R&D Intensity and Firm Growth and Institutions in Germany

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Abstract

The purpose of this paper is to examine the validity of Gibrat's Law as shaped by the context of country-specific institutions, industry, and time frame. Studies testing Gibrat's Law for North American have found that either the law holds (earlier studies) or that a negative relationship exists between firm size and growth. In this study we find a positive relationship emerges between firm size and growth in Germany, which may reflect differences in institutions such as the system of finance. Just as the empirical evidence suggests that the relationship between firm size and growth has been different in Germany than for North America, we also find that the results vary systematically across the industry context and the time.

JEL Classification Codes: (L00, O3, O4)

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I INTRODUCTION

Interest in establishing or refuting the empirical validity of the *Law of Proportional Effect*, or what has become known as *Gibrat's Law* has exploded in recent years. In his comprehensive survey on "Gibrat's Legacy", Sutton (1997, p. 40) interprets the Law as an "expected value of the increment firm's size in each period is proportional to the current size of the firm." The plethora of empirical studies has produced such a body of evidence, that it has taken three major surveys (Caves, 1998; Sutton, 1997; and Geroski, 1995) two of which are published in the *Journal of Economic Literature*, to interpret and digest the wealth of empirical results.

The fundamental question addressed by these studies, as articulated by Mansfield (1962, pp. 1030-1031), "is the probability of a given proportionate change in size during a specified period is the same for all firms regardless of their size at the beginning of the period." As Sutton (1997) points out, research testing Gibrat's Law produces an answer that is either "yes" or "no". While the earlier studies (Hart, 1962; Mansfield, 1962) provided compelling evidence that the answer is "yes", that is Gibrat's Law seemed to hold, more recent studies (Evans, 1987; Hall, 1987; Dunne, Roberts and Samuelson, 1989; Audretsch, 1995) suggested exactly the opposite answer –"no", Gibrat's Law did not seem to hold. As Sutton (1997) points out, resolution to these seemingly contradictory results lies in systematic differences in the samples selected. The earlier studies included only large firms, but the more recent studies included a broader spectrum of firm sizes, including small enterprises as well as large firms. However, one thing both the earlier and more recent studies have in common is their formulation of the hypothesis, which, once subjected to an empirical test would be either confirmed or refuted.

The purpose of this paper is to suggest that perhaps the literature testing Gibrat's Law has focused on the wrong question. Rather than asking whether the Law holds or not, we argue that the more relevant question may be "Under what contexts is the empirical evidence compatible with Gibrat's Law and under what contexts is it not?" In particular, in this paper we suggest that the relationship between firm size and growth is shaped by the context, which reflects the country, time period and particular industry. We test for the validity of Gibrat's Law in Germany[1] in different time periods and across different industries and then compare these results with the findings summarized in Caves (1998), Geroski (1995) and Sutton (1997).

In the second section we explain why the validity of Gibrat's Law may vary according to context. The data base and measurement issues are explained in the third section. In the fourth section the empirical model to be estimated is introduced. Empirical results are provided in the fifth section. Finally, in the sixth section a summary and conclusions are provided. In particular, the empirical evidence suggests that whether or not Gibrat's Law holds very much depends upon the context, in terms of country-specific institutions, the industry, and the time period.

2. Gibrat's Law: Why Context Matters

2.1 The Country Context

There are many ways in which German institutions differ sharply from those in the United States. One institutional difference that may directly impact the relationship between firm size and growth involves the system of firm finance. The systematic

[1] Wagner(1992) has tested Gibrat's Law for establishments (not firms) in Lower Saxony. Almus and Nerlinger (1998 and 2000 have tested Gibrat's Law for young firms in Germany.

differential ability of firms of different sizes to obtain finance may influence the relationship between firm size and growth. The different financial systems between the United States and Germany might then account for differences in the size-growth relationship between the two countries.

A series of recent papers based on the U.S. has found that liquidity constraints tend to have a greater impact on smaller enterprises than on their larger counterparts. In particular, small firms are more likely to be unable to obtain capital at market interest rates and therefore subject to credit rationing. Fazzari, Hubbard, and Petersen (1988) found that smaller publicly traded firms face liquidity constraints and that such smaller enterprises in particular experience difficulties obtaining capital during periods of macroeconomic downturns. That is, the likelihood of a firm experiencing a liquidity constraint decreases along with increasing firm size. According to Fazzari, Hubbard and Petersen, smaller firms tend to be more dependent upon internal finance or bank loans than are their larger counterparts.[2] While the large firms in their study issued 99 percent of all new equity shares and 92 percent of all new corporate bonds, they accounted for only 74 percent of total manufacturing assets. Because smaller firms are more dependent upon loans from commercial banks, they are more prone to experiencing a credit crunch, especially during recessions. Fazzari, Hubbard and Petersen find evidence suggesting that the credit sources for smaller firms tend to dry up more rapidly during economic downturns than do the credit sources for larger enterprises.

[2]Not surprisingly, small enterprises more frequently turn to commercial banks for funding of capital projects. But, as Stoll (1984) notes, smaller firms typically face higher credit costs than do their larger counterparts. For example, a Federal Reserve Board study of loan rates charged by commercial banks on loans made between November 3 and November 7, 1986 found that short-term loans at a fixed rate had an average rate of 11.2 percent for loans of less than $24,000. However, the rate fell steadily to a mean of 6.8 percent for loans exceeding $1 million. For loans with a floating rate, the differential was not quite as great. The smallest loans had an average rate of 9.7 percent, while the largest loans were for 7.5 percent. Very similar patterns were identified for long-term loans at both fixed and floating rates (United States Small Business Administration, 1987, Table A2.7, p. 91). Thus, the evidence clearly indicates that the cost of capital tends to fall as the size of the loan increases.

There has been a series of recent studies suggesting that the institutional structure of Germany precludes such liquidity constraints from occurring.[3] There are two institutional features of the German financial system that sharply contrast to that practiced in the United States and the United Kingdom, both of which may impact the extent to which liquidity constraints occur. First, companies in Germany typically rely almost exclusively upon banks for external finance. The external capital market remains relatively undeveloped. Second, not only do the banks represent the major financial intermediary supplying capital to firms, but they are also extensively represented on the supervisory boards of companies. Cable (1985, p. 119) refers to this peculiarity of the German financial system which links finance to supervision as a "quasi-internal capital market".

Some studies such as Vitols (1998), have mentioned that the spread in lending rates between the largest and the smallest firms is lower in Germany than in the UK or the US. This is due in part to the effect of strong local and regional bank networks that target as customers the small and medium firms. It is still unclear however, how much this spread in rates effects German firm investment behavior between different sizes of firms.

While considerable attention has been placed on the role that the *Big Three* private banks play[4] in terms of financing the largest manufacturing corporations of Germany,[5] considerably less emphasis has been placed on the other institutions comprising the German financial system. Vitols (1998) points out that, in fact, the *Big Three* German banks only account for slightly less than one-tenth of all banking assets.[6] The bulk of credit from the *Big Three* private banks is channeled into the largest German

[3] See for example Allen (1990), Cable (1985), and Soskice (1992)
[4] The *Big Three* German banks are the Deutsche Bank, Dresdner Bank and the Commerzbank.
[5] See for example Cable (1985).
[6] The Monthly Report of the Deutsche Bundesbank (April 1989, p. 15, Table 4.1) points out that the market share of the *Big Three* fell from 10.2 percent in 1970 to 10.6 percent in 1978 to 8.9 percent in 1988.

firms. According to Vitols (1998, these banks have traditionally confined their industrial lending activities to larger corporate accounts. The largest financial institutions are the *Sparkassen*, which are essentially public savings banks, and the *Genossenschaftsbanken*, which essentially are co-operative banks. While the *Sparkassen* account for around 40 percent of all banking assets, the *Genossenschaftsbanken* account for about 15 percent of total banking assets (Deeg, 1992 and 1998). These financial institutions are generally oriented towards financing the *German Mittelstand*, or small- and medium-sized firms in Germany. While the economic and political power of the *Big Three* German banks, particularly in terms of providing finance and direction to the largest firms of Germany, has tended to pre-empt the attention from overseas, what must be one of the better kept secrets of Germany is the magnitude and role that these other institutions play in shaping the overall financial landscape of Germany -- particularly in providing finance to smaller enterprises.

The existence of these financial intermediaries channeling funds into the German *Mittelstand* has resulted in the emergence mechanisms providing smaller banks access to long-term, fixed rate funds. As Vitols (1998, p. 12) points out, these mechanisms, which are less developed or less absent in the United States and United Kingdom, include (1) special credit institutes which among other things issue bonds on national bond markets to refinance long-term fixed-rate loans to small firms, (2) refinancing and risk pooling mechanisms within both the savings bank and co-operative bank sectors, and (3) mechanisms allowing for the channeling of a high proportion of long-term savings held at insurance companies to the banks through bank bonds. Roughly two-thirds of long-term bank lending to small companies is refinanced through these three mechanisms.

It is the existence of this infrastructure of financial institutions mandated with providing the German *Mittelstand* , or medium-sized enterprises, with finance that

supposedly defuses the problem of liquidity constraints confronting smaller enterprises found by Evans and Jovanovic (1989) and Fazzari, Hubbard and Petersen (1988), among others, to exist for the United States. Whether, of course, whether the financial institutions under the German model are, in fact, able to avoid financial constraints imposed upon firms, and particularly smaller sized firms, is an empirical question which will be answered in the following sections. As Petersen and Rajan (1992, p. 1) point out, "One way to overcome frictions is for firms to build close relationships with the suppliers of capital. These relationships allow the lender to collect information about the borrower and their investments and to monitor the actions of the borrower."

If the degree to which different sized firms experience liquidity constraints differs systematically in Germany from the U.S., then the validity of Gibrat's Law might also be different in Germany than in the U.S. That is, significant differences in institutional factors across countries suggest differences in context that may lead to significant differences in performance.

2.2 The Industry Context

Why should the industry context make a difference? One important dimension of heterogeneity across industries is the relative importance of new ideas, or knowledge as an input. Stephan (1996) and Dasgupta and David (1994) argue that firms engaging in knowledge-based activities are typically associated with a greater degree of uncertainty, or *hyper-uncertainty*, and *hyper-knowledge asymmetries*, about the potential economic value of their investments. As Arrow (1962) emphasizes, more than most other economic goods, the production of new economic knowledge generally suffers from three sources constituting market failure – indivisibilities and monopoly, uncertainty, and externalities.

The first source of market failure emanates from the propensity for knowledge to be a discrete rather than a continuous commodity. As a result, both economies of scale and scope are often associated with the production of knowledge (Mueller and Tilton, 1969). The second source of market failure involves the extraordinarily high degree of uncertainty inherent in new economic knowledge. While virtually every economic good is subject to uncertainty, almost none is exposed to the degree of risk involved knowledge-based new technologies. There are two additional elements of uncertainty inherent in innovative activity that are not present in other goods. The first is in the realm of production. How a new good can be technically produced is typically shrouded in uncertainty. The second involves marketing the product. Whether a demand for the new product exists is not known. Even if the knowledge can result in a new product, it is not at all clear that the product can be profitably sold. Knowledge leading to a new economic good can be produced, but there is no guarantee that the new knowledge is economic knowledge.

The third source of market failure stems from the public good nature and non-exclusive externalities inherent in knowledge-based economic activity. The production of knowledge does not preclude other economic agents from applying that knowledge for economic gain. It is difficult to delineate and enforce property rights to newly created knowledge. The externalities associated with the production of new knowledge make it difficult for firms undertaking such activities to appropriate the economic returns accruing from their investment.

Since firms engaged knowledge-based activity are subject to *hyper-uncertainty*, *hyper- knowledge asymmetries*, as well as *non-exclusivity* it might be expected that they

experience a greater degree of liquidity constraints imposed upon them by traditional lending institutions than do non-knowledge based firms. Thus, firm size would be expected to be positively related to growth in such knowledge-based industries.

Larger firms can finance capital expenditures from internal earnings, issuance of equity, or debt. By contrast, smaller firms are limited in the extent of their internal earnings and the potential for issuing equity.

2.3 The Time Period

The third dimension that may influence the context involves the time period. In the case of Germany, there are compelling reasons to think that the validity of Gibrat's Law may differ before and after the mid-1970s. In Germany in particular since 1974, firms have been obligated by law to retain pension funds for employees. These funds, which can run into billions of Deutsche marks, have become an important alternative source of firm financing, particularly for the larger firms. It is expected that this would loosen the impact of liquidity constraints across firms, but particularly for the largest firms. In terms of the study, any results indicating binding liquidity constraints after 1974 should be strengthened.

The evidence found by Audretsch and Elston (2001) shows a systematic difference in the impact of liquidity constraints on the investment behavior of smaller firms. Apparently smaller firms were not subject to significant liquidity constraints prior to the mid-1970s but became subject to liquidity constraints subsequent to 1970s. Consistent with these results were the changes in the West German discount lending rates which rose substantially from a mean rate of 4.7% between 1968 and 1973 to 5.1% between

1974 and 1980, then down slightly to 4.9% on the average between 1981 and 1992. It may be that the financial institutions of Germany did provide a system of finance that was different from the Anglo-Saxon model, in that liquidity constraints could be avoided -- but only prior to the mid-1970s. Since then, there is no evidence suggesting that the German model of finance has managed to mitigate the impact of liquidity constraints.

3. Data and Measurement

3.1 Description of the Data

The firm level data for this study were taken from the Bonn Database. The Bonn Database is a relatively new data source tracking the financial performance of a comprehensive set of German firms, and was constructed from annual business reports of firms, the *Handbuch Der Aktiengesellschaften*, and the *Statistisches Jahrbuch*. It contains effectively all publically traded German firms from 1970-1984.

It is important to consider the possibility of bias in results due to entry and exit of firms during the sample period. We examined firm survival and hazard rates for this sample using the methodology outlined in Cox (1972) for a set of standard for 50-250 year time estimates and found no evidence of bias introduced from firm entry or exit in this data. In fact on the average, firm survival rate was rather high at 99% over the sample time period. We tested for and found heteroskedasticity in the data and subsequently corrected for it in all estimations.

Firm growth is calculated as the log of employment in the ending time period minus the log of employment in the initial time period over the log of employment in the initial time period.[7] The variable Size is the log of employment, and Age is the log of

[7] All log variable transformations use the natural log.

the life span of the firm in the initial time period. In order to examine the potential importance of industry specific growth behavior, firms were grouped using four-digit industry sector codes into four groups. Industry Group1 contains all 61 firms from metals, minerals, chemicals and fiber industries, Group2 has 77 firms from mechanical engineering, electric and precision instruments, and motor vehicles. Group3 has 67 food, tobacco, and textiles firms, and Group4 contains all other firms in the sample, which totals 70 firms, including utility companies.

High technology firms were defined using criteria from Audretsch and Weigand (2000) on firm total expenditures for R&D and innovation as a percent of sales revenue in 1980. The 75 high technology firms, are in fact the larger firms in the sample in terms of net sales and number of employees. This is interesting because empirical studies on the US have generally found that the smaller firms were doing more of the research. One reason for this may be that during the 1970's and 1980's in Germany larger firms supposedly had better access to capital markets for R&D funding, which was one justification for the new capital markets (eg. Neuer Markt was initiated in 1997) to channel investment capital for R&D to smaller high technology firms.

4. The Empirical Growth Models and Refutable Hypotheses

The empirical growth equations which are well established in the growth literature, are derived from "Gibrat's Law" which suggests that the present size of firm i in period t may be decomposed into the product of a "proportional effect" and the initial firm size as:

$Size_{i,t} = (1 + \varepsilon_t)\, Size_{i,t-1}$ where $(1 + \varepsilon_t)$ denotes the proportional effect for firm i in period t. Here the random shock ε_t is assumed to be identically and independently distributed. Taking the natural log and using the fact that for small ε, $\ln (1 + \varepsilon) \approx \varepsilon_t$, we derive the following relationship, $\ln (Size_{i,t}) = \ln(Size_{i,0}) + \sum^{t}_{k=1} \varepsilon_{it}$ which as $t \to \infty$ results is a distribution which is approximately log normal with properties that $\ln (Size_{i,t}) \sim N(t\mu_\varepsilon , t\sigma^2_\varepsilon)$. [8]

Annual percentage firm growth can be then measured using number of employees $Growth_{it}$, of the firm as $Growth_{it} = \ln(S_{i,t}) - \ln(S_{i,t-1})$, where growth is calculated as the difference in the log of size for firm i between this period t and the initial period (t - 1) size, over log of the initial period size.

Based on Hall (1987) or Evans (1987) the traditional empirical growth equation for testing the hypothesis that initial firm size and impacts firm growth can be specified:

$$Growth_{it} = B_1 \ln(Size_{i,t-1}) + B_2 \ln(Size_{i,t-1})^2 + B_3 Age_{i,t-1} + B_4 D_{ind} + \varepsilon_I \quad (1)$$

where Growth is a function of Size, measured by the log of employment in the initial time period, Age, measured by the log of the life span of the firm in the initial time period, and ε_I, is a stochastic error term. Regressions control for D_{ind} industry effects by using a vector of industry dummies -except when regressions are divided into industry groups.

[8] Almus and Nerlinger (2000) confirm this distributional assumption via kernal density estimates for

To test for the importance of size on growth for different class of industries these equations are run on an all firm sample, as well as on subgroups of firms sorted into high and low technology, the four industry groupings, and five year time periods from 1970 to 1984.

5. Results

The results estimating the validity of Gibrat's Law for the entire sample of firms over the entire sample period, 1970-1984 are shown in Table 1. As the positive and statistically significant coefficients of both the size and size-squared terms suggest, the results suggest that, for the most general sample Gibrat's Law does not hold. While this finding is compatible with results for North America, there is an important difference. In the North American context firm size is negatively related to growth. However, for the entire sample over the entire sample period for Germany, firm size is found to be positively related to growth.

Table 1 also suggests that industry context matters. For the low R&D industries, a positive relationship emerges between firm size and growth. By contrast, for the knowledge-intensive industries, there is no statistically significant relationship observed between firm size and growth. That is, Gibrat's Law apparently holds in knowledge-based industries over this period.

The relationship between firm age and growth also varies systematically between industry contexts. As the negative and statistically significant coefficient of age in low-knowledge industries suggests, growth rates tend to decline systematically over the life-cycle of the firm. By contrast, in the high-knowledge industries, the positive and

German firms 1990-1996.

statistically significant coefficient of age indicates that growth rates tend to increase systematically over the life-cycle of the firm. Thus, different results emerge for both the firm size-growth relationship and the firm age-growth relationship between the low- and high-knowledge industry contexts.

Separate results from the four industry groups provide even further evidence that the industry context matters. Gibrat's Law is found to hold for Group 3, engineering & vehicles. However, Gibrat's law clearly does not hold for Group 1, metal & chemicals, Group 2, engineering & vehicles, or Group 4, utilities & others. While a negative relationship exists between firm size and growth for metals & chemicals, and for engineering & vehicles, a positive relationship is found for utilities & other industries.

Table 2 provides results for the early 1970s. Between 1970 and 1974 Gibrat's Law is found to hold for all firms. In fact, during this period, the industry context plays no significant role. Gibrat's Law is found to hold for low-knowledge industries, high-knowledge industries, and for all four of the industry groups.

Table 3 provides results for the late 1970s. Between 1975-1979 the evidence does not support Gibrat's Law. Rather, a positive relationship exists between firm size and growth. While these results hold for both of the industry contexts based on R&D intensity, there is support for Gibrat's Law in metals & chemicals, engineering & vehicles, and utilities & other industries. Gibrat's Law apparently does not hold in food & textiles.

The results for the 1980s are provided in Table 4. As for the late 1970s, Gibrat's Law is found not to hold. However, one difference in the 1980s is that the evidence does

support the validity of Gibrat's law in high knowledge industries. Other differences are that the Law apparently does not hold in metals & chemicals, food & tobacco, and utilities & others, while it does hold in engineering & vehicles.

6. Conclusions

A massive literature has been compiled that tests the validity of Gibrat's Law. In posing the question, "Is Gibrat's Law valid or not?" these studies have generally produced results that either confirm or refute the Law. The results of this study suggest that perhaps this literature has been asking the wrong question. Rather a slightly different question may be more relevant, "Under which context does Gibrat's Law hold and under which context does it not?"

In fact, the empirical evidence provided by this paper suggests that the validity of Gibrat's Law is shaped by context. In particular, the context of country-specific institutions, the industry, and the time period apparently make a difference in determining the validity of Gibrat's Law. Studies testing Gibrat's Law for North American have found that either the Law holds (earlier studies) or that a negative relationship exists between firm size and growth. For Germany a positive relationship emerges between firm size and growth. The different relationship between size and growth may reflect differences in institutions such as the system of finance. Just as the evidence suggests that the relationship between firm size and growth has been different in Germany than for North America, we also find that the results vary systematically across the industry context and the time period context.

The relationship between firm size and growth may be considerably different in Germany with the development of high-technology entrepreneurial startups in the last several years. The establishment of the Neuer Markt (New Market) has led to an explosion of such knowledge-based startups. Future research needs to identify how this new context influences the relationship between firm size and growth in Germany.

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Table 1

Descriptive Statistics

Variables	All Firms 1980-1984	Low R&D Intensity	High R&D Intensity
Size	6958 (19688)	6012 (18882)	13750 (24368)
Growth	-0.047* (0.1162)	-0.050* (0.100)	-0.036 (0.155)
Age	122.99 (62)	130.12 (86.88)	115.85 (36.50)
N	263	229	34

Standard Deviations in parenthesis. Size is number of employees.

Table 2

Industry Fixed-Effects Growth Model
1970-1984

Growth	All Firms 1970-1984	Low R&D Intensity	High R&D Intensity	Ind Group 1	Ind Group 2	Ind Group 3	Ind Group 4
Size	0.343678*	0.48915*	1.010471	-0.16551*	-0.21328**	-0.04395	0.224059*
	(3.30)	*(3.98)*	*(1.33)*	*(-2.34)*	*(-1.68)*	*(-0.70)*	*(2.39)*
Size2	-0.04314*	-0.06817*	-0.1088	0.026946*	0.031195	0.012227	-0.02802
	(-2.75)	*(-3.42)*	*(-1.18)*	*(2.20)*	*(1.63)*	*(0.85)*	*(-1.59)*
Size3	0.001773*	0.003069*	0.003805	-0.00133*	-0.00134	-0.00092	0.001161
	(2.37)	*(3.02)*	*(1.04)*	*(-2.01)*	*(-1.43)*	*(-0.93)*	*(1.16)*
Age	-0.01731	-0.03854*	0.156247*	0.050805	0.07602	-0.00529	-0.13399*
	(-0.94)	*(-2.22)*	*(2.13)*	*(1.62)*	*(1.16)*	*(-0.24)*	*(-4.12)*
N	226	168	58	49	66	53	58
Adj. R2	0.0777	0.1640	0.1674	0.0215	0.0046	0.0181	0.2984

Stars indicate statistically significant at the * 5% and ** 10% levels. Regressions include industry and annual dummies.

Industry Groups: Group 1 metal & chemicals, Group 2 engineering & vehicles, Group 3 food and textiles, Group 4 utilities & other.

Table 3

Industry Fixed-Effects Growth Model
1970-1974

Growth	All Firms	Low R&D Intensity	High R&D Intensity	Ind Group 1	Ind Group 2	Ind Group 3	Ind Group 4
Size	-0.00325	-0.01443	0.213387	-0.02005	-	0.01073	-0.00323
	(-0.10)	*(-0.32)*	*(1.02)*	*(-0.91)*	*(-0.76)*	*(0.32)*	*(-0.10)*
Size2	0.000512	0.002314	-0.02628	0.003945		-0.0022	0.000912
	(0.10)	*(0.32)*	*(-1.04)*	*(1.02)*	*(0.43)*	*(-0.28)*	*(-0.19)*
Size3	-0.00003	-0.00012	0.001037	-0.0002	-0.00006	0.000058	-0.00007
	(-0.11)	*(-0.32)*	*(1.04)*	*(-0.97)*	*(-0.22)*	*(0.11)*	*(-0.19)*
Age	0.00271	0.000901	0.014204	0.001799	0.019489	-0.00028	0.000795
	(0.45)	*(0.14)*	*(0.75)*	*(0.19)*	*(1.04)*	*(-0.03)*	*(0.07)*
N	259	190	69	58	73	62	66
Adj. R2	0.0417	0.0263	0.0720	0.0337	0.0181	0.0038	0.0013

Stars indicate statistically significant at the * 5% and ** 10% levels. Regressions include industry and annual dummies.

Industry Groups: Group 1 metal & chemicals, Group 2 engineering & vehicles, Group 3 food and textiles, Group 4 utilities & other.

Table 4

Industry Fixed-Effects Growth Model
1975-1979

Growth	All Firms 1975-1979	Low R&D Intensity	High R&D Intensity	Ind Group 1	Ind Group 2	Ind Group 3	Ind Group 4
Size	0.1603*	0.2432*	0.3983*	-0.0553	0.0023	-0.0471	0.02375
	(3.88)	*(3.98)*	*(3.14)*	*(-0.95)*	*(0.11)*	*(-1.62)*	*(0.50)*
Size2	-0.0230*	-0.0368*	-0.046*	0.0080	-0.00158	0.0123**	-0.0029
	(-3.71)	*(-3.73)*	*(-2.94)*	*(0.98)*	*(-0.53)*	*(1.70)*	*(-0.32)*
Size3	0.001*	0.0017*	0.0017*	-0.0004	0.0001	-0.0009**	0.0001
	(3.54)	*(3.45)*	*(2.78)*	*(-0.91)*	*(0.83)*	*(-1.71)*	*(0.20)*
Age	0.0087	0.0075	0.0110	0.0085	0.0028	0.0029	-0.0115
	(1.22)	*(0.90)*	*(0.86)*	*(0.40)*	*(0.27)*	*(0.33)*	*(-0.69)*
N	257	189	68	59	73	62	63
Adj. R2	0.0715	0.098	0.1225	0.0177	0.0338	0.0377	0.0135

Stars indicate statistically significant at the * 5% and ** 10% levels. Regressions include industry and annual dummies.

Industry Groups: Group 1 metal & chemicals, Group 2 engineering & vehicles, Group 3 food and textiles, Group 4 utilities & other.

Table 5

Industry Fixed-Effects Growth Model
1980-1984

Growth	All Firms 1980-1984	Low R&D Intensity	High R&D Intensity	Ind Group 1	Ind Group 2	Ind Group 3	Ind Group 4
Size	0.20874*	0.3134*	-0.2752	-0.1104*	-0.1099	-0.0659*	0.2111*
	(3.39)	*(5.08)*	*(-0.68)*	*(-2.11)*	*(-1.12)*	*(-1.67)*	*(3.64)*
Size2	-0.02554*	-0.044*	0.0450	0.0154**	0.0195	0.0204*	-0.0291*
	(-2.64)	*(-4.25)*	*(0.86)*	*(1.75)*	*(1.36)*	*(2.12)*	*(-2.63)*
Size3	0.001029*	0.0020*	-0.0022	-0.0007	-0.0009	-0.0015*	0.0013*
	(2.16)	*(3.68)*	*(-0.99)*	*(-1.53)*	*(-1.35)*	*(-2.16)*	*(2.12)*
Age	-0.02299**	-0.0361*	0.1076*	0.0505*	0.0182	-0.0056	-0.1174*
	(-1.69)	*(-3.15)*	*(1.80)*	*(2.22)*	*(0.35)*	*(-0.45)*	*(-6.19)*
N	230	171	59	49	67	55	59
Adj. R2	0.1430	0.3134	0.1542	0.0697	0.0110	0.0471	0.4760

Stars indicate statistically significant at the * 5% and ** 10% levels. Regressions include industry and annual dummies.
Industry Groups: Group 1 metal & chemicals, Group 2 engineering & vehicles, Group 3 food and textiles, Group 4 utilities & other.