Firm Growth and Firm Size

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Abstract

This study uses a sample of all firms in eight aggregate industries over the period 1998 to 2001 to examine the relationship between firm growth, firm size and firm age. It finds that firm size is negatively related to firm growth in small size class firms. When firms become large enough, the growth-size relationship is positive. Thus Gibrat's Law fails. The study also that finds the growth-age relationship is negative: younger firms have larger growth potential than older ones.

1. Background

The relationship between firm size and firm growth has received considerable attention from economists. For several decades, the traditional wisdom has been that firm growth rates are independent of firm size. This view, widely known as Gibrat's Law, or the "Law of Proportionate Effect", postulates that firm size has no systematic effect on the growth rate of firms, implying that although the actual rate of growth of a firm is stochastic, the expected growth rate is the same across all size classes of firms.

The Law of Proportionate Effect

In 1931, Robert Gibrat's *Inégalités Économiques* was published in Paris. [1] Gibrat's book provided the first formal model of the dynamics of firm size. He postulated that the expected value of the increment to a firm's size in each period was proportional to the current size of the firm. Gibrat's Law asserts that:

$$x_t - x_{t-1} = \varepsilon_t x_{t-1},$$

where x_t denotes the size of the firm at time t and the random variable ε_t denotes the proportionate rate of growth between period *(t-*1*)* and period *t*. Then,

$$x_t = (1+\varepsilon_t)x_{t-1} = x_0(1+\varepsilon_1)(1+\varepsilon_2)...(1+\varepsilon_t)$$

By taking logs, we get

$$\log x_t \cong \log x_0 + \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_t \quad \text{for} \quad \log(1+\varepsilon_t) \cong \varepsilon_t .$$

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[1] I was unable to find this study, but it is discussed in Sutton (1997).

When t goes to infinity, $\log x_0$ will be small compared to $\log x_t$, such that the distribution of $\log x_t$ is an approximately normal distribution and the limiting distribution of x_t is lognormal.

As Hart and Prais mentioned in their studies, the law of proportionate effect is "the most important consequence of the log-normal distribution hypothesis." [2] An event *i* that results in the size of the firm changing from x to $\varepsilon_i x$ would also change the size of the firm from y to $\varepsilon_i y$. This hypothesis, which says that firms of all sizes have the same chance of a certain proportional increment in size, has generated a great deal of interest among economists. It is known as the Law of Proportionate Effect (LPE), also called Gibrat's Law. It states that the probability of a firm growing at a given proportionate rate during any specified period of time is independent of the initial size of the firm. The current size of the firm depends only on its size in the previous period.

The LPE has some important economic implications. First, the LPE implies no relationship between size and growth. As a result, there is no optimal size of the firm since every firm no matter how large it is has the same chance to experience the same growth rate. Second, it implies that the growth rate in one period has no effect on the growth rate in the next period.

2. Literature review

Since the 1950s, many economists have tested whether the LPE holds or not. There are two approaches to empirical testing of this growth-size relationship. The first is based

[2] See Hart and Prais (1956, p.161) for details.

on the work of Gibrat, who developed a simplest version of the model, in which growth rates are independent of size. These studies focus on the size distribution of firms. Purely "stochastic models"[3] were used by Simon and Bonini (1958) and Ijiri and Simon (1977). The other approach is to investigate the relationship between growth and size using cross-sectional firm data, examples of which include Mansfield (1962) and Evans (1987a,b).

Other authors have explored the relationship between firm growth and firm size through "maximizing" models of firm behavior. Represented by Jovanovic (1982) and Cabral (1995), these models focus on the firm's optimization problem: to maximize the profit of the firm. Through the cost function, the growth-size relation is defined.

From all these studies, one can draw two main conclusions about the LPE: LPE holds, and firm growth is independent of firm size; or LPE doesn't hold, firm size has some effect on firm growth. Both negative and positive relationships were found by different studies; a positive relationship means a smaller firm has a higher rate of growth than larger ones, and vice versa for a negative relationship. In this section, I will provide a brief review of the main results on the growth-size relationship looking first at studies that find that the LPE holds and then at studies that conclude that it does not hold.

2.1 LPE holds.

In the 1950s and 60s, some economists found that the LPE holds. Hart and Prais (1956) grouped firm data for the UK into three approximately numerically equal classes

[3] See Sutton (1997).

by size called big, medium and large for two 16-year periods (average of 1907-1924 and 1924-1939). The distribution of firm growth rates in these three size classes was quite similar. Gibrat's law tended to hold.

Simon and Bonini (1958) also found no relation between the size and the mean growth rate of firms. In other words, they found that the law of proportionate effect holds. Simon and Bonini's research was based on the British manufacturing data of Hart and Prais (1956), and data on large US firms in 1955 which was published in *Fortune* magzine. They constructed the transition matrices from one time period to another for the US and British data as Hart and Prais did in their research. They found that the frequency distributions of percentage changes in the size of small, medium and large firms were quite similar in the periods 1954 to 1955 and 1954 to 1956 for the 500 largest US corporations. They also used another simple way to test the law of proportionate effect, which consisted of constructing on a logarithmic scale a scatter diagram of firm sizes at the beginning and end of the time interval. If the regression line has a slope of 45 degrees and if the plot is homoskedastic, the LPE holds. Those conditions were well satisfied by the US data for the 1955-1956 period.

2.2 LPE does not holds

Some studies find a positive relationship between firm size and firm growth, while others find a negative relationship. Each case will be discussed in turn below.

2.2.1 Positive relationship between firm size and growth

Whittington and Singh's (1975) study used individual industry data. They believed the industry was a very important variable because the characteristics of industries might vary significantly. Their analysis was based on data for 2000 individual firms in 21 industrial groups over the period 1948-60. They fitted a model to the cross-section of firms in each industry for each period (1948-60,1948-54,1954-60). Their estimating equation was:

$$\text{Growth} = a + b * \log OpeningSize + e,$$

where *opening size* is the size at the beginning of each of the relevant periods, and a geometric scale has been used for division into size-classes.

A table in their paper shows that there was a positive relationship between size and average growth rate in all three periods and that the standard deviation of growth rates decreases with an increase in firm size. The latter result means that larger firms have a smaller standard deviation of growth rates than smaller ones.

Whittington and Singh (1975) also used another method to test the LPE, which was to study the relationship between the logarithms of firm sizes at the beginning and at the end of a period. The estimating equation in this case was:

$$\log S_{it} = a_t + b * \log S_{i,t-1} + \log \varepsilon_{i,t}$$

where $S_{i,t-1}$ denotes the size of the *i*th firm at time *t* and $\log \varepsilon_{it}$ is a homoskedastic random variable with zero mean.

If $b = 1$, the LPE holds. If $b > 1$, it means that smaller firms will grow proportionately faster than larger ones and the dispersion will tend to decrease. The results showed that *b* is greater than 1 in almost every industry in all three time-periods, which confirms the conclusion that the data reject the first essential requirement of the LPE.

The authors also tried to find out whether firms that had high growth rates over the period 1948-54 would also have high growth rates in the sequential six-year period, 1954-1960. The following regression equation was used both for the cross-section of firms in each industry separately and in all industries together:

$$g_{it} = a + b * g_{i,t-1} + e_{it},$$

where g_{it} denotes the proportionate growth per annum of the ith firm over the period 1954-60 and $g_{i,t-1}$ denotes the growth rate over the period 1948-1954.

The *b* coefficient was positive in almost all industries individually and together. These results implied that the relative growth rates of individual firms tended to persist.

2.2.2 Negative relationship between firm size and growth

Mansfield's (1962) study was based on samples of all firms in four specific industries (steel, petroleum, tires and auto) over a number of different time periods (periods 1916-26, 1926-35,1935,45 and 1945-54 for the Steel industry; periods 1921-27, 1927-37, 1937-47 and 1947-57 for the Petroleum industry; periods 1937-45 and 1945-52 for the Tires industry; periods 1939-49 and 1949-59 for the Auto industry). The data were summarized in the form of transition matrices. "If all firms are classified into *n* size classes, the *ij*th element of the transition matrix for a particular period ($i, j = 1,\ldots,n$) is the number of firms in the *i*th class at the beginning of the period that were in the *i*th class at the end (p.1044)."[4]

By Gibrat's Law,

$$S_{ij}^{t+\Delta} = U_{ij}(t,\Delta)S_{ij}^{t}$$

where S_{ij}^{t} is the size of the *j*th firm in the *i*th industry at time *t*, $S_{ij}^{t+\Delta}$ is its size at time $t+\Delta$, and $U_{ij}(t,\Delta)$ is a random variable distributed independently of S_{ij}^{t}. Mansfield "classified firms by their initial size (S_{ij}^{t}), computed the frequency distribution of $S_{ij}^{t+\Delta}/S_{ij}^{t}$ within each of these classes, and used a χ^2 test to determine whether the frequency distributions are the same in each class".[5]

Mansfield pointed out that Gibrat's Law can be interpreted in different ways. First, it may hold for all firms, including those firms that leave the industry in the period. Second, the law may hold only for the firms that survive during the period. Third, the law holds for firms exceeding "the minimum efficient size" in the industry.[6]

Mansfield's results rejected the first interpretation of Gibrat's Law in seven of his ten samples. The principal reason for the failure of the law is that the probability that a firm will die is definitely dependent on its size. The smaller firms were more likely to leave the industry than the larger ones. The second interpretation of the law was also rejected in four of the samples. Mansfield tested the last interpretation in two ways. One was to estimate the slope of the regression of $\ln S_{ij}^{t+\Delta}$ on $\ln S_{ij}^{t}$. He found that the results were

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[4] See Tables A, B and C of Mansfield (1962), p.1045-1047, for the data for the three different industries.

[5] See Mansfield (1962) for a statement of the detailed method.

[6] Mansfield (1962) defines minimum efficient size to be "the size below which unit costs rise sharply and above which they vary only slightly"(p.1033)."

quite consistent with Gibrat's Law. F tests implied that the variance of $S_{ij}^{t+\Delta} / S_{ij}^{t}$ was inversely related to S_{ij}^{t} instead of being constant among these firms. Thus, these results led Mansfield to conclude that Gibrat's Law does not hold very well no matter which interpretation we choose. Mansfield also provided some evidence which indicated "on the average the successful innovators in these industries grew about twice as rapidly as other comparable firms during the relevant period."(p.1036)

Ijiri and Simon (1964) used a simple stochastic model. They assumed the probability that a firm will increase in size during the next time period is proportional to a weighted sum of the increments it had in the past. The expected increment in size of the *jth* firm during the (t+1)*th* interval is:

$$w_j = p[x_j(t+1)=1] = K(t)\sum_{\tau=1}^{t} x(\tau)\beta^{\tau},$$

where $\sum_{\tau=1}^{t} x(\tau)$ is the size of the *jth* firm at the end of the *ith* interval, K(t) is a function of time which is same for all firms and β is the fraction that determines how rapidly the influence of past growth on new growth drops out.

The authors considered a sample of 247 firms. Their statistical results indicated that Gibrat's Law was very far from being satisfied for the individual firms.

Hall (1987) used data on publicly traded manufacturing firms, drawn from the Compustat files. The data cover approximately ninety percent of employment in the manufacturing sector in 1976. The author selected two different panels of data: all the firms with employment data from 1972 through 1979, and all the firms with employment data from 1976 to 1983.

She first proposed the following simple random walk model:

$$\text{(a) } y_t = X_t + w_t$$

$$\text{(b) } X_t = X_{t-1} + u_t$$

where w and u denote uncorrelated white noise errors, X is the unobserved, true size of the firm and y is the observed logarithm of employment. From this model she derives an estimating equation in which the growth rate is regressed on the observed size in the initial period, a proxy for the true size. The coefficients of the logarithm of size (X_t) for two samples are –1.14 and –1.06. The hypothesis that the coefficient is equal to zero, as predicted by the random walk model, is rejected. The author concludes that there was a negative relationship between size and growth, which implies smaller firms in the sample grow faster.

The author then tried to find out what time series model could sufficiently describe the data so that the way in which firm growth deviates from Gibrat's Law can be specified more fully. The results of the simple random walk model indicated that the coefficient of lagged size in the growth equation is negative, which suggested that an autoregressive component should be added to the model. The expanded model was written as:

$$\text{(c) } X_t = \beta X_{t-1} + u_t, Eu_t^2 = \sigma_t^2,\ E(X_{t-1}u_t) = 0$$

$$\text{(d) } y_t = X_t + w_t, Ew_t^2 = \sigma_w^2, E(X_s w_t) = 0, \forall s,t$$

The author separated the sample into three different panels of firms (1972-1979, 1976-1983, 1972-1983) and used maximum likelihood estimation under the assumption that the disturbances are homoskedastic and normal to obtain the estimates for the model. The estimate of β is equal to 0.991, 0.990 and 0.991 for the three time periods, respectively. This time, a series of conclusions were drawn from the time series analysis of employment growth: (a) the failure of Gibrat's Law is not because of serially uncorrelated measurement error in the size variable, but rather to a very slight tendency for large firms to become smaller and small firms to become larger; (b) the variance in growth rates across firms changes significantly from year to year (σ_w^2 is equal to 0.0018, 0.0036 and 0.1127 respectively).

Because a figure in the article plotting 1976-1983 Growth Rate versus Size in 1976 suggests that the variance of growth rates is size-related, Hall used a Lagrange Multiplier test in order to test for heteroskedasitcity.[7] The test statistics are equal to 60.6 and 43.2 for samples for the periods 1976-1979 and 1976-1983 respectively. The null hypothesis of homoskedasticity is obviously rejected in favor of size-related heteroskedastity.

In the last part of the article, Hall also tried to determine the relationship between investment and firm growth. Three variables were added to the standard growth rate equation: the logarithm of capital expenditures in 1976, the logarithm of R & D investment in 1976, and a dummy equal to one for those firms who do no or negligible R & D. The investment coefficients showed that an increase of four million dollars in physical investment is associated with a one percent increase in the annual growth rate

[7] The figure can be found on pp. 595 of Hall (1987).

from 1976 to 1979, while it takes only two million dollars of R & D investment to generate a one percent increse in the annual growth. The effects are the same in the second period, which suggested considerable persistence in the correlation of growth and investment. On average, firms that have no R & D program grow about one to two percent more slowly than those that do R & D.

The studies of Evans (1987a,b) investigated age as well as size effects on firm growth. He pointed out that firm age was an important determinant of firm growth and the variability of firm growth. Evans (1987a) was based on a sample of approximately 20,000 US manufacturing firms drawn from the Small Business Administration data set (SBDB). Firm growth between 1976 and 1982 was analyzed. He assumed that the firm growth relationship could be specified as:

$$S_{t'} = [G(A_t, S_t)]^d (S_t) e_t,$$

where t denotes time with $t' > t$, $d = t' - t$, and e is a lognormally distributed error term with a possibly nonconstant variance.

This equation suggests the regression model:

$$\frac{\ln S_{t'} - \ln S_t}{d} = \ln G(A_t, S_t) + u_t.$$

Taking a second-order expansion of $G(A_t, S_t)$ yielded

$$\ln G = b_0 + b_1 \ln size + b_2 \ln age + b_3 (\ln size)^2 + b_4 (\ln age)^2 + b_5 (\ln size)(\ln age) + u. \quad (1)$$

By White's specification test, the hypothesis that the specification of the model is correct could not be rejected. Heteroskedasticity and additional nonlinearity in the functional

form of ln *G(A, S)* were rejected. The parameter estimates implied that g_A, the partial derivative of the logarithmic growth rate with respect to logarithmic firm age, was equal to –0.0381 and g_S, the partial derivative of the logarithmic growth rate with respect to firm size, was equal to -0.0374. Evans (1987a, p.669) concluded that "firm growth decreases with firm size when firm age is held constant and decreases with firm age when firm size is held constant."

Evans mentioned two econometric issues which had been ignored by other studies. In his research, he pointed out that the relationship is highly nonlinear so that the growth-size relationship varies over the size distribution of firms. The second question is the possibility of heteroskedasticity and specification errors.

In Evans' other study (1987b), he examined the relationship between a firm's size, age and the number of plants it operated. Compared to the former study, he examined all firms in 100 manufacturing industries between 1976 and 1980 and he added one explanatory variable B_t representing the number of plants to the regression model:

$$\frac{\ln S_{t'} - \ln S_t}{d} = \ln G(A_t, S_t, B_t) + u_t .$$

The results were consistent with the author's former study of the 100 manufacturing industries firm data: a negative relationship between growth and size held for 89 percent of the industries and a negative relationship between growth and age held for 76 percent of the industries. The results also showed that firm growth increases with the number of plants operated by the firm.

Dunne and Hughes (1994) used data on 2000 firms in 19 industries to check out the growth-size relation by estimating the log linear regression:

$$\log S_{it} = \alpha + \beta \log S_{it-1} + e_{it}.$$

They fitted the equation to data on all companies which survived from 1980 to 1985 and from 1975 to 1980, and found that small firms grow faster than large firms. The null hypothesis that Gibrat's Law holds was rejected. They also found that the variance of growth rates declined with increasing firm size by analyzing growth by size class. An examination of the residuals in the OLS equations suggested that they were heteroskedastic. After adding another explanatory variable, AGE, the authors concluded that AGE, which is negatively related to firm growth, was the significant factor causing the heteroskedasticity,.

Hart and Oulton (1996) used data from the EXSTAT database of 29,000 independent firms in the U.K., divided into 12 size classes over period 1989-1993. They denoted the natural logarithm of the employment of the *i*th firm at time *t* by $Y_t(t)$. In deviations from the mean, $y_t(t) = Y_t(t) - \mu$, they extended Gibrat's model to a first-order Galton-Markov process to provide another stochastic model:

$$y_t(t) = \beta y_t(t-1) + \varepsilon_t(t).$$

If $\beta < 1$, the small firms grew more quickly than large firms during the period.

The regression was estimated using OLS, with White's heteroskedasticity consistent covariance matrix. Within the OneSource database of surviving companies, firms in small size classes -- those with no more than 8 employees -- grew more rapidly than the larger survivors over the four-year period, which implies that smaller firms created proportionately more jobs than larger ones. Therefore, Gibrat's law was rejected.

All the above studies used empirical models to test the LPE. Jovanovic (1982) and Cabral (1995) provided theoretical research to explain why the LPE does not hold and the growth-size relationship is negative.

Jovanovic (1982) proposed a theory of "noisy" selection. Firms differ in size because some are more efficient than others. Efficient firms grow and survive. He denoted by q the output of a firm and $c(q)$ a cost function which satisfies $c(q)=0, c'(0)=0, c'(q)>0, c''(q)>0$ and $\lim c'(q)=\infty$. Total costs are $c(q_t)x_t$ where x_t is a random variable that is independent across firms.

Assuming a homogeneous-goods industry, firms will maximize expected profits by choosing their output level q_t, as in the following maximization problem:

$$\max_{q_t}\left[p_t q_t - c(q_t)x_t^*\right]$$

where x_t^* is the expectation of x_t conditional on information received prior to t. The growth rate then was defined to be $\left[\frac{p_{t+1}}{p_t}\right]^{\delta}\left[\frac{x_t^*}{x_{t+1}^*}\right]^{\delta}-1$. δ is a positive constant. $x_{t+1}^* = x_t^*(1+u_t)$, where u_t is a random variable with zero mean. Because the variance of u_t declines as the firm becomes more mature, younger firms have more variability in their growth rates and also will grow faster than the older firms. The results showed that LPE failed.

Cabral (1995) provided a theoretical explanation for the negative relation by using a "maximizing" model similar to that of Jovanovic. The author also found that Gibrat's

Law did not hold under sunk costs, assuming that capacity costs are entirely sunk. Small firms are more likely to exit and are also expected to grow more rapidly than larger firms.

2.3 Summary

Some early studies in the 1950s found the LPE holds, while the most recent research found that the LPE does not hold. Moreover, negative relationship was detected. There are many reasons for the differences in the results obtained by different researchers: the development of technology, the different econometric methods being used, the data set, and the measures of size and growth.

In order to get precise results on the relationship between firm growth and size, the measures of size and growth used are very important. There are different possible measures; different measures have their own limitations. Employment, assets, sales, and market value are the most common measures of company size. Assets and employment are widely used in studies of company size.

The number of employees is a discrete variable, and we may encounter problems when we use it. For example, we cannot include part-time workers even though their numbers have increased. This will affect the precision of our variables in the regression model. Hall (1987) used employment as the measure of size. Mansfield (1962) also used this size measurement for Tires, one of the four industries in his research.

More companies use net assets as a measure of company size. It is a continuous variable. But we may have another problem if we use this variable because net assets could be negative when employment and sales are non-negative. Whittington and Singh

(1975), Ijiri and Simon (1964), Dunne and Hughes (1994) Hart and Oulton (1996), Simon and Bonini (1958), Hart and Prais (1956) used assets as the measure of size.

3. Empirical Framework

My starting point is to test whether Gibrat's Law holds for my data. My initial specification will include firm age as well as firm size. Following Blonigen and Tomlin's (2001) work, the firm growth equation is specified as:

$$\textit{Growth Rate} = \alpha + \beta_1 \log(\textit{FirmSize}) + \beta_2 \log(\textit{FirmAge}) + \varepsilon \, . \qquad (2)$$

Following the proposed estimating equation, the set of explanatory variables includes initial firm size and firm age as basic determinants of firm growth. I define *Growth Rate* as the 3-year percentage change in plant-level employees from 1998 to 2001. *Firm Age* is measured in years. *Firm size* is measured as employment at the beginning of the period under consideration and ε is a classical error term.

If Gibrat's law holds, β_1 in Equation (2) should be zero. A negative β_1 indicates that smaller firms grow faster than larger ones; a positive β_1 mean larger firms grow faster. A negative coefficient on the plant age β_2 indicates younger firms grow faster.

4. The data

To date, no one has examined these issues using Canadian firm level data. The data were obtained from *FP Survey-Industrials 1999 and 2001,* which is a guide to all industrial companies publicly traded in Canada. The listings cover those companies involved in manufacturing, real estate development, forestry, investment holding, and financial management, as well as communications, transportation, banking, retailing, and other service industries.

I collected the information on employee numbers and firm age for the companies that survived during the three successive years period from 1998 to 2001. The Standard Industrial Classification (SIC) was used by the FP-Survey in the classification of establishment data. The Canadian firm data covers the entire field of economic activities: agriculture (01,02,07); forestry (08); mining (10); construction (15,16,17); manufacturing (20-39); transportation (40-47); communications (48); electric, gas and sanitary services (49); wholesale trade (50,51); retail trade (52-59); finance, insurance and real estate (60-67); personal business, professional, repair, recreation and other services (70-89) and public administration (91-97). Table 1 reports the numbers of firm in every industry. From the table, we find that the number of firms is largest for industries in SIC 20, 28 35, 36, 38, 48, 49, 67 and 73.

Table 2 shows the three-year growth rates in employment of Canadian firms in different age classes. The data show that the youngest age-group does not have the largest growth rate -- instead, the group from age 5 to 8 does; and it also shows quite clearly that there is a very high average growth rate in the initial 8 years of firm life.

5. Empirical Results

5.1 Ordinary Least Square Estimates.

Table 3 reports the estimates of equation (2) using the entire sample of all Canadian firms. I control for heteroskedasticity using White's heteroskedasticity-consistent

Table 1

The classification of Canadian firms by two-digit manufacturing SIC industries.

SIC	Industry	NO of firm	SIC	Industry	NO of firm
07	Agricultural Services	1	50	Wholesale Trade - Durable Goods	13
08	Forestry	3	51	Wholesale Trade - Nondurable Goods	4
10	Metal Mining	2	52	Building Materials and Garden Supplies	3
13	Oil and Gas Extraction	12	53	General Merchandise Store	1
14	Nonmetallic Minerals, except Fuels	1	54	Food Store	6
20	Food and Kindred Products	23	55	Automotive Dealers & Service Stations	3
22	Textile Mill Products	3	56	Apparel and Accessory Store	8
23	Apparel and Other Textile Products	2	57	Furniture and Homefurnishings Stores	6
24	Lumber and Wood Products	13	58	Eating and Drinking Places	10
25	Furniture and Fixtures	3	59	Miscellaneous Retail	6
26	Paper and Allied Products	10	60	Depository Institutions	19
27	Printing and Publishing	15	61	Nondepository Institutions	7
28	Chemicals and Allied Products	41	62	Securities and Commodity Brokers	6
29	Petroleum and Coal Products	3	63	Insurance Carriers	9
30	Rubber and misc. Plastics Products	8	64	Insurance Agents, Brokers and Service	3
32	Stone, Clay and Glass Products	9	65	Real Estate	18
33	Primary Metal Industries	15	67	Holding and Other Investment Office	26
34	Fabricated Metal Products	13	70	Hotel and Other Lodging Places	6
35	Industrial Machinery and Equipment	29	72	Personal Services	3
36	Electronic and Electric Equipment	40	73	Business Services	49
37	Transportation Equipment	16	75	Auto Repair, Services and Parking	1
38	Instruments and Related Products	20	76	Miscellaneous Repair Services	1
39	Miscellaneous Manufacturing Industries	8	78	Motion Pictures	5
40	Railroad Transportation	2	79	Amusement & Recreation Services	3
42	Trucking and Warehousing	6	80	Health Services	10
44	Water Transportation	2	82	Educational Services	3
45	Transportation by Air	5	87	Engineering & Management Services	8
48	Communications	27	89	Services, etc.	1
49	Electric, Gas and Sanitary Services	28		**Total**	**598**

Table 2
1998-2001 employee growth of Canadian firms by age

Age (in years)	Number of firms	1998-2001 growth rate (%)
1--4	6	75. 87
5--8	89	262. 55
9--12	55	30. 27
13+	452	50. 49
Total	598	80. 45

Table 3
OLS estimation results for equation (2).

	Constant	log(*FirmSize*)	log(*FirmAge*)
Estimated coefficient	3. 4787	−0. 1689**	−0. 5593*
	(2. 044)	(-3. 305)	(−1. 062)
t value	1. 702	−1. 3623	2. 9306
F-value		5. 6525	
R^2		0. 0099	
$\overline{R}^2$		0. 0066	

**, *indicate statistically significant at the 1% and 5% significance levels, respectively.
Figures in parentheses are standard errors.
F-value is for the hypothesis of overall significance.
Standard errors are corrected for heteroskedasticity.

covariance matrix.

The estimated coefficient on the log of firm size is –0.1689 and it is statistically significant at the 95% confidence level. The magnitude of the deviation from Gibrat's Law is quite large. The estimate suggests that if we double the size of the firm, the 3-year growth rate will decrease by about 11% from 1998 to 2001. The LPE therefore does not hold.

There is also a negative relationship between firm growth and age. The estimated coefficient of the log of firm age, -0.5593, is statistically significant at the 10% significance level. It means that if we double the age of the firm, the growth rate will decrease by 38%.

The F-statistic for the test of overall significance is 5.6525 and the Wald Chi-square statistic for the same test is 11.305. Therefore, one can reject the null hypothesis that growth is independent of both size and age at the 99% significance level.

I will use Evans' nonlinear model as shown as equation (1) next to check out the growth-size relationship using the same data set. The definitions of $\ln size$ and $\ln age$ are same as that in equation (1). The growth rate is defined as the average growth rate of the logaritham of firm size between 1998 and 2001. The OLS estimation results are shown in Table 4.

The results are consistent with those for Blonigen and Tomlin's (2001) regression model: the independent variables $\ln size$ and $\ln age$ are both negatively related to the firm growth rate. But the magnitude of the deviation from Gibrat's Law is not so large as that for equation (2). The estimated coefficient of $\ln size$ is –0.077. It implies that the growth rate will decrease by 6% if the firm size doubles. It is less than that I obtained for equation (2), 11%. The estimated coefficient of $\ln age$ is –0.03, which is much less than

–0.5593. It implies that if we double the firm age, the growth rate will decrease by 3%.[8]

From the results of the individual t-tests, the estimated coefficients of $\ln age$, $(\ln age)^2$ and the interaction term between $\ln age$ and $\ln size$ are all not statistically significant. For a test of their joint significance, the F-value is 2.1010 and the Wald Chi-square statistic is 6.3030; therefore one cannot reject the hypothesis that all three coefficients are zero at the 5% significance level. Since these three variables don't have any explanatory power at all, I can remove them from the equation.

After removing these three independent variables from equation (1), the regression model looks like:

$$Growth\ rate = b_0 + b_1 \ln size + b_2 (\ln size)^2 + u. \qquad (3)$$

The estimation results of this regression equation, using the whole sample set of 598 observations, are shown in Table 5.

The results are similar to those obtained for equations (1) and (2). The coefficient of $\ln size$ is –0.0074 and also statistically significant at 1% significance level. Its negative sign means firm size is negatively related to firm growth.

Substituting the estimated coefficients into equation (5), I obtain:

$$Growth\ rate = 0.32785 - 0.074(\ln size) + 0.00464(\ln size)^2. \qquad (4)$$

By solving the equation, one can find the local minimum value of the growth rate when $\ln size$ is equal to 8.189. Therefore, *size* is equal to 2902 employees. This result means

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[8] In order to compute the percentage effect of firm age and firm size on firm growth, I fix the second variable of the interaction term of firm size and firm age at the sample mean value.

Table 4

OLS estimation results of equation (1).

	Estimate coefficient	t-value
$\ln size$	-0.0770**	-5.127
	(0.0150)	
$\ln age$	-0.0308	-0.4442
	(0.0694)	
$(\ln size)^2$	0.0047**	3.649
	(0.0013)	
$(\ln age)^2$	-0.0013	-0.1192
	(-0.0112)	
$(\ln age)(\ln size)$	0.0019	0.437
	(0.0043)	
Constant	0.4131**	3.640
	(0.1135)	
F- value	28.275	
R^2	0.0872	
$\overline{R}^2$	0.0795	

**Indicate statistical significance at the 1% significance level.
Figures in parentheses are standard errors.
F-value is for the hypothesis of overall significance.
Standard errors are corrected for heteroskedasticity.

that when firms are small, the relationship between firm size and growth is negative. Small firms will have a greater growth rate than larger firms. When the firm size reaches the point where employment is 2902, the size-growth relationship changes: it becomes positive. Larger firms are expected to grow faster than relatively smaller firms.

Table 5
OLS estimation results of equation (3).

	Estimate coefficient	t-value
$\ln size$	-0.0740**	-5.112
	(0.0144)	
$(\ln size)^2$	0.0046**	3.922
	(0.0012)	
Constant	0.32785**	8.0846
	(0.0405)	
F-value	22.068	
R^2	0.077	
$\bar{R}^2$	0.074	

**Indicate statistical significance at the 1% significance level.
Figures in parentheses are standard errors.
F-value is for the hypothesis of overall significance.
Standard errors are corrected for heteroskedasticity.

5.2 Industry effects

A few recent studies showed that industry characteristics could affect firm growth.[9] The growth rate may be different in different industries. The relationship between size and growth may be different too.

Because there were so few firms in some categories as shown in Table 1, I combined some SIC industries together in order to exam the industry effects on firm growth. Table 6 shows the average firm sizes in Canada for 1998 and 2001 and the growth rate for the

[9] See Blonigen and Tomlin (2001) and Sleuwaegen and Goedhuys (2002).

combined industries over the 3 years. Firm size is measured by employment. Among these 8 industries, the growth rate in SIC 40-48 is very high while in SIC 49 it is relatively low.

First, I try to measure the industry effects in this size-growth relationship by adding dummy variables to the regression model. Seven dummy variables are added to equations (2) and (1) to avoid perfect multicollinearity with the constant term. The new equations are defined as:

$$GrowthRate = \alpha + \beta_1 \log(FirmSize) + \beta_2 \log(FirmAge) + \beta_3 D_1 + \beta_4 D_2 + \beta_5 D_3 + \beta_6 D_4 + \beta_7 D_5 + \beta_8 D_6 + \beta_9 D_7 + \varepsilon \ . \quad (5)$$

$$\ln G = b_0 + b_1 \ln S + b_2 \ln age + b_3 (\ln size)^2 + b_4 (\ln age)^2 + b_5 (\ln size)(\ln age) + \beta_3 D_1 + \beta_4 D_2 + \beta_5 D_3 + \beta_6 D_4 + \beta_7 D_5 + \beta_8 D_6 + \beta_9 D_7 + u \quad (6)$$

The regression results are shown in Table 7 and Table 8. The two sets of results are similar. Most of the industry dummy variables have negative estimated coefficients, except for D3 and D5. The estimated coefficient of D3 is positive in both equations (5) and (6), while the coefficient of D5 is negative in equation (5).

Industries 3 and 5 look different from the other industries in the above results. As shown in Tables 7 and 8, most of the estimated coefficients of the industry dummy variables are not statistically significant. The signs of the estimated coefficients do not matter much, so that further investigation is needed. I will add interaction terms between the industry dummy variables and the other explanatory variables into equation (3). The extended equation looks like:

$$Growth\ rate = b_0 + b_1 \ln size + b_2 (\ln size)^2 + \delta_{11} D_1 + \delta_{12} D_2 ... + \delta_{17} D_7 + \delta_{21} D_1 * \ln szie + \delta_{22} D_2 * \ln size + ... + \delta_{27} D_7 * \ln size + \delta_{31} D_1 * (\ln size)^2 + \delta_{32} D_2 * (\ln size)^2 + ... + \delta_{37} D_7 * (\ln size)^2 + u. \quad (7)$$

First I carry out a joint F test to test whether the coefficients of the 21 dummy and interaction variables are jointly zero. The F value is 1.93 and the Wald Chi-square statistic is 40.23. Therefore, the null hypothesis that all coefficients are zero is rejected at the 1% significance level. This result means that at least one industry is not homogeneous with the others, which has some impact on the growth rate. The growth-size relationship may be different in this industry. I also carry out a Chow test to test whether all coefficients in the regression model are the same for all industry subsamples. The F-value for the Chow test is 7.2428. Therefore I can reject the hypothesis that the coefficients are the same across industry subsamples. The result of Chow test is consistent with the joint F-test, which shows the industry has an effect.

In order to figure out which industry or industries are different, a joint F test is needed to test the hypothesis that the coefficients of each dummy variable and the corresponding two interaction variables are all equal to zero. The seven null hypotheses are: $\delta_{11} = \delta_{21} = \delta_{31} = 0$, $\delta_{12} = \delta_{22} = \delta_{32} = 0$, ... , and $\delta_{17} = \delta_{27} = \delta_{37} = 0$. The results of the seven F tests are shown in Table 9.

Table 6

Canadian firms average sizes in 1999, 2001, and 1999-2001 growth rates by two-digit manufacturing SIC industries (combined).

SIC	Dependent variable	Industry	NO of firms	Average firm size in 1998 (employees)	Average firm size in 2001 (employees)	Growth rate, 1999-2001 (%)
07--14	D1	Agricultural, Forestry, fishing, Hunting, Trapping, Mining, Oil, Gas	19	2208. 5	2058. 6	40. 26
20--39	D2	Manufacturing	271	3304. 2	3977. 5	42. 61
40--48	D3	Transportation and communication	42	7716. 6	8111. 9	459. 35
49	D4	Electric, gas and sanitary services	28	2925. 5	2973. 2	13. 70
50-59	D5	Wholesale and retail trade	60	6290. 0	8657. 2	48. 39
60-64	D6	Finance and insurance	44	7986. 7	8502. 2	21. 80
65-67	D7	Real estate, holding and Other Investment Office	44	3123	4650	66. 5
70-89	D8	Personal, business, Professional, repair, recreation services	90	1681. 3	2229. 9	103. 30

Table 7
OLS regression results of equation (5).

	Estimate coefficient	T-value
log *FirmSize*	-0.2139**	-2.364
	(0.0905)	
log *FirmAge*	-0.6378	-1.023
	(0.6234)	
D1 (dummy variable)	-0.3661	-1.086
	(0.3370)	
D2	-0.1952	-0.4753
	(0.4107)	
D3	4.3541	0.9604
	(4.534)	
D4	-0.0240	-0.0364
	(0.6606)	
D5	0.1275	0.2273
	(0.5614)	
D6	-0.1098	-0.1881
	(0.584)	
D7	-0.2698	-0.6329
	(0.4264)	
Constant	3.7886	1.833
	(2.067)	
F value	2.894	
R^2	0.035	
$\overline{R}^2$	0.0203	

**indicate statistically significant at 1% significance level.
Figures in parentheses are standard errors.
F-value is for the hypothesis of overall significance.
Standard errors are corrected for heteroskedasticity.

Table 8
OLS regression results of equation (6)

	Estimate coefficient	T-value
ln*size*	-0.07954**	-5.006
	(0.0159)	
Ln*age*	-0.0444	-0.6728
	(0.0660)	
$(\ln size)^2$	0.0046**	3.435
	(0.0013)	
$(\ln age)^2$	0.00006	0.006
	(0.0105)	
(ln *size*) (ln *age*)	0.0031	0.7056
	(0.0045)	
D1 (dummy variable)	-0.0317	-0.9004
	(0.0352)	
D2	-0.0413*	-1.659
	(0.0249)	
D3	0.0416	0.8125
	(0.0512)	
D4	-0.0594*	-1.957
	(0.0303)	
D5	-0.0308	-0.9889
	(0.0311)	
D6	-0.0983**	-2.645
	(0.0372)	
D7	-0.0518	-1.392
	(0.0372)	
Constant	0.4707**	4.221
	(0.1115)	
F value	14.534	
R^2	0.1124	
$\bar{R}^2$	0.0941	

**,* indicate statistically significant at 1% and 10% significance level, respectively.
Figures in parentheses are standard errors.
F-value is for the hypothesis of overall significance.
Standard errors are corrected for heteroskedasticity.

Table 9
F tests for industry effects.

	F-value	P-value
D1	3. 187	0. 02344
D2	1. 452	0. 22667
D3	1. 180	0. 31673
D4	1. 860	0. 13513
D5	0. 551	0. 64734
D6	2. 744	0. 04242
D7	0. 923	0. 42945

We can reject the null hypotheses that $\delta_{11} = \delta_{21} = \delta_{31} = 0$ and $\delta_{16} = \delta_{26} = \delta_{37} = 0$. Therefore, the coefficients in industry groups 1 and 6 are different with others; there is some difference in industries 1 and 6.

From the above tests, only industries 1 and 6 are likely to be different. Further tests are needed in order to confirm this point. After removing all other dummy variables and interaction variables except for the variables related to D1 and D6 from equation (7), the equations are:

$$\textit{Growth rate} = b_0 + b_1 \ln S + b_2 (\ln size)^2 + \delta_{11} D_1 + \delta_{21} D_1 * \ln size + \delta_{31} D_1 * (\ln size)^2 + u \quad (8)$$

$$\textit{Growth rate} = b_0 + b_1 \ln S + b_2 (\ln size)^2 + \delta_{16} D_1 + \delta_{26} D_1 * \ln size + \delta_{36} D_1 * (\ln size)^2 + u \quad (9)$$

The F-values of the tests that $\delta_{11} = \delta_{21} = \delta_{31} = 0$ and $\delta_{16} = \delta_{26} = \delta_{36} = 0$ are 4.6298779 and 1.7485242, (p-values are 0.00328 and 0.15592) respectively for equations (8) and (9). The F values for the Chow tests are 0.4426813 and 2.432153 for industries 6 and 1 respectively. The results of the joint F test and the Chow test are consistent with each other. Therefore, industry group 1 is different from the others, but industry group 6 is not.

Finally, we estimate equation (3) for the 8 industry subsamples separately. Table 10 shows the estimated coefficients of the firm growth-size relationship.

Table 10
Estimated coefficients of equation (3) by 8 industry subsamples.

	Coefficient on plant size	Coefficient on plant size square
D1	−0. 00884	−0. 002264
D2	−0. 06796**	0. 004479*
D3	−0. 10251	0. 004156
D4	−0. 12934	0. 009278
D5	−0. 09736**	0. 006659**
D6	−0. 10661*	0. 007175*
D7	−0. 05294	0. 003905
D8	−0. 09325*	0. 006495

**,* represent statistically significant at 1% and 5% significance level.

From Table 10, I find the estimated coefficients of $\ln size$ are all negative and the magnitude of the coefficient of $\ln size$ in industry 1 is very small. Considering all the tests I did to identify an industry effect, a possible explanation for the difference between industry 1 and the others is that in this industry group, the deviation from Gibrat's Law is very low.[10] However, the industry effect is not strong enough to change the sign of this growth-size relationship.

5.3 Results for age groups

Following Evans' previous work, I will divide the whole sample into different age groups: firms between 0 and 6 years, 7 and 20, 21 and 45, and 46 and over. The third and fourth powers of $\ln size$ are needed in the regression model:[11]

$$Growth\ rate = b_0 + b_1 \ln size + b_2 (\ln size)^2 + b_3 (\ln size)^3 + b_4 (\ln size)^4 + \varepsilon. \qquad (10)$$

The results in table 11 are not completely consistent with Evans' work. The coefficient of $\ln size$ in the three groups "0-6", "7-20" and "21-45" is negative. It is positive in the age group "older than 45". Taking a look at the data set "older than 45", I find that for half of the firms, the initial size in 1998 is larger than 2907. This subset of the observations seems dominant, which makes the coefficient of $\ln size$ positive in this age group. The positive estimated coefficient in this group supports the finding that there is a positive growth-size relationship in large size-class firms.

I also find that the magnitude of the estimated coefficient of $\ln size$ is increasing across the age groups: it is -0.3381 for firms less than 7 year-old, -0.1341 for firms

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[10] We can reject the hypothesis that $b_1 = b_2 = 0$ because the F value is 7.753, which means the two variables have explanatory power though t-values show the estimated coefficients of ln *size* and $(\ln size)^2$ are both not statistically significant. In industry 1, the growth-size relationship is still negative even though the magnitude is very small.

[11] See Evans (1987a) for a statement of the detailed explanation.

between age 7 and 21, -0.1258 for firms between age 21 and 45 and –0.1101 for firms older than 45 years of age. When we double the firm size, the growth rate will decrease by 23.4% for the group "less than 7," and by 9.2% and 8.7% for firms in age groups "7-21" and "21-45", respectively. When firm size increases, the growth rate will decrease at a decreasing rate as age increases. In other words, when firms get older, the effect of size on the firm growth rate will be less obvious, and the deviation from Gibrat's Law becomes smaller.

Table 11
Firm growth estimates for firms by age groups.

	Age			
	<7	7--20	21--45	>45
$\ln size$	−0. 3881	−0. 1341	−0. 1258	0. 1601
	(0. 8558)	(0. 1103)	(0. 2621)	(0. 3063)
$(\ln size)^2$	0. 1066	0. 01555	−0. 07821	0. 0742
	(0. 2865)	(0. 03718)	(0. 0689)	(0. 0781)
$(\ln size)^3$	−0. 014597	−0. 00034604	0. 0092264	−0. 0059754
	(0. 038767)	(0. 005017)	(0. 007448)	(0. 008136)
$(\ln size)^4$	0. 00073268	−0. 000026568	−0. 00037034	0. 00017977
	(0. 0018205)	(0. 0002307)	(0. 000283)	(0. 00029813)
Constant	0. 80003	0. 41316	−0. 21564	0. 80584
	(0. 86016)	(0. 1156)	(0. 34)	(0. 40108)
R^2	0. 107	0. 0843	0. 0145	0. 0954
Observations	88	279	166	107
F-value	1. 23	6. 309	0. 592	2. 69

5.4 Heteroskedasticity

In the analysis of the growth-size relationship, firm size has impact on the growth rate. The residuals in the estimated OLS equations are likely to be heteroskedastic, which implies that the estimates are inefficient although unbiased and the estimated standard errors biased.

Because tests for normality indicated that disturbances of equations (1), (2) and (3) are not normally distributed,[12] the Koenker-adjusted Breusch-Pagan-Godfrey LM test for heteroskedasticity is used. The Chi-square statistic is 5.354 for equation (3), and it is statistically insignificant. Therefore, we cannot reject the hypothesis that the disturbances in the regression are homoskedastic. For equations (1) and (2), the corrected LM statistics are 9.225 and 2.526, respectively. These are both statistically insignificant. The errors are not heteroscedastic.

The test results for equations (5) and (6) with seven industry dummy variables seem a little different. The LM statistics for equation (6) and (5) are 17.766 and 18.053, which implies that the disturbances of equation (5) are heteroskedastic.

Overall, from the heteroskedasticity test results, only for equation (5) are the disturbances heteroskedastic. The cause of the heteroskedasticity is likely to be the industry effect because heteroskedasticity was detected after we added the industry dummy variable into the regression equation. However, this finding is not consistent with

[12] The Jarque-Bera Normality test statistic is 4236.3747, 4702.4582 and 4607.1286 for equations (1), (2) and (3) respectively and the p-value is 0.000 for all three equations. Therefore one can reject the null hypothesis that the disturbances are normally distributed.

other studies. Instead, Hall (1987) and Dunne and Hughes (1994) found the variance of growth rates declined with increasing firm size. The heteroskedasticity is size-related.

5.5 Low R^2.

The R^2 values of all regression models are less than 10%, which is relatively low. This means that the explanatory power of all variables is not strong. There are several possible explanations for these low R^2 values. First, these equations may omit some relevant variables. As some researchers found out, the number of plants is positively related to firm growth;[13] Hall (1987, p.602) found that "at the mean level of investment for these firms, an increase of four million dollars in physical investment is associated with a one percent increase in the annual growth rate from 1976 to 1979." Because of the limitations of my data set, these two variables cannot be included in the regression model in this study. There are also some intangible explanatory variables that may have an effect on the growth rate, for example, a firm's reputation and legitimacy, management efficiency, and employees' capabilities. Common sense suggests that these factors will surely affect a firm's growth rate, but they are difficult to measure. As a result, we can hardly involve them in the regressions. Because so many important variables cannot be included, R^2 cannot be large. The residuals contain the unexplained part and become dominant.

The second reason is that R^2 can measure only linear relationship between the dependent variable and the independent variables. Equation (1) is a nonlinear model in

[13] See Evans (1987b) for details.

ln*size,* ln*age* and also the interaction variable. In Evan's research (1987a), the R^2 value for his OLS estimates is 0.1438, and 0.1405 for his maximum likelihood estimates. These values are higher than the value of 0.0872 obtained here, but they seem too not good enough. The value of R^2 for equation (10), which includes four powers of ln*size*, is even lower than for equation (1) in Evans' work. He obtained 0.0622, 0.0499 and 0.0461 for the size classes 7-20, 21-45, 46+ respectively. Adding industry dummy variables to equation (1) certainly increases R^2, but not by much. As shown in Table 4 and Table 8, R^2 changed from 0.0872 to 0.1124, while $\overline{R}^2$ changed from 0.0795 to 0.0941.

6. Comparison and Conclusion

This paper examines the relationship among firm size, age and growth of Canadian firms in different SIC industries. The data source for the study is the *FP Survey-Industrials 1998 and 2001.* Using a firm level data set for 598 firms over the years 1998 and 2001, the relationship between firm growth and size is negative when estimating Blonigen and Tomlin (2001)'s model. The results are consistent with those of Blonigen and Tomlin (2001). Gibrat's Law does not hold.

Using the same data set, I used Evans's model (1987a,b) and obtained results similar to those for Blonigen and Tomlin (2001)'s model. The growth-size and growth-age relationships are both negative, which is supportive of Evans' research. Furthermore, using a quadratic equation, we find that when the firm size reaches a specific level, the growth-size relationship becomes positive. For large size-class firms, the larger they are, the higher their growth rates.

Firm age does not seem to have any effect on firm growth in my sample because the coefficients of firm age are all statistically insignificant. This result is different from the negative growth-age relationship Blonigen and Tomlin (2001) and Evans (1978a,b) obtained.

The industry has an effect on the growth rate. We used the same regression equation but eight industry subsamples to check the industry effect. From eight sets of estimates, we found the coefficients of $\ln size$ are all negative but with different magnitudes. Industry 4 shows the largest deviation from Gibrat's Law and Industry 1 shows the smallest. Compared with studies using manufacturing industry data by Evans (1987a,b) Mansfield (1982) and Hall (1987), the estimate result I obtained for the manufacturing industry is consistent with theirs: the growth-size relationship is negative.

Due to the limitations of the data set of this study, further explanatory variables can hardly be added into the growth rate regression model, which is one of the reasons I obtained very low R^2. Further analysis in this area is needed.

Reference

Blonigen, Bruce A. and Tomlin, KaSaundra (2001), 'Size and Growth of Janpanese Plants in the United States,' *International Journal of Industrial Organization*, vol. 19 (2001) 931-952.

Cabral, Luis (1995), 'Sunk Costs, Firm Size and Firm Growth,' *Journal of Industrial Economics*, Vol. 43, No. 2. (Jun., 1995), 161-172.

Dunne, Paul and Hughes, Alan (1994), 'Age, Size, Growth and Survival: UK Companies in the 1980s', *The Journal of Industrial Economics*, June 1994, 115-140.

Evans, David S. (1987a), 'Tests of Alternative Theories of Firm Growth', *The Journal of Political Economy*, Vol. 95, No. 4. (Aug., 1987), 657-674.

Evans, David S. (1987b), 'The Relationship Between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries,' *Journal of Industrial Economics,* Vol.34, Issue 4, (Jun., 1987) 56-581.

FP Survey, Industrials, Vol. 1998 & 2001 (published by Financial Post).

Hall, Bronwyn H. (1987), 'The Relationship Between Firm Size and Firm Growth in the US Manufacturing Sector,' *The Journal of Industrial Economic*, June 1987, 583-605.

Hart, Peter E. and Oulton, Nicholas (1996), 'Growth and Size of Firms,' *The Economic Journal*, 1996 (September), 1242-1252.

Hart, P.E. and Prais, S.J. (1956), 'The Analysis of Business Concentration: A Statistical Approach,' *Journal of the Royal Statistical Society*, Series A, Vol.9, Issue 2 (1956), 150-191.

Ijiri, Yuji and Simon, Herbert A. (1964), 'Business Firm Growth and Size,' *The American Economic Review*, Vol. 54, No. 2, Part 1. (Mar., 1964), 77-89.

Jovanovic, Boyan (1982), 'Selection and the Evolution of Industry,' *Economietrica*, Vol.50, No.3 (May,1982).

Mansfield, Edwin (1962), 'Entry, Gibrat's Law, Innovation, and the Growth of Firms,' *The American Economic Review,* Vol. 52, No. 5. (Dec., 1962), 1023-1051.

Simon, Herbert A. and Bonini, Charles P. (1958), 'The Size Dsitribution of Business firms,' *The American Economic Review*, Vol. 48, No. 4. (Sep., 1958), 607-617.

Sleuwaegen, Leo and Goedhuys, Micheline (2002), 'Growth of Firms in Developing countries, Evidence from Côte d' Ivoire,' *Journal of Development Economics*, Vol. 68 (2002), 117-135.

Sutton, John (1997), 'Gibrat's Legacy,' *Journal of Econonmic Literature*, Vol.xxxv (Mar. 1997), 40-59.

Whittington, Geoffrey and Singh, Ajit (1975), 'The Size and Growth of Firms,' *The Review of Economic Studies*, Vol. 42, No. 1 (Jan., 1975), 15-26.

Whittington, Geoffrey (1968), *Growth, Profitability and Valuation* (London: Cambridge University Press, 1968).