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Does Gibrat's Law Hold? Evidence from Canadian Retail and Manufacturing Firms

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ABSTRACT. This paper investigates the validity of Gibrat's Law holding for firms in manufacturing and retail trade sectors. The object is to expand our knowledge of Gibrat's Law to include non-manufacturing firms. A unique longitudinal firm-level database, which contains information on Canadian incorporated establishments, enables the inter-industry comparison. The findings of the analysis are that Gibrat's Law is violated in both manufacturing and retail sectors. Violations of Gibrat's Law for both sectors include (i) growth rates that depend on firm size (ii) growth variability that depends on firm size and (iii) a negative persistence of firm growth. Finally, age effects or selection effects are not the causes of these violations.

KEY WORDS: firm growth, retail trade, manufacturing, Gibrat's Law.

JEL CLASSIFICATIONS: D21, L11, L60, L80, L26.

1. Introduction

Gibrat's Law has become the focus of a large number of empirical studies in industrial economics. Robert Gibrat, in his book *Inégalités Économiques*, sought a model of firm and industry dynamics to explain his finding that firm size distributions within an industry appeared highly skewed and approximately lognormal. His simple explanation for this finding is the Law of Proportionate Effect or what has become known as Gibrat's Law. The law constitutes the hypothesis that firms (within an industry) draw growth rates from a distribution that is the same for all firms regardless of their current size or previous size history. From this, it follows that growth rates are independent of firm size or as Sutton (1997) states, ''the expected value of the increment to a firm's size in each period is proportional to the current size of the firm.''

There have been a number of empirical studies testing Gibrat's Law. However, almost all focus on the validity of Gibrat's Law holding exclusively for manufacturing firms. Non-manufacturing firms, such as service or retail sector businesses, have largely been ignored by the Gibrat's Law literature. This is unfortunate for two reasons. First, we have limited information about growth and industry dynamics for non-manufacturing firms. Second, there is no reason to believe that industry dynamics are the same for retail trade and manufacturing firms. Manufacturing and retail firms differ in fundamental ways. Service/retail trade firms contain fewer employees, experience higher entry and failure rates, have lower sunk costs and invest less in capital. Manufacturing firms are typically characterized as large, capital intensive firms. These differences create a greater discrepancy between large and small firms in the manufacturing sector which does not necessarily occur in the retail trade sector. Small manufacturing firms must grow and realize economies of scale or face the consequence of lower probability of survival. Grow or die prospects facing small manufacturing firms means that small manufacturing firms should be the fastest growers as they catch up to larger competitors and overcome any survival problems created by lack of scale economies, capital intensity or sunk costs.

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In contrast, it is not clear that small retail trade firms face such survival problems, as a result of the lack of capital intensity and small economies of scale. One view of retail trade sector firms is that these firms tend to be very small and serve only localized markets, as Audretsch et al. (2004) suggest for service sector firms. If this view is correct then small retail trade firms operate in markets where economies of scale are exploited at relatively small levels of output and these firms do not have to grow to overcome any problems related to surviving. Therefore, growth distributions for retail firms should be the same whether they are large or small. A second view of the retail trade industry, with the creation of large chain stores such as Wal-Mart or Costco, is that scale economies exist in retail trade market. Typically, these large retail trade firms enjoy relationships with suppliers that allow for lower prices and do not rely on wholesalers to supply and distribute goods. Thus, small firms are forced to exit or become more specialized due to competitive pressures created by the arrival of one of these large retail trade firms into a market. We might expect growth to favour the large chain stores with their continual product expansion. Similar to manufacturing, the lack of scale economies hurts smaller retail trade firms in the alternative view of the retail trade industry and the small firms must grow to catch up to their larger rivals. This paper addresses the question "Does Gibrat's Law hold for Canadian retail trade and manufacturing firms?"

The previous literature on Gibrat's is large and too extensive to survey here. Audretsch et al. (2004) provide an extensive review of the previous investigations of Gibrat's Law.[1] The authors list 51 empirical studies on firm growth rates. We note the following details about this list. Firstly, Audretsch et al. (2004) point out that most of the evidence concerns manufacturing firms. There are only four studies that limit attention to service/retail trade sector firms. Fourteen studies look at a sample that includes both manufacturing and non-manufacturing firms. The rest of the studies look at samples that contain only manufacturing firms.

This paper fills the gap in the Gibrat's Law literature by examining the size–growth relationship for retail trade and manufacturing firms. Of the 18 studies mentioned to have looked at service sector firm, only four of these studies provide analysis specific to retail trade firms with one study accepting Gibrat's Law for UK retail trade firms (Dunne and Hughes, 1994). Singh and Whittington (1975) find that firm growth appears independent of firm size UK retail trade firms, but reject Gibrat's Law on the basis of finding that the standard deviation of growth rates varies inversely with firm size and finding that growth persistence exists. A third study by Phillips and Kirchhoff (1989) does not examine directly Gibrat's Law but looks at survival patterns across various industries for US firms. Finally, Hart and Oulton (1999) find a negative relationship between firm growth and firm size for independent UK firms. It is unclear whether the growth dynamics for retail trade firms is similar to growth dynamics for manufacturing firms. The support for Gibrat's Law in the retail trade sector is very limited at best. Also, the retail trade sector has evolved in many countries to include the large chain stores, so that further study is required to assess the impact these large chain stores have on the industry dynamics in the retail trade sector. Given the potential differences and similarities between retail trade industries and manufacturing industries, we test whether Gibrat's Law is valid for a group of manufacturing firms and a group of retail firms operating over the same period. The results of the analysis are used to show the differences, if any, in the growth process across the two sectors.

A second contribution of the paper is to examine the validity of Gibrat's Law for Canadian firms. Two previous studies look at the whether Gibrat's Law holds for Canadian farm businesses (Shapiro et al. 1987; Clark et al. 1992), while another study tests the validity of Gibrat's Law in the Canadian high-tech industry (Hamilton et al. 2002). We are able to check if the growth dynamics of Canadian firms match the growth dynamics of firms from other countries in addition to making comparisons between retail trade and manufacturing firms.

Evans (1987a, b) notes that theories of firm dynamics generate growth patterns that vary with the age of the firm.[2] The growth process of small firms may appear different from the growth process of large firms because of age effects. Younger firms, typically with substantial growth rates and highly volatile growth, tend to make up the majority of small firms and the minority of large firms. We further split firms in each sector into two age categories: (i) firms that existed before 1985 and (ii) firms that entered in 1985. The age groupings allow for two things. First, age effects are controlled for by analyzing firms with the same age. Group (ii) in each sector provides such a group. Second, by looking at young firms, we provide analysis of the post-entry performance of new retail and manufacturing firms.

The paper is organized as follows. The next section contains a brief discussion of previous studies of Gibrat's Law. Section 3 discusses testing Gibrat's Law and sample selection issues. Section 4 contains a discussion of the data and measurement issues. A longitudinal database that tracks Canadian firms between 1985 and 1995 is used. Section 5 presents empirical findings. Section 6 concludes. The paper reports the following finding. Gibrat's Law does not hold for Canadian retail and manufacturing firms.

2. Results from previous studies

Generally Gibrat's Law generally fails to hold in the previous studies (Audretsch et al., 2004). There are 27 studies, out of the 51 studies listed, which reject Gibrat's Law. A further 16 studies find mixed results, with rejection or acceptance of Gibrat's Law depending on the industry chosen and sample of firms chosen.[3] Typically, rejection occurs in these studies because of one of three reasons. One reason for rejection is that often studies find that smaller firms grow at an expected rate that is greater than larger firms. Examples of studies that find such a result include Kumar (1985) and Dunne and Hughes (1994) for UK firms and Evans (1987a, b) and Hall (1987) for US manufacturing firms. Alternatively, a second reason for rejection is that other studies find growth favours larger firms. Singh and Whittington (1975), and Hart and Prais (1956) provide examples where growth is positively related to firm size.

A final reason for the rejection of Gibrat's Law is that the assumption of no persistence in firm growth over time fails to hold. For example, Chesher (1979) examines growth persistence for UK manufacturing firms, while Kumar (1985) looks at growth persistence for UK manufacturing and service firms. These studies find a positive serial correlation, which is the normal finding when growth correlation across periods exists. One exception is Contini and Revelli (1989), who find negative growth correlation for Italian manufacturing firms. Alternatively, Tschoegl (1983) finds that growth rates are serially uncorrelated when looking at a sample of large international banks. Audretsch et al. (2004) investigate Dutch firms in the service sector. This study generally finds that growth persistence does not occur for the sample of Dutch service sector firms.

A further detail regarding the previous Gibrat's Law studies is that there is a small amount of evidence on the firm size-firm growth relationship for new firms. The list includes eleven studies on new firms. These studies are concerned with post-entry performance of new firms by linking future survival prospects and growth rates to industry and firm characteristics at the time of firm birth.[4] With the exception of Wagner (1994), these studies find evidence that smaller start-up firms have higher growth rates than do larger start-ups. Therefore, previous evidence suggests that Gibrat's Law does not hold for new firms, because of an inverse firm size-firm growth relationship.

3. Testing Gibrat's law

The Law of Proportionate Effect, or Gibrat's Law, says that all firms within a given sample draw growth rates from a common distribution, which is independent of individual firm size. A firm's expected growth is then independent of its size or the logarithm of firm size follows a random walk.[5] If Gibrat's Law holds then three main propositions are valid: (i) that firms of different size classes have the same average proportionate growth; (ii) that the variance of growth rates is the same for all size classes; and (iii) that there is no serial correlation in growth rates. Each proposition can be tested with firm size data. Rejection of any one of these propositions is a rejection of Gibrat's Law.

Mansfield (1962) notes that the chosen sample of firms could lead to different conclusions regarding acceptance or rejection of Gibrat's Law. Slow growing firms exit. However, it is possible that slow growing small firms are more likely to exit than compared to slow growing large firms because the smaller firms are closer to an exit threshold. An inverse size-growth relationship could be the result of survival effects with shrinking small firms exiting quickly and shrinking large firms moving slowly toward their death. In order to control for such effects, Gibrat's Law has been tested on three different populations in the literature: (1) all firms, (2) only surviving firms and (3) firms that are larger than the Minimum Efficient Scale (MES) level of output. The third group represents the large firms in an industry. Previous studies have looked at large firms based on the belief that Gibrat's Law is only valid for large firms. Part of our sample includes firms at the early stages of their lives. The majority of young firms are small and well below the MES. For this reason, attention is restricted to the first two samples of firms.

All firms versus surviving firms only categories along with the three Gibrat's Law propositions lead to the following hypotheses that are being tested on retail and manufacturing firms:

H1 The growth rate of each surviving firm ver a period is independent of its size

H2 The growth rate of each firm (surviving and non-surviving) over a period is independent of its size

H3 The variability of growth rates for surviving firms is independent of a firm's size

H4 The variability of growth rates for all firms is independent of a firm's size

H5 The growth for surviving firms over a period does not exhibit persistence

The rejection of H1 or H3 provides evidence against Gibrat's Law holding for surviving firms. Similarly, the rejection of H2 or H4 provides evidence against Gibrat's Law holding for the sample of firms that includes survivors and exits. Again, sample selection creates the distinction. The test of growth persistence or H5 applies to only surviving firms, as pointed out by Audretsch et al. (2004), "it is not possible to analyse persistence of growth for firms that leave the industry during the observation period." It is difficult to know what growth persistence means for firms that exit an industry. Death is an absorbing state, so growth persistence is meaningless for exiting firms.

4. Data and measurement issues

4.1. *Data*

This section provides a brief description of the data set and the variables used to measure firm size. The data are taken from the T2LEAP database. This database was created by Statistics Canada. The database contains annual employment and balance sheet information on incorporated employer enterprises within Canada. The sample period is 1984 through to 1996. We analyze growth performance of Canadian firms that exist in 1985. Each firm is tracked using a business registry number (BSNUM). Exit and re-entry by the same firm does not occur when a firm changes its name, since the BSNUM does not change for this firm.

Firms are broken into two groups for analysis. The choice of sample period allows for the identification of one age group: firms that enter in 1985. For simplicity, we refer to this group throughout as the entrants. A firm is part of the entrants if it meets the following criteria. First, the firm must hire employees for the first time in 1985 and, second, the firm must have an incorporation date between January 1, 1985 and December 31, 1985, inclusive. The entrants group provides a set of firms with the same age. The second group contains those firms that were in existence before 1985. We call this second group the incumbents. The incumbents contain all firms that first hired employees before 1985 and have an incorporation date before January 1, 1985. We split each entrant and incumbent groups into retail (600–699) and manufacturing (101–399) samples by three-digit Standard Industry Classification (SIC) number. Any non-manufacturing and non-retail firms are dropped from the analysis. Each hypothesis, H1-H5, is tested for: (i) 1985 manufacturing entrants, (ii) 1985 manufacturing incumbents, (iii) 1985 retail trade entrants, and (iv) 1985 retail trade incumbents.

4.2. *Measurement*

Firm employment measures firm size. The measure of annual employment is called "average labour units" or ALUs. ALUs for a firm are computed by dividing the total annual payroll of an enterprise by the average annual income for workers in the relevant province, size class, and industry at the 3-digit SIC level. This means that the reported ALUs for a given firm can be thought of as the number of "standardized employees" working for a firm during that year.

Partial reporting is possible in the first and last operating year of a firm. A firm under reports its annual payroll when it operates for a partial portion of a year. This leads to an under-reporting of the number of ALUs for the firm. Partial reporting could be a problem for the entrant firms in 1985. Further, partial reporting could be a problem for entrant and incumbent firms in 1996, since exit is possible in that year.[6] For this reason, we examine the growth process between 1986 and 1995 for the sample of firms.[7]

For most of the analysis firm growth is measured by the following formula:

$$\mathrm{Gr}_i = \frac{\mathrm{Emp}_{i1995} - \mathrm{Emp}_{i1986}}{\mathrm{Emp}_{\mathrm{i}1986}}$$

where Gr denotes growth rate and Emp is employment size. If a firm exits between 1986 and 1995 the firm's growth rate over this period equals – 1 when we examine growth for surviving and exiting firms. Table I reports summary statistics of 1986–1995 firm growth, 1986 firm size and 1995 firm size for new entrants, while Table II reports similar summary statistics for incumbent firms. Statistics Canada imposes confidentiality restrictions which prevents the reporting of summary statistics for samples with ten or fewer firms. The following patterns emerge from the tables. Firstly, with the exception of textiles products, the average 1995 size of surviving new entrant firms within an industry is larger the corresponding 1986 mean size. Alternatively, incumbent firms which survive until 1995 appear to change size greatly between 1986 and 1995. Secondly, new entrants have a higher mean value of growth rate than compared to incumbent firms.

5. Empirical results

5.1. *Are firm growth and the variance of firm growth related to firm size?*

The analysis of firm growth begins by dividing firms into size classes based on their 1986 size and comparing growth rates of firms across different size classes. The size classes are chosen to have a common cut off for all samples of firms. This does not mean that roughly equal numbers of firms are placed in each group. Retail firms tend to be smaller than manufacturing firms, while younger firms tend to be smaller than older firms. Therefore, it is impossible to have common size cut-offs and equal numbers of firms in each size class for the different age and industry groups. Common size cut-offs are chosen. The size groups are: (i) two or less employees, (ii) greater than two but less than or equal to five employees, (iii) greater than five but less than or equal to ten employees, (iv) greater than ten but less than or equal to twenty-five employees, and (v) greater than twenty-five employees.

A series of two tests are performed on the surviving firms sample and the survivors plus exits sample. The first test compares the mean growth rates across size classes. This test is a joint difference of means test. If firms of different size classes have similar growth rates then differences in mean growth rates across size classes are zero and the first implication of Gibrat's Law holds. The second test compares the variance of growth rates across size classes. If variances are the same across size classes then the second implication of Gibrat's Law holds.

Table III presents the mean and variance of growth rates from 1986–1995 across size classes for firms that survive until 1995. Two general patterns emerge from the table that foreshadow the results of future analysis. First, growth decreases with firm size. With a few exceptions, firms in larger size classes have lower growth rates on average. Second, growth rate variances are quite different across size classes with firms in larger size classes tending to have lower variability of growth rates. In all cases, extreme growth and variability of growth occurs for

TABLE I
Summary statistics of 1986–1995 Growth[a], 1986 firm size[a], and 1995 firm size[a] for new entrants

Industry	All firms[e]			Survivors only			
	Growth[b, c]	1986 Size[d]	N[f]	Growth[b]	1986 Size[d]	1995 Size[e]	N[f]
All manufacturing	1.00	11.89	819	2.70	11.51	22.39	444
10. Food	0.44	9.16	52	1.42	8.40	25.8	31
11. Beverage products	–	–	4	–	–	–	3
12 Tobacco products	–	–	–	–	–	–	–
15. Rubber products	–	–	6	–	–	–	5
16. Plastic products	1.40	25.59	34	2.71	34.19	39.12	22
17. Leather products	–	–	10	–	–	–	5
18. Primary textile	–	–	4	–	–	–	1
19. Textile products	−0.15	20.99	30	0.83	39.92	32.67	14
24. Clothing	−0.35	17.12	63	0.94	25.70	43.61	21
25. Wood products	0.57	16.49	71	1.79	7.57	17.31	40
26. Furniture and fixture	0.05	12.75	45	1.62	10.92	18.71	18
27. Paper and allied products	–	–	6	–	–	–	4
28. Printing, publishing, and allied	0.16	7.21	111	1.26	9.37	16.42	57
29. Primary metal	–	–	4	–	–	–	1
30. Fabricated metal	0.71	9.65	117	1.50	5.95	10.10	80
31. Machine	1.43	12.70	56	3.00	9.40	24.51	34
32. Transportation equipment	0.74	9.26	42	2.66	12.47	49.69	20
33. Electrical and electrical products	2.05	13.03	39	4.66	6.36	27.35	21
35. Non-metallic mineral products	0.62	9.92	19	1.80	4.18	8.70	11
36. Refined petroleum and coal products	–	–	1	–	–	–	–
37. Chemical and chemical products	−0.02	11.31	25	0.88	12.58	18.53	13
39. Other manufacturing	4.97	5.64	80	10.12	5.27	13.35	43
All retail	0.07	6.15	1,210	1.04	6.32	9.77	637
60. Food, beverage and drug	0.04	8.22	238	0.91	9.05	12.90	130
61. Shoe, apparel, fabric and yarn	−0.25	6.59	123	0.73	3.53	5.93	53
62. Household furniture and furnishings	−0.05	3.90	167	1.05	3.91	4.29	77
63. Automotive vehicles and parts	0.04	7.26	377	0.81	8.04	12.31	216
64. General retail merchandising	0.01	10.21	13	–	–	–	8
69. Other retail stores	0.36	3.94	292	1.60	3.73	7.76	153

Notes: [a] Numbers are means.
[b] Growth is measured as the change in firm employment for the period 1986–1995 divided by employment in 1986.
[c] Growth for firms that exit between 1986 and 1995 is set equal to −1.
[d] 1986 firm size is measured as the average employment (ALUs) per firm in 1986. Similarly, 1995 firm size is measured as the average employment (ALUs) per firm in 1995.
[e] We do not report the 1995 size for all firms.
[f] N is the number of observations in each group.

firms in the lower size classes. Entrant firms have higher growth rates and variability of growth compared to incumbent firms in both industries. Thus, age effects cause differences in growth patterns between age groups, which is consistent with the predictions of life-cycle models such as the Jovanovic (1982) learning model.

Table IV presents the mean and variance of growth rates from 1986–1995 across size classes for all firms. Exiting firms are given a growth rate equal to −1. Again, the patterns remain similar to those in Table III. Average growth rates decrease when moving up size classes with a few more exceptions compared to Table III. Variability of growth rates tends to be smaller for firms in larger size classes. Growth and growth variability does not vary greatly for incumbent manufacturing and retail firms in the upper three size classes. Table IV also shows that entrant firms continue to grow at a rate greater than incumbents even when exits are included in growth calculations.

TABLE II
Summary statistics of 1986–1995 Growth[a], 1986 firm size[a], and 1995 firm size[a] for incumbents

Industry	All firms[e]			Survivors only			
	Growth[b, c]	1986 Size[d]	N[f]	Growth[b]	1986 Size[d]	1995 Size[e]	N[f]
All manufacturing	−0.08	58.72	26,624	0.38	74.61	73.87	17,656
10. Food	−0.01	84.95	2,130	0.38	104.80	116.20	1,520
11. Beverage products	−0.31	179.79	154	0.46	311.93	376.87	73
12 Tobacco products	–	–	10	–	–	–	7
15. Rubber products	0.55	154.92	138	1.16	203.87	188.06	99
16. Plastic products	0.31	40.13	782	0.83	45.51	53.64	557
17. Leather products	−0.54	58.65	248	−0.03	75.82	69.89	118
18. Primary textile	−0.47	176.01	130	0.00	293.29	197.75	69
19. Textile products	−0.41	42.11	637	−0.08	51.35	48.94	405
24. Clothing	−0.47	51.48	1,820	0.04	65.92	62.24	934
25. Wood products	−0.10	51.72	2,275	0.41	66.91	66.82	1,458
26. Furniture and fixture	−0.29	37.68	1,227	0.24	44.54	49.26	698
27. Paper and allied products	0.17	273.16	368	0.61	357.64	279.74	268
28. Printing, publishing, and allied	−0.29	28.97	3,906	0.10	34.76	40.59	2,537
29. Primary metal	2.40	334.77	286	3.55	435.44	325.71	214
30. Fabricated metal	0.04	28.67	4,468	0.46	32.05	33.63	3,181
31. Machine	0.20	36.89	1,547	0.67	40.56	49.38	1,112
32. Transportation equipment	0.07	156.02	1,112	0.63	219.74	227.27	729
33. Electrical and electrical products	−0.03	111.49	984	0.52	150.85	130.57	624
35. Non-metallic mineral products	−0.09	46.81	1,046	0.29	54.17	48.91	737
36. Refined petroleum and coal products	0.04	345.27	53	0.49	485.10	309.20	37
37. Chemical and chemical products	0.04	88.40	801	0.46	106.24	106.17	573
39. Other manufacturing	−0.26	22.85	2,502	0.08	26.37	28.31	1,706
All retail	−0.27	20.34	48,487	0.23	27.36	27.75	28,772
60. Food, beverage and drug	−0.24	23.67	9,663	0.29	32.13	46.69	5,694
61. Shoe, apparel, fabric and yarn	−0.50	27.07	5,387	0.05	35.62	33.20	2,572
62. Household furniture and furnishings	−0.33	12.66	5,499	0.20	18.16	12.69	3,077
63. Automotive vehicles and parts	−0.26	12.77	15,795	0.14	15.18	16.46	10,287
64. General retail merchandising	−0.46	191.19	1,112	−0.02	333.37	236.57	614
69. Other retail stores	−0.15	11.56	11,031	0.44	14.70	14.35	6,528

Notes: [a] Numbers are means.
[b] Growth is measured as the change in firm employment for the period 1986–1995 divided by employment in 1986.
[c] Growth for firms that exit between 1986 and 1995 is set equal to −1.
[d] 1986 firm size is measured as the average employment (ALUs) per firm in 1986. Similarly, 1995 firm size is measured as the average employment (ALUs) per firm in 1995.
[e] We do not report the 1995 size for all firms.
[f] N is the number of observations in each group.

We move on to formally test equality of means. Let μ_i be the mean growth rate for those firms belonging to size class i. H1 or H2 can now be stated as the following hypothesis:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 \quad \text{vs.}$$

$$H_1 : \mu_i \neq \mu_j$$

for some $i \neq j$.

This test now can be expressed as a joint difference of means test. Therefore, we write:

$$H_0 : \begin{bmatrix} \mu_1 - \mu_2 \\ \mu_2 - \mu_3 \\ \mu_3 - \mu_4 \\ \mu_4 - \mu_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{1}$$

Rencher (2002) shows that the test statistic is given by

$$\chi^2 = n(R\bar{\mu})'(RSR')^{-1}(R\bar{\mu}) \tag{2}$$

TABLE III
1986–1995 Growth and variance of growth by 1986 size class, survivors

Mean growth rate (standard deviation) number of firms					
Group	1986 Size class				
	0–2	2–5	5–10	10–25	> 25
Manufacturing: Entrants	6.05	1.77	2.30	0.94	0.74
	(26.75)	(4.03)	(5.60)	(2.10)	(1.70)
	108	132	94	75	35
Incumbents	2.16	0.35	0.20	0.20	0.27
	(20.07)	(1.90)	(1.95)	(1.59)	(1.57)
	1,229	2,848	3,377	4,662	5,540
Retail: Entrants	2.05	0.56	0.52	0.69	0.36
	(3.44)	(1.70)	(1.50)	(2.53)	(0.86)
	207	225	109	69	27
Incumbents	1.07	0.22	0.03	0.09	0.24
	(4.70)	(1.25)	(0.84)	(1.20)	(0.93)
	3,090	8,128	8,064	6,311	3,179

Note: Growth is measured as the change in firm employment for the period 1986–1995 divided by employment in 1986.

TABLE IV
1986–1995 Growth and variance of growth by 1986 size class, all firms

Mean growth rate (standard deviation) number of firms					
Group	1986 Size class				
	0–2	2–5	5–10	10–25	> 25
Manufacturing: Entrants	2.30	0.51	1.11	0.17	−0.18
	(18.58)	(3.28)	(4.74)	(1.88)	(1.45)
	231	242	147	125	74
Incumbents	0.37	−0.15	−0.18	−0.17	−0.08
	(13.36)	(1.64)	(1.71)	(1.43)	(1.46)
	2,810	4,538	4,932	6,699	7,645
Retail: Entrants	0.45	−0.15	−0.15	−0.02	−0.22
	(2.82)	(1.47)	(1.35)	(2.09)	(0.94)
	435	413	196	119	47
Incumbents	−0.23	−0.33	−0.33	−0.23	−0.05
	(3.03)	(1.11)	(0.84)	(1.12)	(0.97)
	8,318	14,768	12,259	8,971	4,171

Note: Growth is measured as the change in firm employment for the period 1986–1995 divided by employment in 1986. Firms that exit between 1986 and 1995 have a growth rate equal to −1.

where n is the number of observations, $\bar{\mu}$ is a vector of sample estimates of μ, S is the sample variance matrix and R is matrix that defines H_0 given by:

$$R = \begin{bmatrix} 1 & -1 & 0 & 0 & 0 \\ 0 & 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 1 & -1 \end{bmatrix}. \tag{3}$$

The test statistic is distributed as under the null hypothesis.

Now, the methodology discussion turns to comparing the variability of growth rates across size classes. In a similar manner as with means comparisons, an equality of variance test is used. We let be the variance for the firms belonging to group i. H3 or H4 can be stated as the following hypothesis:

$$H_v : \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \sigma_4^2 = \sigma_5^2 \quad \text{vs.} \quad H_{v1} : \sigma_i \neq \sigma_j$$
for some $i \neq j$.

From Rencher (2002), we have a test statistic, which is approximately distributed as , given by:

$$\frac{m}{c} \tag{4}$$

where

$$c = 1 + \frac{1}{3(k-1)}\left[\sum_{i=1}^{k}\frac{1}{v_i} - \frac{1}{\sum_i v_i}\right],$$

$$s^2 = \frac{\sum_{i=1}^{k} v_i s_i^2}{\sum_{i=1}^{k} v_i}, \tag{5}$$

and

$$m = \left(\sum_{i=1}^{k} v_i\right)\ln s^2 - \sum_{i=1}^{k}(\ln v_i)s_i^2 \tag{6}$$

s_i^2 are sample variances with V_i degrees of freedom. k is the number of sample groups. In our case, k equals five.

The tests of H1 and H2 using firm growth from 1986 to 1995 are presented in Table V. We reject both H1 and H2 at the aggregate manufacturing and retail trade levels. The results provide evidence against proposition (i) of Gibrat's Law holding. The rejection of proposition (i) occurs when the sample includes only survivors and when the sample includes survivors and exits. Further, whether we control for entrant versus incumbents has no relevance in the rejection of proposition (i). Dunne et al. (1988), (1989) focus on firms with more than 5 employees. A possible concern is that rejection of the null hypothesis occurs because of the extreme growth rates for the group of firms with two or less employees. For comparison reasons, we repeat the above analysis for more than 5 employees. H1 and H2 are rejected at the one percent level of significance for all aggregate groups with the exception of retail entrants.

Next, we examine whether hypotheses H1 and H2 hold for individual two-digit sub-industries. For new entrants, rejection of H1 at the ten percent level of significance arises in 4 out of 14 two-digit manufacturing industries. The four industries include furniture and fixtures, fabricated metal, machine equipment, and other manufacturing. Alternatively, H1 rejection occurs in 4 out of 5 retail trade industries with the exception being shoe, apparel, fabric and yarn stores. We reject H2 in 5 out of 14 manufacturing industries. While household furniture, appliances and furnishings stores, and shoe, apparel, fabric and yarn stores are the only two retail trade industries with a rejection of H2 for the new entrant sample. Rejection of both H1 and H2 occurs in only three industries. These industries include fabricated metals, machine equipment, and household furniture, appliances and furnishings stores.

The first two columns under Incumbents section of Table V examine whether H1 and H2 holds for incumbents. H1 is rejected at the ten percent level of significance in 11 out of 21 manufacturing industries. Similarly, H2 is rejected in 12 of the manufacturing industries with 8 industries experiencing a rejection of both H1 and H2. The results for manufacturing indicate that growth is not necessarily correlated with firm size when examining firms within a two-digit industry and across age groups. Turning to retail trade firms, both H1 and H2 are rejected at a significance level greater than one percent in all industries. Thus, proposition (i) does not hold for retail trade firms as growth rates vary across size classes.

Tests of H3 and H4 using firm growth from 1986 to 1995 are also presented in Table V. In all cases, H3 and H4 are rejected at the aggregate manufacturing and retail trade levels. The results provide evidence that the variance of firm growth does vary across size classes. When looking at new entrant firms, we find that food, transportation equipment, electric and electrical products, and chemical and chemical products are the 4 out of 14 manufacturing industries where we do not reject H3 at the ten percent level of significance. Similarly, transportation equipment, and chemical and chemical products are the only industries where we do not reject H4. Rejection of H3 occurs in all retail trade industries, while shoe, apparel, fabric and yarn stores, and general retail merchandising are the only retail trade industries where we do not reject H4 for new entrants. The results are even more complete when looking at the incumbents.

TABLE V

Test of firm size-firm growth independence, 1986–1995 growth

Chi-squared value[a] Industry	New entrants				Incumbents			
	H1	H2	H3	H4	H1	H2	H3	H4
All manufacturing	13.47**	15.57**	757.13**	1,206.42**	28.15**	21.52**	33,577.31**	46,056.21**
10. Food	7.52	5.49	6.96**	12.69*	22.65**	13.52**	254.01**	289.02**
11. Beverage products	–	–	–	–	5.70	5.85	51.12**	111.92**
12 Tobacco products	–	–	–	–	–	–	–	–
15. Rubber products	–	–	–	–	1.59	1.07	79.66**	95.42**
16. Plastic products	3.81	5.49	19.11**	−35.84**	10.53*	4.84	992.41**	1,131.26**
17. Leather products	–	–	–	–	2.78	4.13	151.25**	230.58**
18. Primary textile	–	–	–	–	0.23 [c]	118.73**	3.63 [c]	43.78**
19. Textile products	3.86	3.00	16.16**	44.48**	4.76	13.28*	74.41**	56.73**
24. Clothing	3.24 [b]	15.65**	22.66[b]**	40.51**	8.82	2.61	535.53**	632.83**
25. Wood products	7.31	9.58*	13.78**	27.55**	29.83**	24.34**	1,235.98**	1,394.08**
26. Furniture and fixture	20.94**	5.41	22.07**	63.97**	5.01	11.01*	131.60**	135.53**
27. Paper and allied products	–	–	–	–	1.98	4.32	23.84**	35.51**
28. Printing, publishing, and allied	4.07	0.58	9.38*	10.62*	50.30**	28.25**	1,436.82**	1,529.92**
29. Primary metal	–	–	–	–	2.24	6.87	1,397.32**	1,765.87**
30. Fabricated metal	16.06**	20.98**	48.03**	75.87**	26.32**	8.23	3,857.85**	4,181.70**
31. Machine	17.16**	12.70**	40.33**	55.21**	19.01**	13.41**	1,116.22**	1,195.28**
32. Transportation equipment	0.60	3.54	3.20	7.81	13.41**	15.45**	842.28**	1,002.79**
33. Electrical and electrical products	2.01 [b]	7.61	6.25 [b]	32.82**	3.25	3.70	66.39**	94.92**
35. Non-metallic mineral products	2.72 [c]	2.61 [b]	6.03 [c]	12.23 [b]*	24.24**	8.87	159.79**	167.20**
36. Refined petroleum and coal products	–	–	–	–	3.49	14.40**	3.36	13.92*
37. Chemical and chemical products	5.62 [b]	7.56	3.11 [b]	3.70	10.58*	4.93	220.42**	218.34**
39. Other manufacturing	9.21	12.69**	123.74**	226.62**	18.79**	12.53*	164.57**	154.26**
All retail	38.73**	18.05**	177.48**	269.28**	342.57**	307.82**	23096.95**	24278.24**
60. Food, beverage and drug	10.96*	6.37	64.51**	98.87**	100.70**	76.10**	1,736.51**	1,552.67**
61. Shoe, apparel, fabric and yarn	2.07 [b]	31.89**	25.75[b]**	7.52	53.96**	31.35**	1,412.59**	1,978.77**
62. Household furniture and furnishings	17.88**	23.46**	40.35**	88.22**	58.51**	20.61**	2,379.26**	2,569.53**
63. Automotive vehicles and parts	31.91**	7.50	135.21**	145.08**	146.19**	211.38**	9,598.81**	8,906.62**
64. General retail merchandising	–	1.83 [b]	–	5.83 [b]	19.76**	35.60**	182.37**	201.58**
69. Other retail stores	17.25**	6.42	22.42**	42.14**	76.16**	33.55**	7,283.25**	7,952.02**

Notes: [a] Unless otherwise noted all tests are Chi-Squared with four degrees of freedom under the null hypothesis.
[b] Firms filled four of the size groups. Resulting test is Chi-Squared with three degrees of freedom under the null hypothesis.
[c] Firms filled three of the size groups. Resulting test is Chi-Squared with two degrees of freedom under the null hypothesis.
* The null hypothesis is rejected at the 5 percent level of significance. ** The null hypothesis is rejected at the 1 percent level of significance.

For incumbents, primary textile, and refined petroleum and coal products are the only two industries where we do not reject H3 at the 10% level. Further, H4 is rejected for all industries at the one percent level of significance. Proposition (ii) of Gibrat's Law does not hold across the various samples of firms considered.[8]

As a robustness check, we repeat the equality of means tests and equality of variance tests using alternative cut-offs on the size classes. These results are robust to varying the limits on the size classes.

5.2. *Growth persistence*

A regression framework provides the other traditional methodology used to examine Gibrat's Law. We have the following logarithmic equation to describe firm size evolution

$$\ln(S_{it}) = \alpha + \beta \ln(S_{it-1}) + e_{it} \tag{7}$$

where t is an index for time, i is an index for the firms, S_{it} is the employment size of firm i at time t and e_{it} is a random error with zero mean and finite variance. Equation (7) provides a method to test proposition (i) of Gibrat's Law. The proposition is not rejected when $\beta = 1$ in the above regression.[9] If $\beta < 1$ then expected growth rates are higher for smaller firms, while if $\beta > 1$ then expected growth rates are higher for larger firms.

The specification of Equation (7) allows for alternative methods to handle issues surrounding the testing of Gibrat's Law.[10] Persistence of firm growth represents a violation of Gibrat's Law. It is possible to modify Equation (7) to account for growth persistence. The reader is reminded that attention is limited to surviving firms since growth persistence of exiting firms cannot be analyzed. If proposition (iii) of Gibrat's Law holds then e_{it}. are serially uncorrelated. However, if $e_{it.}$ are serially correlated then firm growth in one period affects firm growth in the next period. Following Chesher (1979), growth correlation is modelled as e_{it}. having a first order autoregressive process, so that:

$$e_{it} = \rho e_{it-1} + u_{it} \tag{8}$$

where u_{it} is assumed to be a zero mean, finite variance and serially uncorrelated random variable. If we substitute between (7) and (8) then we obtain

$$\begin{aligned}\ln(S_{it}) = {} & (1 - \rho)\alpha + (\beta + \rho)\ln(S_{it-1}) \\ & + (-\beta\rho)\ln(S_{it-2}) + u_{it}\end{aligned} \tag{9}$$

Equation (9) is specified in such a manner, so that both proposition (i) and (iii) of Gibrat's Law can be tested. These two propositions are valid if the joint hypothesis of $\beta = 1$ $\rho = 0$ and is accepted. Proposition (iii) is valid if $\rho = 0$ is accepted.

Estimation of Equation (9) is done across individual years. This discussion focuses on estimation results from the years of 1989, 1992, and 1995. The alternative years control for changes related to the business cycle and allow for age comparisons. The growth correlation patterns may be different for younger and older firms. Comparisons are made between entrant and incumbent firms, and between the entrant group at different ages. The discussion initially focuses on estimates for the aggregate manufacturing and retail trade sets and then moves on to look at similarities and differences across the sub-industries.

The following results emerge from the estimation of Equation (9).[11] First, Gibrat's Law is rejected for both new entrants and incumbents because of growth persistence when looking at the aggregate manufacturing and retail trade samples. In all cases, ρ is negative and statistically different from zero. The growth correlation coefficients typically vary between −0.1 and −0.2. The patterns are similar across industry and age groups regarding estimates of β. For example, β is less than one and statistically different from one for all groups in 1989. In 1992, β is less than or equal to one for all groups, but β is statistically different from one for only one group – incumbent manufacturing firms. Finally, in 1995, β is greater than one for all groups and statistically different from one for entrant manufacturing firms, incumbent manufacturing firms, and incumbent retail firms.

Second, the results vary slightly across the two-digit sub-industries for new entrants. For new entrants, 16 out of 20 industries experience at least one rejection at the five percent level of significance of Gibrat's Law. About 14 out of these 16 industries experience a rejection of the law because of growth persistence with 11 of these rejections due to a negative value of ρ. All 6 of the retail trade sub-industries experience a rejection of Gibrat's Law due to growth persistence occurring at least once across the three years. No further systematic patterns emerge across sub-industries or within sub-industries across years for new entrants.

Incumbents experience more consistency across sub-industries. With the exception of tobacco products, each sub-industry experiences at least one rejection of $\beta = 1$ or $\rho = 0$ at the five percent level of significance. Across the years, the estimates of β for the sub-industries follow patterns similar to those at the aggregate manufacturing or retail trade levels. Further, in addition to tobacco products, beverage products and rubber products are the only industries where we do not reject $\rho = 0$. In all cases of rejection, ρ is found to be negative. For both new entrants and incumbents the results suggest negative growth persistence. This result contrasts the typical result of positive growth persistence found in previous studies listed by the Audretsch et al. (2004) review. Further, the result of a negative autocorrelation coefficient (ρ) does not change across years.[12]

6. Conclusions

This paper looks at the validity of Gibrat's Law holding for retail and manufacturing firms. A sample of new firms is created for retail and manufacturing sectors to control for age. If Gibrat's Law holds for a sample of firms then three characteristics are valid for the sample. First, firm growth must be independent of firm size. Second, the variance of firm growth must be independent of firm size. Finally, firm growth is independent across time. These three propositions are tested for each of the four samples of firms.

The results are quite clear and consistent across Canadian manufacturing and retail firms at two different age classifications. At least one of the propositions implied by Gibrat's law fails to hold for each sub-industry within manufacturing and retail trade. In general, Gibrat's Law does not hold for these firms. The findings for retail trade firms are particularly striking where all of the sub-industries experience highly significant rejections of firm growth-firm size independence and firm growth variance-firm size independence. The results of this paper are summarized by three findings. First, smaller firms tend to have higher growth rates on average than do larger firms. The variability of firm growth varies with firm size, so that the variability of growth tends to be larger for smaller firms. Finally, there is a quantity of evidence showing negative correlation between growth rates across time, which means that firm growth exhibits negative growth persistence. Taken individually, the three propositions of Gibrat's Law are rejected.

The results presented here do appear to be consistent with previous studies, since Gibrat's Law is rejected. Audretsch et al. (2004) provide a comprehensive review of previous Gibrat's Law studies. Most of these studies look at manufacturing firms or a combination of large manufacturing and service sector firms. The total number of studies listed is 51. There are 8 acceptances of Gibrat's Law, 27 rejections of Gibrat's Law, and 16 with mixed results. Gibrat's Law is also rejected for Canadian retail and manufacturing firms. Industry dynamics are similar across the two sectors.

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Notes

[1] Further, Sutton (1997) and Caves (1998) provides a critical discussion of both empirical investigations and related theoretical implications of industry and firm dynamics.

[2] Jovanovic (1982) provides such a life cycle theory.

[3] Sample of firms refers to whether the sample includes (1) all firms, (2) surviving firms or (3) large firms. For example, Mansfield (1962) looks at firms in three manufacturing industries (steel, petroleum refining and rubber tire). He finds that Gibrat's Law is rejected in 7 out of 10 cases when looking at the sample of firms that includes all firms. When examining survivors, Mansfield rejects Gibrat's Law in 4 out of 10 cases. Mansfield finds that growth patterns for large firms are consistent with Gibrat's Law.

[4] Examples include Dunne et al. (1988), (1989) for U.S. firms, Wagner (1994) and Almus and Nerlinger (2000) for German establishments, and Audretsch et al. (1999) for Italian firms.

[5] Sutton (1997) provides a formal description.

[6] A firm's exit year is defined as the last year that it hires employees. We cannot identify those firms that exit in 1996 since we would need 1997 information to determine if 1996 is the last year, a firm hires employees.

[7] Partial reporting is similar to the measurement error problem, which has been analyzed by Hall (1987).

[8] Again, analysis is repeated for firms with more than 5 employees. H3 and H4 are rejected for all groups. One could argue that proposition (ii) fails to hold because small firms with highly variable and turbulent growth rates dominate results. This result shows that turbulence growth of small firms is not the cause for failure of proposition (ii).

[9] Equation (7) has been estimated using a least squares approach. Lotti et al. (2003), and Fotopoulos and Louri (2004) use quantile regression methodology to estimate Equation (7). Wooldridge (2002) notes that the quantile regression allows us to determine how conditional quantiles of the dependent variable change with a change in a regressor. Fotopoulos and Louri (2004) point out that the quantile regression estimates are robust to non-normality in the error term, since the quantile regression looks at particular point in the distribution of the dependent variable. Least squares estimation looks at the impact regressors have on the conditional mean of the dependent variable. A least squares estimate of $\beta \neq 1$ indicates that firm growth conditionally depends on firm size. Therefore, $\beta \neq 1$ is sufficient to reject Gibrat's Law without the need to further examine the firm growth distribution. Nonparametric methods used in the previous section to test the validity of Gibrat's Law also look at how the conditional mean growth rate changes with firm size, but also allow for a non-linear relationship between firm size and growth.

[10] Firm exit creates a potential sample selection problem when estimating Equation (7). The size of exiting firms will be zero, which creates a problem when using the logarithmic transformation. Thus, these firms cannot be included in the estimation of Equation (7). This is only a problem in the situation when investigating Gibrat's Law on the sample of all firms including exits. Evans (1987 a, b), Hall (1987), and Dunne and Hughes (1994) overcome the problem of exit using a maximum likelihood sample selection model, which includes the estimation of firm survival determinants. Audretsch et al. (1999) use a second method to deal with exit within the logarithmic regression by augmenting a firm's size numbers by 0.1. Lotti et al. (2003) mention that if exit and growth are treated as separate events then growth can be examined independent of survival by focusing on the growth of survivors.

[11] Although not reported, estimates of Equation (9) are available from the author upon request.

[12] We repeated estimation of Equation (9) with the panel that included the years 1988–1995. Year dummy variables were added as controls. The estimate of ρ was approximately -0.10 for new entrants and incumbents at the aggregate manufacturing and retail trade levels.

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