0.13	0.58*
4†	0.56*	0.81*	0.61	0.83*	0.10	0.68*
5	0.63*	0.85*	.	.	.	.
6	0.61	0.87*	.	.	.	.
7	0.68	0.84*	.	.	.	.
8	0.72	0.90*	.	.	.	.
9	1.07	1.18	.	.	.	.
			Mean of the Growth Rate Distribution			
1	-0.63**	-0.48**	-0.65**	-0.48**	-0.60**	-0.48**
2†,‡	-0.10*,**	-0.09*,**	-0.14*,**	-0.12*,**	-0.01*,**	-0.04*,**
3†,‡	-0.03*	0.01*	-0.05*	-0.02*	0.06*	0.09*
4†,‡	-0.02*	0.01*	-0.04*	-0.01*	0.18*	0.18*
5	-0.02*	-0.01*	.	.	.	.
6	0.03*,**	0.00*	.	.	.	.
7	0.03*	0.02*	.	.	.	.
8	0.10*,**	0.04*	.	.	.	.
9	0.09*,**	0.01*				

Note: In the columns labeled "All Firms" all firm-year observations in the given cell are used to construct the distribution, in the columns labeled "Continuing Firms" only non-failing firm-year observations in the given cell are used to construct the distribution, in the columns labeled "Old Firms" only non-failing firm-year observations for firms six years old and older in the given cell are used to construct the distribution, and in the columns labeled "Young Firms" only non-failing observations firm-year observations for firms five years old and younger in the given cell are used to construct the distribution.

Note: "*" indicates that the mean value for the group is significantly different, at the 1% level, from the mean value for firms one year prior to exit, "**" indicates that the mean value for the group is significantly different, at the 1% level, from the mean value for firms four years prior to exit. "†" indicates that the mean value for Old Firms in manufacturing is significantly different, at the 1% level, from the mean value for Young Firms in manufacturing and "‡" indicates that the mean value for Old Firms in FIRE is significantly different, at the 1% level, from the mean value for Young Firms in FIRE.

TABLE 4

DEFINITION OF VARIABLES

Variable	Definition
Age	Age of the firm in years
Age^2	Age squared
Age^3	Age cubed
Eage	Years Prior to Exit
$Eage^2$	Years Prior to Exit squared
$Eage^3$	Years Prior to Exit cubed
Rsize1-Rsize5	Dummy variable for the relative size of the firm
Prsiz1-Prsiz5	Interaction of continuous measure of relative firm size and Rsize1-Rsize5
Tran	Dummy variable, 1 if the firms is ever transferred
Postran	Dummy variable, 1 in every period after the firm is transferred
Urban	Dummy variable, 1 if the firm is located in a urban area
Lgrow	Yearly average of long run industry growth
Sgrow	Yearly deviation from long run industry growth
Industry Dummies	Dummy variable for the firm's two digit industry
Year dummies	Dummy variable for the year of operation
Age-Size Interactions	Interaction of Age variable and Rsize1-Rsize5
Age-Year Interactions	Interaction of Age variable and Year dummies
Eage-Size Interactions	Interaction of Eage variable and Rsize1-Rsize5
Eage-Year Interactions	Interaction of Eage variable and Year dummies

TABLE 5

REGRESSION OF FIRM GROWTH: MANUFACTURING

Regressor	All Firms	Continuing Firms	Successful Firms	Unsuccessful Firms
Intercept	0.2480 (5.3929)	0.3405 (9.4146)	2.4284 (4.3030)	0.6387 (3.7580)
Age	-0.2201* (-15.3297)	-0.1573* (-13.9306)	-0.9273* (-3.8109)	-0.7476* (-3.3102)
Age^2	0.0307* (13.1845)	0.0201* (11.2752)	0.0995 (1.2005)	0.2873* (2.3075)
Age^3	-0.0013* (-11.6015)	-0.0008* (-9.7010)	-0.0074 (-0.6806)	-0.0361* (-2.5457)
Rsize1	-0.9885* (-26.8594)	-0.3530* (-11.9779)	-0.3539* (-3.4937)	-0.5955* (-6.6311)
Rsize2	-0.3435* (-9.0793)	-0.1101* (-3.7864)	-0.0990 (-1.002)	-0.0193 (-0.2106)
Rsize3	-0.2269* (-5.7320)	-0.0571 (-1.9038)	-0.0453 (-0.4434)	0.0523 (0.5146)
Rsize4	-0.1026* (-2.4754)	-0.0073 (-0.2193)	-0.0229 (-0.1987)	0.2728* (2.4755)
Tran	0.2418* (5.1808)	0.0813* (6.0579)	0.0426 (1.6731)	0.0886* (2.3554)
Postran	-0.1821* (-5.7470)	-0.0440 (-1.9591)	-0.0081 (-0.0773)	-0.0561 (-0.9669)
Urban	-0.0031 (-0.3280)	0.0034 (0.4796)	0.0087 (0.5743)	-0.0001 (-0.0035)
Prsiz1	13.0574* (25.1263)	3.2655* (7.8066)	3.9128* (4.5796)	6.3569* (6.2481)
Prsiz2	1.8759* (8.0057)	0.4638* (2.5563)	0.7847 (2.0805)	0.1106 (0.2200)
Prsiz3	0.8507* (7.4372)	0.2099* (2.4197)	0.2310 (1.1288)	0.2798 (0.9522)
Prsiz4	0.2410* (4.8672)	0.0441 (1.0594)	0.1645 (1.5782)	-0.1568 (-1.1759)
Prsiz5	0.0070* (3.1942)	0.0046 (2.1852)	0.0295 (1.1099)	-0.0041 (0.8475)
Industry Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Age-Size Interactions	Yes	Yes	Yes	Yes
Age-Year Interactions	Yes	Yes	Yes	Yes
$\bar{R}^2$	0.1375	0.0639	0.0744	0.1537
Sample Size	25873	23799	5381	5016

Note: A "*" indicates that the hypothesis that the estimated coefficient is not different from zero is rejected at the .01 significance level using a two tailed test.

TABLE 6

REGRESSION OF FIRM GROWTH: FIRE

Regressor	All Firms	Continuing Firms	Successful Firms	Unsuccessful Firms
Intercept	0.3426	0.3022	0.4507	0.5973
	(8.3977)	(9.6816)	(2.4900)	(4.0091)
Age	-0.1434*	-0.1073*	-0.3949*	-0.4763*
	(-11.2397)	(-11.6325)	(-2.4418)	(-2.3776)
Age^2	0.0211*	0.0141*	0.1052	0.1427
	(10.1169)	(9.2936)	(1.5016)	(1.5718)
Age^3	-0.0009*	-0.0006*	-0.0088	-0.0178
	(-9.3515)	(-8.5246)	(-0.9517)	(-1.4301)
Rsize1	-1.0948*	-0.3469*	-0.5636*	-0.7452*
	(-32.0339)	(-12.1716)	(-5.9081)	(-8.2396)
Rsize2	-0.5957*	-0.1964*	-0.3569*	-0.4570*
	(-16.1605)	(-7.2985)	(-4.3150)	(-4.8791)
Rsize3	-0.4796*	-0.1589*	-0.2034*	-0.2819*
	(-13.5946)	(-5.7787)	(-2.4570)	(-2.9046)
Rsize4	-0.2887*	-0.0862*	-0.0778	-0.1810
	(-8.4592)	(-3.1619)	(-0.9161)	(-1.6513)
Tran	0.1534*	0.0432*	0.0133	0.0391
	(13.4784)	(4.0630)	(0.6070)	(0.7875)
Postran	-0.0961*	0.0574	0.0823	0.0588
	(-2.5842)	(2.0331)	(0.7779)	(0.8038)
Urban	-0.0295*	-0.0066	-0.0179	0.0216
	(-4.4429)	(-1.3849)	(-1.4314)	(1.3304)
Prsiz1	2.2333*	0.0867	0.8386*	0.7611*
	(19.0791)	(1.3031)	(3.8416)	(2.9928)
Prsiz2	1.3160*	0.2453*	0.2308	0.3387
	(13.3189)	(3.4788)	(1.1691)	(1.3195)
Prsiz3	0.6925*	0.1488*	0.1758	0.1640
	(13.4898)	(3.9377)	(1.6506)	(1.0992)
Prsiz4	0.2810*	0.0372	0.0324	0.1482
	(9.4770)	(1.6380)	(0.5118)	(1.4272)
Prsiz5	0.0024	0.0013	0.0127*	0.0104
	(1.3188)	(0.7612)	(2.5428)	(1.0143)
Industry Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Age-Size Interactions	Yes	Yes	Yes	Yes
Age-Year Interactions	Yes	Yes	Yes	Yes
$\bar{R}^2$	0.1209	0.0383	0.0556	0.1281
Sample Size	40316	37188	6708	5183

Note: "*" indicates that the hypothesis that the estimated coefficient is not different from zero is rejected at the .01 significance level using a two tailed test.

TABLE 7

GROWTH RATE REGRESSION USING LONG- AND SHORT-RUN MEASURES OF GROWTH

Parameters	Manufacturing	FIRE
Intercept	0.3661 (11.8779)	0.2738 (9.8036)
Age	-0.1415* (-12.4104)	-0.0996* (-10.4988)
Age^2	0.0178* (9.8434)	0.0127* (8.2149)
Age^3	-0.0007* (-8.4088)	-0.0005* (-7.0711)
Rsize1	-0.3096* (-10.2072)	-0.3009* (-10.3208)
Rsize2	-0.0576 (-1.9757)	-0.1255* (-5.2111)
Rsize3	-0.0212 (-0.6989)	-0.1036* (-3.9157)
Rsize4	0.0093 (0.2791)	-0.045 (-1.6655)
Tran	0.0768* (5.4306)	0.0398* (3.4907)
Postran	-0.0455 (-1.6726)	0.0579 (2.0471)
Urban	0.0171* (2.4183)	-0.0078 (-1.7441)
Lgrow	-0.0152 (-0.8497)	0.107* (9.7677)
Sgrow	0.2444* (4.4473)	0.1398* (3.0220)
Prsiz1	2.6912* (6.2045)	-0.0242 (-0.3119)
Prsiz2	0.0023 (0.0133)	0.0374 (0.7171)
Prsiz3	0.054 (0.6592)	0.0412 (1.3438)
Prsiz4	0.0137 (0.3352)	-0.0011 (-0.0531)
Prsiz5	0.0051 (0.0024)	0.0011 (0.5846)
Year Dummies	Yes	Yes
Age-Size Interactions	Yes	Yes
Age-Year Interactions	Yes	Yes
$\bar{R}^2$	0.0559	0.0326
Sample Size	21709	33276

TABLE 8

REGRESSION OF FIRM GROWTH ON YEARS PRIOR TO EXIT (EAGE)

	Manufacturing			Fire		
Parameters	All Firms	Old Firms	Young Firms	All Firms	Old Firms	Young Firms
Intercept	-0.89255	-0.87035	-0.92244	-0.68015	-0.66966	-0.72501
	(-15.8778)	(-6.6518)	(-13.7053)	(-12.7404)	(-8.7330)	(-9.4229)
Eage	0.7179*	0.62862*	0.75511*	0.56302*	0.56777*	0.56138*
	(20.5534)	(8.6841)	(18.4779)	(17.5431)	(13.3087)	(11.7056)
$Eage^2$	-0.1435*	-0.11812*	-0.15316*	-0.10944*	-0.1081*	-0.11071*
	(-18.5258)	(-7.4706)	(-16.1445)	(-15.4772)	(-11.3947)	(-9.7099)
$Eage^3$	0.00865*	0.00703*	0.0093*	0.00653*	0.00645*	0.00661*
	(15.7143)	(6.3387)	(14.6135)	(12.709)	(10.2111)	(8.0875)
Rsize1	-0.04822	0.07896	-0.08056	-0.03844	0.01075	-0.05964
	(-1.4345)	(0.7746)	(-2.1084)	(-0.9795)	(0.1733)	(-1.1415)
Rsize2	-0.04385	0.02075	-0.04418	0.13271*	0.16774*	0.11989*
	(-1.2820)	(0.2009)	(-1.1602)	(3.8471)	(3.0473)	(2.6100)
Rsize3	-0.00073	0.1294	-0.02025	0.02185	0.06503	-0.00634
	(-0.0205)	(1.2355)	(-0.5078)	(0.5903)	(1.1286)	(-0.1258)
Rsize4	-0.06566	-0.01346	-0.06505	-0.04971	-0.00226	-0.07952
	(-1.7805)	(-0.1233)	(-1.6063)	(-1.2878)	(-0.0379)	(-1.5275)
Urban	-0.0002	0.00927	-0.00316	-0.0206	-0.02029	-0.02081
	(-0.0163)	(0.3883)	(-0.2235)	(-2.06)	(-1.6041)	(-1.3722)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Eage-Size Interactions	Yes	Yes	Yes	Yes	Yes	Yes
Eage-Year Interactions	Yes	Yes	Yes	Yes	Yes	Yes
$\bar{R}^2$	0.1528	0.1247	0.1620	0.1088	0.1094	0.1106
Sample Size	9723	2643	7080	11251	5696	5555

Note: "*" indicates that the hypothesis that the estimated coefficient is not different from zero is rejected at the .01 significance level using a two tailed test.

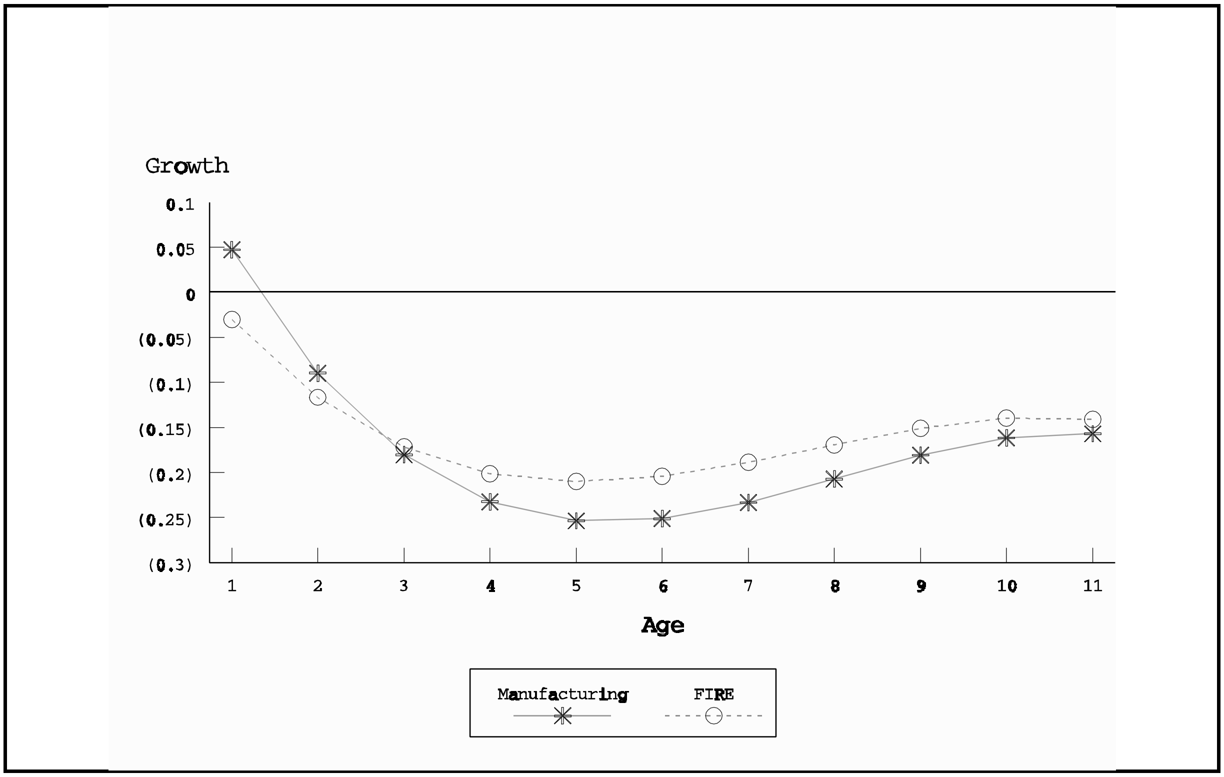

Figure 1 The Age-Growth Relationship for Manufacturing and FIRE

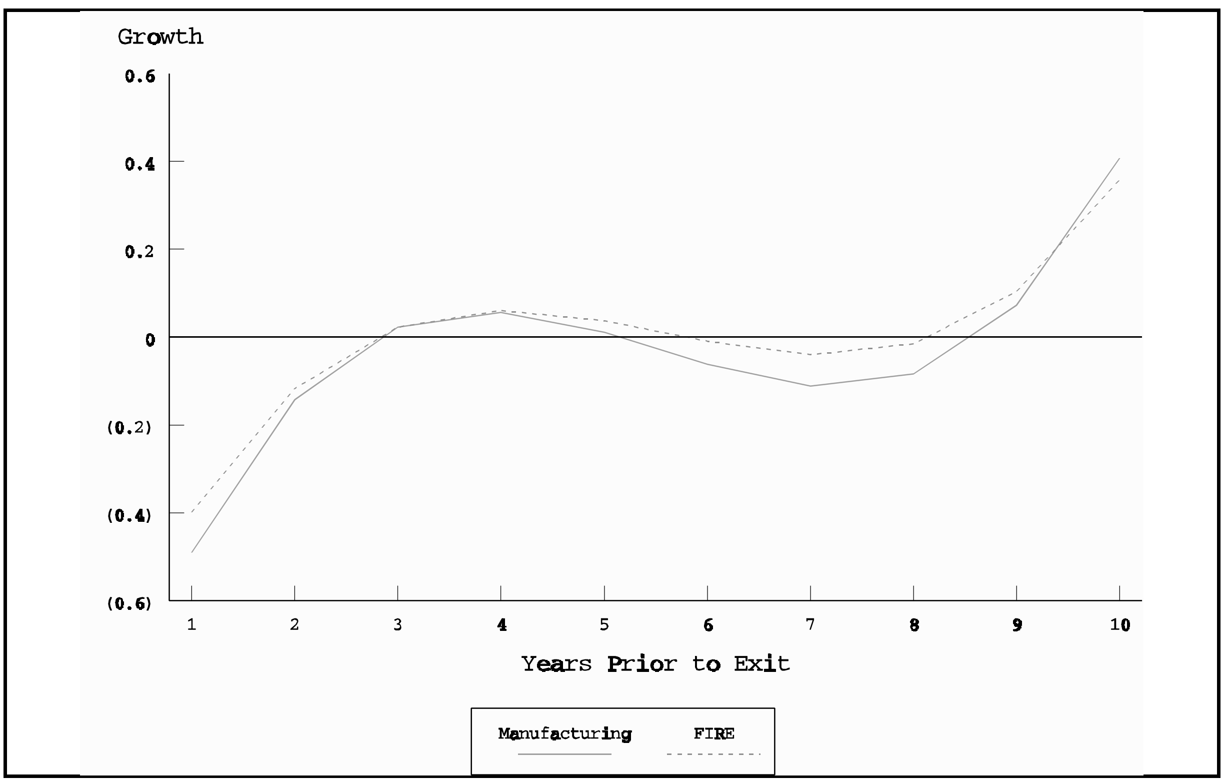

Figure 2 The Years-Prior-to-Exit Growth Relationship for Manufacturing and FIRE

REFERENCES

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

Davis, Steve J., and John Haltiwanger. ``Gross Job Creation, Gross Job Destruction and Employment Reallocation.'' forthcoming *Quarterly Journal of Economics* (1992).

Dunne, Timothy, and Mark Roberts and Larry Samuelson. ``Patterns of Firm Entry and Exit in U.S. Manufacturing Industries.'' *RAND Journal of Economics* 19, no. 4 (Winter 1988): 495-515.

________. ``Firm Entry and Post-Entry Performance in The U.S. Chemical Industries.'' *Journal of Law and Economics* 7 supplement (Oct. 1989): S233-S271 (a).

________. ``The Growth and Failure of U.S. Manufacturing Plants.'' *The Quarterly Journal of Economics* (November 1989): 671-698 (b).

________. ``Plant Turnover and Gross Employment Flows in the U.S. Manufacturing Sector.'' *Journal of Labor Economics* 7, no. 1 (January 1989): 48-71 (c).

Ericson, Richard, and Ariel Pakes. ``An Alternative Theory of Firm Dynamics.'' Working paper New York: Columbia University 1989.

Evans, David S. ``The Relationship Between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries.'' *Journal of Industrial Economics* 35 (June 1987): 567-582 (a).

Evans, David S. ``Tests of Alternative Theories of Firm Growth.'' *Journal of Political Economy* 95 (August 1987): 657-674 (b).

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

Holmes, Thomas and James Schmitz. ``A Theory of Entrepreneurship and its Applications to the Study of Business Transfers.'' *Journal of Political Economy* 98 (April 1990): 265-294.

House, John L., and Gunnar Du Rietz. ``Entry, Industry Growth, and the Microdynamics of Industry Supply.'' *Journal of Political Economy* 92 (August 1984): 733-56.

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

Lorenzen, Gunter. ``A Unified Approach to the Calculation of Growth Rates.'' *The American Statistician* 44, no. 2 (May 1990): 148-150.

Pakes, Ariel and Richard Ericson. ``Empirical Implications of Alternative Models of Firm Dynamics.'' Working paper no. 2893 Cambridge, Mass.: NBER 1989.

Törnqvist, Leo and Pentti Vartin and Yrjö O. Vartin. ``How Should Relative Change be Measured?'' *The American Statistician* 39, no. 1 (Feb 1985):

43-46.

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