International Review of Applied Economics
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713426883

Are Firm Growth Rates Random? Analysing Patterns and Dependencies

Toke Reichstein [a]; Michael S. Dahl [a]
[a] Aalborg University, Denmark

Online Publication Date: 01 April 2004

To cite this Article Reichstein, Toke and Dahl, Michael S.(2004)'Are Firm Growth Rates Random? Analysing Patterns and Dependencies',International Review of Applied Economics,18:2,225 — 246
To link to this Article: DOI: 10.1080/0269217042000186705
URL: http://dx.doi.org/10.1080/0269217042000186705

International Review of Applied Economics,
Vol. 18, No. 2, 225–246, April 2004

Are Firm Growth Rates Random? Analysing Patterns and Dependencies

TOKE REICHSTEIN & MICHAEL S. DAHL

Aalborg University, Denmark

ABSTRACT *Using Danish firm data covering almost 9000 observations, we find significant proof that firm growth cannot be considered as a simple Gibrat growth process. Key variables, such as size, age, geographical location and industry structure are tested against firm growth rates in turnover and employment. Besides running the regressions on all observations, we also consider and find highly interesting patterns in an industry context. Thus, we conclude that firm growth cannot be considered idiosyncratic. Firm growth is highly dependent on industry and geography.*

KEY WORDS: Firm growth; geographical location; industrial differences

Introduction

A large part of the economic environment is determined by the performance of firms. Macroeconomic growth rates, unemployment and standards of living, just to mention a few, are highly correlated with the economic performance of firms. To explain the performance of the economy in general, the composite, and hence the microeconomic agents, of the economy needs to be analysed.

This paper analyses the economic performance of firms. The term 'performance' may refer to two things: profitability or firm growth (Geroski, 1994). The latter of these is investigated here. The term 'performance' in this paper therefore should be perceived as another term for firm growth.

It will be highlighted that although empirical generalisation implies that firms grow at a rate proportionate to size and as a random walk (e.g. Gibrat's Law), a large number of empirical studies have shown a statistically significant relationship between firm growth and a number of other variables. This paper investigates such variables as firm size, firm age, the geographical location of the firm, the market concentration of the specific industry and the characteristics of the industry to which the firm is associated. The value of the view of the firm growth process as completely stochastic is questioned by regressing a number of variables against firm growth measures.

Correspondence Address: Toke Reichstein & Michael S. Dahl, Department of Business Studies, Aalborg University, Fibigerstræde 4, DK-9220 Aalborg Oe, Denmark. Email: tr@business.auc.dk & md@business.auc.dk

ISSN 0269-2171 print; ISSN 1465-3486 online/04/020225-22 © 2004 Taylor & Francis Ltd.
DOI: 10.1080/0269217042000186705

The outline of the paper is as follows. The next section builds the foundation of the variables in the model, after which the formal model to be testedis built. The data used and its structure is described. The regression equation to be tested and the results are presented in the penultimate section and the finally section presents conclusions.

Firm Growth and Factors of Dependence

Geroski (2000) summarised the stylised facts concerning the firm growth process. These stylised facts give four implications. First, changes in firm size are driven by unexpected shocks. From this it is evident that the growth rates of firms are random shocks. Furthermore these randomly determined growth rates are not serially correlated.

Second and perhaps more important, unexpected shocks have permanent effects on the size of the firm. This means that growth in size is a path dependent process, since the size of a firm at any time is the sum of the entire history of shocks, which the firm has experienced.

Third, growth rates appear to be idiosyncratic, since empirical studies indicate that the growth of different firms is uncorrelated. This is opposite to common sense, which suggests the growth of firms to be correlated with the growth of the economy or industry. This means that the growth of firms is history dependent with every firm having its own history.

Fourth, growth rates are rather volatile. This is motivated by evidence that firms do not adjust costs according to eventual shocks – not even partially. Firms are not fully able to anticipate shocks and therefore they cannot begin reacting before the shocks occur. Hence growth rates fluctuate considerably.

By characterising firm growth as a random walk, these stylised facts leave little to be explained concerning growth. The paper questions whether this is correct. It leaves nothing for the policy makers and perhaps even less for the business managers, because the firm growth process is entirely stochastic according to these four points. We believe some variables may be singled out as being important for the growth of the firm. Even though a growth process may seem to be stochastic on the surface, it may still be possible to find a few variables that have a significant influence on this process. Here the size and age of the firm, the market condition in term of diversity of firm sizes, the geographical location of the firm and the industry to which the firm is associated are considered important when trying to understand the growth patterns of firms. We consequently regress these variables against firm growth.

Some of the arguments used in the article for selection of explanatory variables go directly against one or more of the points summarised by Geroski. To the extent the model will show significant results, the idea of firm growth solely being stochastic may be dropped. Also the overall fit of the model may give some indications as to what degree the process may be stochastic with no reference point what so ever.

Size

Early studies found no relationship between the growth rate of a firm and its size. The fact that these two characteristics are independent of each other implies that firms grow at a rate proportionate to their size. This is often referred to as Gibrat's Law (Jovanovic, 1982).

It has been argued that Gibrat's Law may be only valid when viewed in relation to larger firms. Including small firms in the considerations, Gibrat's Law becomes invalid (Evans, 1987a, 1987b). Nevertheless Evans (1987a) showed that firm growth decreases with firm size. These findings were reinforced by Hart & Oulton (1996). In a study based on 1989–93 firm data they found that smaller firms generated proportionately more jobs than larger. Keeping in mind that smaller firms generally are more vulnerable indicating a higher death rate.

Similar to these findings, Geroski (2000) points out that the estimates of the slope of a size variable in a growth model are rather small and negative, which indicates 'mean reversion', where small firms tend to show a proportionately higher growth than larger firms. When the differences in firm size are decreasing, this leads to a limited overall increase in the variance of firm sizes.

Hall (1987) and Dunne & Hughes (1994) have presented similar results. Hall showed that smaller firms grow four percentage points faster than larger firms on average annually. Her growth rate analysis covers the 1980–85 period analysing annual averages. Dunne and Hughes generated results for the UK, which were more ambiguous. They showed that the larger firms grew more rapidly in the 1960s, but smaller firms had a higher average annual growth rate in the 1980s. This may be an indication of a time dependent relationship between firm size and firm growth. One factor that may be important in these findings is the structure of the economy at these specific points in time. In the 1960s the western economies, and especially the USA, experienced a general tendency toward higher concentration rates in the industries, while the picture was somewhat reversed in the 1980s. This pattern may have had a significant effect on the results of the UK study by Dunne and Hughes. The general rapid rise in market concentration in 1950s and 1960s is confirmed by the study of Sawyer (1971) on UK manufacturing industries. Recent evidence for the US finds that the aggregate concentration declined in the 1980s and early 1990s and then generally increased in the mid-1990s (White, 2002).

According to Nelson & Winter (1982), firm growth is related to the ability to innovate. Therefore firm growth rates may be expected to be serially correlated. They explain this by referring to the fact that technological advantage today will have a high probability of being a technological advantage tomorrow. This may be referred to as technological path dependency. Nelson and Winter proposed that the average growth rates of firms would first increase and then flatten out or decrease with firm size. The rationale behind this framework is that although larger firms innovate more and therefore should grow more rapidly, their perceived market power restrains their desired investment. Intensive expansion policies in large firms will result in falling prices, keeping them from being aggressive investors. Consequently large firms experience lower growth rate relative to small firms on the mean.

Age

By sorting the firms into intervals related to their age, Evans (1987a, 1987b) showed that firm age is an important factor when explaining the firm growth. Firm growth seems to decrease with age. Similar results were given by Dunne & Hughes (1994). They concluded that young firms grew more rapidly when analysing a specific size class of firms. Again it is emphasised, that young firms to a certain degree are more unstable resulting in a lower survival rate.

The ability of young firms to grow faster has puzzled economists for years. A contribution by Jovanovic (1982) stresses that the negative relationship must be linked to the learning of firms. The life cycle pattern of the firm determines to which extent it will be able to grow. Jovanovic's model includes a selection mechanism. The decision of firms concerns the level of output determined with respect to maximisation of expected level of profits. All firms are assumed to be small and unable to affect prices, and therefore the expectations of the firms concerns the level of total costs. Firms adjust their level of output given their expectations on total cost. An expected increase in total costs drives firms to cut down in output while the firms increase output if they expected a decline in total costs. As the firm gets older the variance of the firm expectations on total cost decline. The firm learns to give more precise predictions about their level of cost as time goes by. Firms with higher expected costs have a lower chance of staying in business. Therefore a high proportion of the young firms leave the market and the remaining young firms get a higher level of profit on average when the firm size is left out of the equation.

In short, maturity adds to the stability of firm growth rates, because firms learn more about their cost structure and efficiency level. This tends to stabilise the investment plans in mature firms owing to fewer surprises in earnings. When exits are left out of the equation, young firms may have a higher growth rate on average.

Geographical Location

Theoretically it has been argued that there is a strong relation between firm localisation and growth. Lower production costs are traditionally used as the main argument for increased growth rates in a specific geographical location. The best place for a firm to be located is in the region with access to the cheapest production factors and the largest market for the firm's final goods, at the lowest transportation costs. Clearly in this type of framework there would be a concentration of firms near the metropolitan regions. These regions are not necessarily those with the largest populations, but the regions where the firms gain the best access to the highest demand for its final goods (Krugman, 1991b).

In addition, a firm would gain an advantage by being located in regions, which already have a large production of similar products. The advantage is to be close to specialised suppliers and potential customers. This concentration is self-reinforcing, because firms choose to produce in regions with good access to large markets, but access to markets tends to be good in regions in which many firms choose to produce (Krugman 1991a, 1998). From this point of view, firms located in regions with many producers and easy access to large markets will be more likely to experience high growth than firms located elsewhere.

However, factor prices and access to markets and production are no longer the main parameters in this theoretical area (Porter, 1990). Two additional interconnected concepts should be considered, when examining firm growth and geography. First, the growth of a firm is highly influenced by the capabilities and institutional set-up of the local environment. This mechanism is driven by the need for firms to access tacit knowledge, which cannot be acquired from the market. In order to acquire this type of knowledge firms have to engage in interactive learning processes (Maskell *et al.*, 1998). For this reason a firm's choice of location is determined by the local capabilities and institutional set-up of the regions in question and not only by factor prices and market size (Porter, 1990).

Second, new innovative firms, which often experience the highest growth rates, tend to emerge in the geographical proximity of firms of the same kind forming a concentration of these firms in single regions (Maskell *et al.*, 1998). This will contribute to local capabilities, when the new innovative firms produce new competencies. Such local capabilities will especially be valuable for these types of firms. Krugman (1991b) adds to this by saying that concentration will form a pooled market for qualified and specialised labour, indicating that these firms will perform better than similar firms in other regions.

One possibility of measurement is the revised Balassa index,[1] which shows in which industry a specific region is specialised. The formal measure is calculated by using equation (1). The measure is referred to as the Revealed Comparative Advantage index (RCA).

$$\text{RCA} = \frac{\frac{Employment_{ri}}{Employment_{r}}}{\frac{Employment_{i}}{Employment}} \tag{1}$$

The subscripts *i* and *r* refer to the specific industry and the specific region respectively. The numerator of the RCA indicates to which degree the specific industry is a major participant of the specific region. The denominator measures how large the same industry is compared to the entire economy. RCA measures to what extent the specific region is relatively more or less specialised in a specific industry than the entire economy (more specialised than the weighted average region in the specified industry).

Instead of looking at the relationship between regional specialisation and its implication for firm growth, focus should be on the change in specialisation in a region and its effect on the growth of the firms located in this area. It is more plausible that firms gain more from being located in a region that are evolving toward becoming more specialised in the specific industry in question rather than being located in a region that historically has build up a specialisation in the same industry. It seems more relevant to be located in a somewhat dynamic region, which is booming in the specific industry, rather than a region in which the industry has matured and firms are rather static or perhaps even declining. The growth rate of the specialisation index well consequently is used as an explanatory variable. This is referred to as Regional Specialisation Growth (RSG).

Market Structure

There may be a trade-off between short-run allocative gains from increased price competition in a specific market and the long-run welfare gains from a higher rate of innovation often related to a more concentrated market structure (OECD, 1996). As a consequence, market structure must be included when analysing firm growth. The composition of firms in a specific market may have some effects on the performance of the firms in this market (Hart and Prais, 1956).

$$\text{MCI} = \frac{1}{\text{N}} \sum_{i=1}^{n} \left(\log \frac{E_i}{E} \right)^2 - \frac{1}{N^2} \left(\sum_{i=1}^{n} \log \frac{E_i}{E} \right)^2 \tag{2}$$

Equation (2) is known as the variance of the logarithms of firm size. *E* refers to the number of employees in the industry. E_i refers to the number of employees in each

of the *n* firms in the specific industry. The measure gives an estimation of how the firms vary in size in each industry. If all the firms have the same size the index will be zero. This causes a problem in calling the index a concentration index. It should be highlighted that the index cannot be perceived as a measure of the general level of competition in the market. Instead it should be perceived as a measure of firm size diversity. Nonetheless it is evident that, when the number of firms in the industry is above a certain level and the firms are somewhat diversified, the industries with a high variance in the logarithms of firm size also have a fairly high level of concentration.

If the industry is composed of equal-sized firms, the index becomes zero. This would for instance be the case when analysing a pure monopoly or duopoly when the measure should be high indicating a high concentration level. Fortunately the data analysed in preceding sections do not contain any industries of completely equal-sized firms. None of the MCI measures have a zero value.

This leads us to formulate our expectations concerning the index. A higher index is expected to stimulate the general technological change in the industry (Geroski, 1994). Thinking back to the writings of Schumpeter it is easy to acknowledge this theory. Schumpeter (1942) proposed that industrial R&D laboratories have an important relevance for technical innovation. By doing so he emphasised that large firms may be inclined to bring about a higher level of innovative activity. The reason being that firms in industries with a high concentration level would be more likely to have the funding needed to engage in formal R&D projects. These additional fundings stem from a higher profit margin. The higher technological change will lead to a high growth of the industry. A high level in the variance of logs measure may indicate the existence of large firms, emphasised by the size distribution of the industry tending to be more right skewed. This may have a positive effect on the growth of firms in the specific industry. The large firm theory of technical change was supported by Acs and Audretsch (1988).

Another way to explain a positive correlation between market concentration and firm growth is by referring to a coordination problem in a market with a handful of firms with equal market power. This would give an uncertainty concerning the future state of the industry and therefore the firms would probably be more reserved in their growth ambitions and hence their investments.

Industrial Distribution

To a large degree, industrial differences have a significant effect on the economic performance. Even though Geroski (2000) points to the stylised facts concerning the idiosyncratic nature of firm growth rates, e.g. that firm growth rate patterns are independent of the general state of the industry to which the single firm is associated, we nevertheless include industry dummies in the analysis.

The technological foundation of the firms differs between industries and there are large differences in how technological change effects the industries (Salter, 1969). This may have an important effect on the individual firm's growth, if not directly, then through productivity improvement.

Pavitt (1984) acknowledged the differences in technological change between industries. He constructed a taxonomy that describes the patterns of technological development in various industries. His taxonomy divides the manufacturing industry into four groups according to the technological focus. Some industries focus on product innovation rather than process. Furthermore in some industries

the size of the firm tends to be decisive in terms of the probability of being successful in the innovative activity. The Pavitt taxonomy consists of the supplier-dominated, scale-intensive, specialised-suppliers and science-based industries.

Considering the size of the service sector in Denmark it is also relevant to disaggregate this sector to different sub-sectors (industries). Following Laursen & Foss (2003) services have been divided into wholesale trade, specialised services, scale-intensive services and ICT intensive services. Here the construction industry is not seen as a service industry. In the paper cited, the construction industry is called crafts and viewed as a service-based industry.

Industry dummies will give an indication of whether or not there are significant differences between the industries. The scale-intensive firms are expected especially to have a significant correlation between the dependent variable and firm size. Laursen & Christensen (1996) point out that there are important relations between the science-based firms and the university environment. The RSG does not give us the full effect of the universities. This is yet another argument for distinguishing between industries.

Building a Model

It is important to realise that the relationship between firm growth and firm size, on the one hand, and firm age, on the other, has often been shown to be non-linear with respect to their non-logarithmic values. In fact it is often argued that the relationship is a decreasing convex function. The growth rate of the firm decreases at a diminishing rate as the firm becomes larger or older. Therefore we model them as log-linear relations. The model has the following structure:

$$FirmGrowth = F(\log(Size),\ \log(Age),\ \mathrm{RSG},\ \mathrm{MCI}, Sec^{i}) \tag{3}$$

log(*Size*), long(*Age*), RSG and MCI refer to the logarithm of firm size, logarithm of firm age, growth of the regional specialisation and market concentration. *Seci*[1] is a vector referring to industry dummies.

We apply two measures as dependent variables. Both turnovers and employment are analysed. In the case of employees the calculations of the firm growth rates are:

$$\mathrm{AAG}(Emp) = \frac{\log(\frac{employment_{t}}{employment_{t-n}})}{n} \tag{4}$$

AAG(*Emp*) is the average annual growth rate measured by employment and *n* is the number of years the analysis cover. We will use AAG(*Tur*) to refer to the average annual growth rate measured using turnover.

Indicators of the independent variables are straightforward. The number of employees in the first year is used as the firm size measure. This might give some problems, as it is a discrete variable. The number of employees does not refer to full time equivalents. These are not reported in the database. This might give a biased result when considering the lack of distinction between part-time and full-time workers. Firm age has been measured as the present year less the year of establishment. Because of data restrictions, firms that were established before 1975 have been assigned the value 25. RSG and MCI are calculated using equations (1)

and (2) respectively. In the case of RSG, the industry aggregation applied in the analysis is used,[2] while a rather disaggregated level of about 600 industries are used when calculating the MCI.

Some of the variables may change their signs from one industry to another, e.g. the importance of a geographical localisation may vary between industries, as it may be an advantage for the firms in some industries to be located in areas with less industry population and not in a area of high activity, as a positive sign would suggest. Also the significance of the variables may differ between industries, as some variables are not equally important for the explanation of growth in all industries.

Data Structure

The database used is the NewBiz database published by Dansk Markeds Information A/S. It covers all Danish limited liability companies, partnerships and limited partnerships. Among other variables, NewBiz contains name, addresses, number of employees, industry, various economic data and the year of birth. The economic data available from 1993 to 1997 are updated quarterly. Using the years 1993 and 1997 results in a substantial loss in number of observations. Consequently the analysis limits itself to using 1994–96.

It should be noted that the period investigated is characterised as a boom period in Denmark. This may influence the general level of the growth rates, but also the dispersion. Therefore the pattern found in this paper may be dependent on the years of investigation. The level effect ought not to have an effect on the significance of the regressions, but the lesser dispersion effect may prove to have a considerable effect. Our greatest concern is the fact that the general selection mechanism of the market will not be as strong during a boom. Consequently we may include observations in the analysis that under less fortunate circumstances would have exited the market. At the moment it is merely acknowledged that pro-cyclical movements may have a significant effect on the results, but it is not taken it into account in the analysis.

Some of the observations have been omitted. The reduction of the number of observations is mainly due to lack of information on some of the chosen variables. There are a considerable number of firms in the database for which there is no information on the number of employees, data on turnovers, industry or year of establishment and which we have been forced to leave out of the analysis. For instance, firms that report the number of employees in the first year and not in the second have been left out of the analysis. This means firms going out of business are not included in the analysis. Other observations have been left out because of extraordinary growth performance. A limited number of observations have been left out because of to their categorisation as outliers.[3] As a result, the analysis is carried out using 8739 observations.

Considering first the growth rates in terms of turnover (AAG(*Tur*)), Table 1 shows that the firms, on average, grow at a 0.05 annual rate in the period of investigation in nominal terms. With a standard deviation on 0.21 some firms are witnessing a decline in turnover during the years of investigation. This conclusion is strengthened by the fact that the distribution of the growth rates seems to be close to normal. The same may be said when looking at the growth rates measured by employment data (AAG(*Emp*). The annual average growth rate is 0.02 on the mean when looking at employment data, which still is a fairly high growth rate

Table 1. Structure of variables of interest (n=8739)

	AAG(Tur)	AAG(Emp)	Size	Age	RSG
Min.	–0.98	–0.99	1.00	4.00	–0.16
Max.	0.98	0.97	11787.00	25.00	0.44
Mean	0.05	0.02	52.78	17.09	0.08
Median	0.04	0.00	6.00	17.00	0.06
Std. Dev.	0.21	0.17	293.15	6.48	0.08
Skewness	–0.10	–0.13	22.89	–0.03	0.79
Kurtosis	3.88	5.77	707.60	–1.51	3.27

Source: NewBiz Database, Version 98,4—Plus X.

considering the Danish labour force annually declined at a –0.006 rate on average. The standard deviation is 0.17.

The divergence between growth in turnover and growth in employment may be attributed to an increase in productivity. A relatively high productivity increase in one industry may result in a relatively higher level of growth in terms of turnover while leaving the relative growth rate in terms of employment unaltered, but the difference between the two may be attributed to price movements as well. Increases in the relative price levels have a positive effect on relative turnover growth rates while the employment growth rates may be left unchanged.

The mean values indicate that the average size of the firms is approximately 53 employees and the average age of the firms is about 17 years bearing in mind that when firms are older than 25 years, the age variable is set to 25 causing the calculated average age of the firms to be smaller than the actual average. From the skewness measure one may conclude that the distribution of firms with respect to size is right skewed. Also the high kurtosis value indicates that the number of observations is centred around a specific size, resulting in a somewhat 'peaked' distribution. Finally one may conclude from the positive mean RSG that the Danish regions on average have become more specialised.

Table 2 depicts a detailed picture of the distribution of firms across industries and regions. Starting with industry distribution, note that a considerable proportion of the firms are service firms, 57%. The manufacturing industry counts for about 23%. Manufacturing is distributed between the four Pavitt taxonomy industries. The largest of these is the scale-intensive industry with just about 47% of the manufacturing firms. Looking at the annual average growth rate in terms of either turnovers or employment, the science-based industry has by far the highest growth rates at 6.9% and 5.3% respectively. Notably this remains the highest even when taking non-manufacturing industries into consideration.

Among the four service industries, specialised services are the largest industries with about 20% of the total number of observations. Looking at the annual average growth rates it is interesting to see that the four service industries position themselves at different relative levels depending on the variable used in the calculations. While it is the scale-intensive services that have the lowest annual average growth rate in terms of turnover, it is the ICT intensive services in terms of employment. One may attribute the latter of these results to be due to a mismatch on the labour market, a difference in the development in productivity or a divergence in the price changes between the industries. In the case of ICT intensive services it is

Table 2. Industrial and geographical distribution of the firms (n=8739)

	No. of Obs.	Share	Ind. Share	AAG(Tur)	Std. Dev.	Cont.	AAG(Emp)	Std. Dev.	Cont.
Industries									
All Firms	8739	100	–	0.0503	0.2087	–	0.0248	0.1714	–
Primary	261	3.0	100.0	0.0497	0.2141	0.0015	0.0248	0.1772	0.0007
Manufacturing	2012	23.0	100.0	0.0542	0.1813	0.0125	0.0307	0.1554	0.0071
Supplier dominated	449	5.1	22.3	0.0405	0.1645	0.0021	0.0179	0.1516	0.0009
Scale intensive	950	10.9	47.2	0.0551	0.1755	0.0060	0.0281	0.1524	0.0031
Specialised supplier	272	3.1	13.5	0.0555	0.1796	0.0017	0.0330	0.1468	0.0010
Science based	341	3.9	16.9	0.0689	0.2159	0.0027	0.0530	0.1729	0.0021
Construction	1488	17.0	100.0	0.0634	0.1914	0.0108	0.0316	0.1839	0.0054
Services	4978	57.0	100.0	0.0449	0.2230	0.0256	0.0204	0.1733	0.0116
Wholesale trade	1297	14.8	26.1	0.0471	0.2200	0.0070	0.0220	0.1606	0.0033
Specialised services	1760	20.1	35.4	0.0462	0.1908	0.0093	0.0207	0.1649	0.0042
Scale intensive services	1352	4.0	7.1	0.0245	0.2259	0.0010	0.0217	0.1950	0.0009
ICT intensive services	1569	18.0	31.5	0.0461	0.2559	0.0083	0.0183	0.1870	0.0033
Regions									
All Regions	8739	100	–	0.0503	0.2087	–	0.0248	0.1714	–
Copenhagen Area	3041	34.8	–	0.0501	0.2188	0.0174	0.0213	0.1812	0.0074
Frederiksborg County	854	9.8	–	0.0579	0.2132	0.0057	0.0234	0.1800	0.0023
Roskilde County	410	4.7	–	0.0447	0.2123	0.0021	0.0190	0.1560	0.0009
Western Sealand	398	4.6	–	0.0532	0.1901	0.0024	0.0217	0.1757	0.0010
Storstrom County	255	2.9	–	0.0577	0.1999	0.0017	0.0251	0.1740	0.0007
Bornholm County	38	0.4	–	0.0319	0.1377	0.0001	0.0004	0.1121	0.0000
Fyn County	647	7.4	–	0.0502	0.1795	0.0037	0.0259	0.1678	0.0019
Southern Jutland	379	4.3	–	0.0585	0.2133	0.0025	0.0345	0.1547	0.0015
Ribe County	251	2.9	–	0.0504	0.2122	0.0015	0.0256	0.1772	0.0007
Vejle County	543	6.2	–	0.0400	0.1940	0.0025	0.0378	0.1582	0.0023
Ringkobing County	323	3.7	–	0.0536	0.2126	0.0020	0.0241	0.1599	0.0009
Aarhus County	822	9.4	–	0.0549	0.1931	0.0052	0.0276	0.1648	0.0026
Viborg County	248	2.8	–	0.0421	0.1795	0.0012	0.0181	0.1608	0.0005
North Jutland	530	6.1	–	0.0390	0.2192	0.0024	0.0325	0.1574	0.0020

Source: NewBiz Database, Version 98,4—Plus X.

worth noticing that these industries especially have experienced a productivity increase, which may explain the bad growth pattern in terms of employment.[4]

We have chosen not to disaggregate construction and primary industry as we have done with manufacturing and services. The primary industry especially is too small for such a disaggregation with 261 observations, which is only 3% of the total number of firms. The construction industry holds 17% of the total observations. The construction industry also distinguishes itself as a relatively high growth industry.

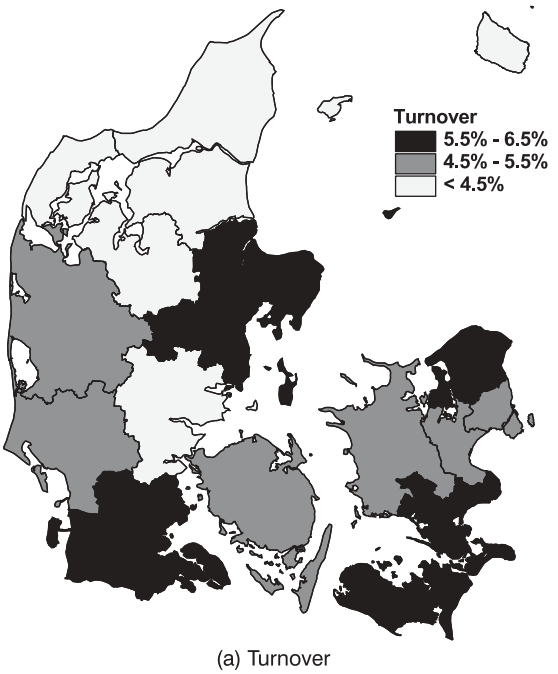
The growth rates vary from firm to firm, not only across industries but also intra-industry. The primary and the service industries, in particular, seem to have a high dispersion of growth rates across firms. Even though the scale-intensive industry is one of the largest, it is still one of the industries with the smallest level of dispersion of growth rates. Only the supplier-dominated industries have a distribution of growth rates with a lower level of standard deviation in terms of turnovers. In terms of employment it is only the supplier-dominated and the specialised suppliers that have a lower level of dispersion.

By multiplying the growth rates with the relative number of employees in the industries an estimate of how much each industry has contributed to the general growth is found. The two columns labelled 'Cont.' in Table 2 show the estimates. Because of the large number of firms in the service industry, it is this industry primarily that has contributed to the general growth. About 2.5% of the 5% in terms of turnover may be attributed to the service industry while 1.1% of the 2.5% in terms of employment may be attributed to the service industry. Otherwise it is the construction industry and the scale-intensive firms that contribute the most. A high contribution level does not necessary mean it is a large industry relatively speaking. The supplier-dominated industry is far from the smallest industry, but the contribution from this industry is rather weak, particularly when considering employment growth.

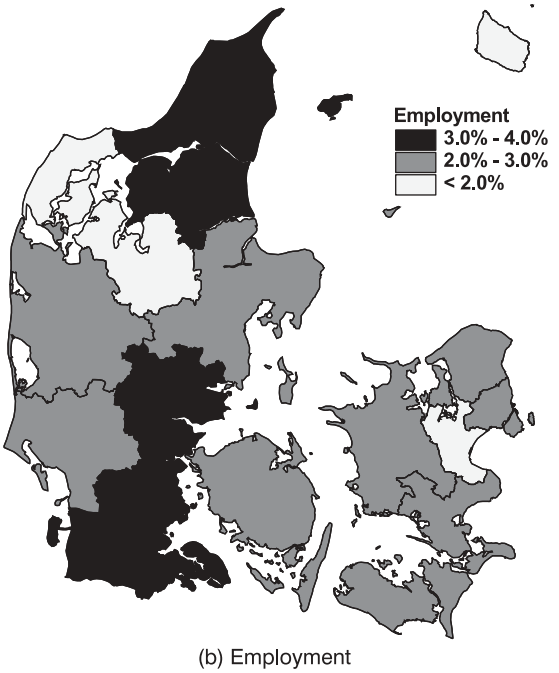
We have allocated the firms geographically into the Danish counties. There are 16 counties in Denmark. The Copenhagen region, which normally consists of three counties, has been aggregated to one. The number of geographical areas is therefore 14. With 10 different industries and 14 different regions, 140 different combinations for 1994 and 1996 amounting to 140 different RSG rates can be calculated from equation (1).

The first thing one should notice in the numbers is the concentration of firms in the Copenhagen region. Nearly 35% of the firms are located here. The Copenhagen region consequently contributes significantly more in a growth perspective than the other regions. From the region part of Table 2 it should also be noted that the growth performance of regions differs depending on the measure we apply. Considering North Jutland, the growth rate in terms of turnover is relatively low, while the growth rate in terms of employment is rather high. This perspective is graphically displayed in Figure 1(a) and (b). (An explanatory version of Figures 1(a) and 1(b) may bee seen in Figure 2.) Figure 1 shows a graphical illustration of the annual average growth rates of the country in terms of turnover (a) and in terms of employment (b). The illustration reveals that the very same pattern exists for Vejle County in the middle of Jutland. In terms of turnover the county is doing rather badly, while in terms of employment its growth performance is relatively good.

One region represents the outlier in one end of the scale. Bornholm County, which is the small white island in the top of Figure 1(a) and (b), is inhabited by firms that on average have an extremely low growth rate. In terms of employment



(a) Turnover



(b) Employment

Figure 1. Graphical illustration of the Danish counties and their annual average growth rates in terms of turnover and employment.

Figure 2. Explanatory figure referring to Figure 1(a) and (b).

Bornholm exhibits an annual average growth rate at 0.04%. In terms of turnover it is also doing rather badly. The annual average growth rate at about 3% is the lowest level of all the counties. Viborg County also exhibits a rather poor growth pattern in terms of both employment and turnover.

Looking at the other end of the scale, it depends on the measure we use in the calculations to show which county that seems to have the highest growth performance. In terms of employment the counties of North Jutland, Vejle and Southern Jutland seem to do rather well as may be seen from Figure 1(a) and (b). The same figure reveals that in terms of turnover it is the counties of Frederiksborg, Storstrom, Aarhus and again Southern Jutland that have the highest growth level on average.

The high growth performance of North Jutland in terms of employment may be attributed to a high unemployment rate. The unemployment rate has been fairly high in this region relative to others. With a higher rate of unemployment the firms might find it easier to get the qualified workers that fit their wants and needs, but Storstrom and Bornholm Counties have had similar high levels of unemployment. This would indicate that the unemployment explanation for regional high average firm growth is rather far-fetched.

Because of the large number of firms in the Copenhagen region, the contribution to the overall growth of employment is fairly high. Approximately 1.7% of the 5%

growth of turnover and about 0.7% of the 2.5% growth in employment may be attributed to this area. Even though Aarhus County has a relatively large number of firms, North Jutland and Vejle Counties almost have a similar contribution rate in terms of employment growth. North Jutland has a contribution rate at 0.20%, Vejle County has one at 0.23% and Aarhus County 0.26%.

Considering the relatively small differences in the standard deviation, it is thought that it was beneficial to relocate to an area with a higher growth potential, except that it has to be taken into account that the relocation of firms from one region to another would change the level of competition in the specific industry and region. Theoretically one would expect that this would cause the average growth rate to decline in that region owing to the decline in the concentration index. The results of the regressions would give some idea whether or not this also holds in practice.

Testing the Model

In order to regress the model of equation (3) a semi-log linear functional form is used. The transformed model is as follows:

$$\mathrm{AAG} = \alpha_1 \log(Size) + \alpha_2 \log(Age) + \alpha_3 \mathrm{RSG} + \alpha_4 \mathrm{MCI} + \alpha_5 Sec^i + \varepsilon \tag{5}$$

The regressions of equation (5) show disturbingly high levels of significance of the estimates. A White test reveals that the model is suffering from heteroscedasticity. The heteroscedasticity is more severe in the regression using employment as a growth variable, but the problem surely also exists in the turnover growth regression as well. This problem causes the ordinary least square method (OLS) to underestimate the variances of the coefficients. This in turn affects the *t*-statistics positively. The consequence may be that we accept a variable as significant, even though it is not. As a remedy for heteroscedasticity we have chosen to redefine some of the variables. An analysis of the log(*Size*) variable shows that it has a different effect on firm growth depending on the industry in question. The standard error of the variable differs greatly between the industries. By multiplying the size variable with the industry dummies we get different coefficients attached to the size variable for each industry. Also we have included an intercept to the function. The regression results of the revised model are presented in columns 1 and 2 in Table 3.

First, it should be noted that the heteroscedasticity has almost vanished. Consequently the level of significance of the included explanatory variables has decreased. Some interesting features do still come through. The log(*Age*) variable is still significant correlated negatively with both dependent growth variables indicating that young surviving firms tend to have a higher growth rate than older established firms. It seems as if Jovanovic's proposed theoretical perspectives on learning to read its cost structure as well as the market have some justification.

Second, the regional variable seems to have some significant role in explaining firm growth. It is an advantage to be located in a region that is increasing its specialisation in the specific industry. A firm should be located in a region toward which other firms in the same industry are moving or at least are expanding. The level of significance is slightly higher in the employment growth regressions though. The employment growth regressions also reveal that it is an advantage to be in an industry with a high concentration rather than in one with a low concentration.

Table 3. Regression results of the firm growth regression model

Dependent variable	AAG(Tur)	AAG(Emp)	AAG(Tur)	AAG(Emp)
Log(*Age*)	***–0.0305	***–0.0302	–0.0123	–0.0038
RSG	**0.0630	***0.0957	***0.1140	***0.1916
MCI	0.0008	***0.0055	**0.0068	**0.0052
Primary*log(*Size*)	0.0044	**–0.0098	–0.0044	*–0.0085
Supplier Dom.*log(*Size*)	0.0015	*–0.0037	–0.0038	**–0.0055
Scale Int.*log(*Size*)	**0.0047	0.0004	–0.0015	–0.0014
Specialised Sup.*log(*Size*)	0.0045	0.0006	–0.0016	–0.0018
Science Bas.*log(*Size*)	**0.0082	0.0023	0.0017	–0.0010
Construction*log(*Size*)	*0.0052	**–0.0045	–0.0020	*–0.0058
Wholesale trade*log(*Size*)	0.0040	–0.0020	–0.0025	–0.0026
Specialised Ser.*log(*Size*)	0.0022	–0.0035	–0.0036	–0.0039
Scale Int. Ser.*log(*Size*)	–0.0006	*–0.0052	–0.0049	*–0.0062
ICT Int. Ser.*log(*Size*)	0.0044	**–0.0044	0.0007	–0.0016
Intercept	***0.1196	***0.0969	***0.0777	0.0250
Number of observations	8739	8739	3512	3512
R^2	0.0052	0.0108	0.0071	0.0159
Adj. R^2	0.0037	0.0093	0.0034	0.0122

Source: NewBiz Database, Version 98,4—Plus X.
*Significant at a 10% level; **Significant at a 5% level; ***Significant at a 1% level.
Note: The difference between the first two regressions and the last is the number of observations. In the last two regressions firms with less than 10 employees are left out.

However the turnover regression does not support this. The log(*Size*)**industry* variables show less significant results giving some support to Gibrat's Law. It is worth noticing, that the significant estimates in the employment growth regressions all correspond to our expectations of a negative correlation. The negative estimates are rather small, which would suggest Geroski's mean reversion theory holds in some industries. It is worth noticing that this is not the case in the turnover growth regressions, which exhibit the opposite.

The last two columns in Table 3 refer to the same regressions as the first two only with the alteration of the number of observations. In the last two we have excluded the observations of firms that in 1994 had less than ten employees. The number of observations consequently falls to 3512.

In general the results of these regressions confirm those from the previous columns. Only the parameter estimates of some of the variables have dropped causing the estimates to be less significant. Running the regressions on the original model still exhibit some heteroscedasticity. So the last two columns are the most relevant in this respect.

Especially the log(*Age*) variable has lost its significance. This suggests that there is a correlation between firm age and firm size, but a correlation analysis reveals that the correlation between the explanatory variables is rather weak. The correlation matrix shows no sign of significant problems of collinearity between the explanatory variables. Table 4 reports the correlation matrix' of the two first regressions reported in Table 3. The variance inflation factor (VIF) shows no sign of multicollinearity (see Table 5). It may be the consequence of deleting the young firms when deleting the firms with less than ten employees, causing the variance of the variable to drop considerably.

Table 4. Correlation matricx of heteroscedasticity corrected model(s)(8739 Obs.)

	Int.	Log(*Age*)	MCI	RSG	Lss1	Lss2	Lss3	Lss4	Lss5	Lss6	Lss7	Lss8	Lss9	Lss10
Turnover														
Int.	1.0000	−0.9344	−0.2244	−0.1346	0.0103	0.0215	0.0531	0.0664	0.0529	−0.0406	0.0736	0.0037	0.0392	−0.0783
Log(*Age*)	−0.9344	1.0000	0.0136	−0.0107	−0.0636	−0.0995	−0.1551	−0.1144	−0.0775	−0.0709	−0.1669	−0.1273	−0.0684	−0.0384
MCI	−0.2244	0.0136	1.0000	−0.0001	−0.1022	−0.0669	−0.0970	−0.0889	−0.1488	−0.0241	−0.1811	0.0215	−0.1709	−0.0745
RSG	−0.1346	−0.0107	−0.0001	1.0000	0.1264	0.0365	0.0477	−0.0283	−0.1112	−0.0883	0.0491	−0.1135	−0.0335	0.0904
Lss1	0.0103	−0.0636	−0.1022	0.1264	1.0000	0.0862	0.1153	0.0666	0.0632	0.1023	0.1316	0.0999	0.0734	0.1212
Lss2	0.0215	−0.0995	−0.0669	0.0365	0.0862	1.0000	0.1615	0.0992	0.1015	0.1691	0.1788	0.1738	0.1029	0.1653
Lss3	0.0531	−0.1551	−0.0970	0.0477	0.1153	0.1615	1.0000	0.1336	0.1362	0.2235	0.2399	0.2306	0.1381	0.2181
Lss4	0.0664	−0.1144	−0.0889	−0.0283	0.0666	0.0992	0.1336	1.0000	0.0945	0.1418	0.1506	0.1473	0.0916	0.1291
Lss5	0.0529	−0.0775	−0.1488	−0.1112	0.0632	0.1015	0.1362	0.0945	1.0000	0.1555	0.1582	0.1585	0.1062	0.1319
Lss6	−0.0406	−0.0709	−0.0241	−0.0883	0.1023	0.1691	0.2235	0.1418	0.1555	1.0000	0.2427	0.2775	0.1456	0.2346
Lss7	0.0736	−0.1669	−0.1811	0.0491	0.1316	0.1788	0.2399	0.1506	0.1582	0.2427	1.0000	0.2468	0.1618	0.2403
Lss8	0.0037	−0.1273	0.0215	−0.1135	0.0999	0.1738	0.2306	0.1473	0.1585	0.2775	0.2468	1.0000	0.1449	0.2354
Lss9	0.0392	−0.0684	−0.1709	−0.0335	0.0734	0.1029	0.1381	0.0916	0.1062	0.1456	0.1618	0.1449	1.0000	0.1375
Lss10	−0.0783	−0.0384	−0.0745	0.0904	0.1212	0.1653	0.2181	0.1291	0.1319	0.2346	0.2403	0.2354	0.1375	1.0000
Employment														
Int.	1.0000	−0.9344	−0.2244	−0.1346	0.0103	0.0215	0.0531	0.0664	0.0529	−0.0406	0.0736	0.0037	0.0392	−0.0783
Log(*Age*)	−0.9344	1.0000	0.0136	−0.0107	−0.0636	−0.0995	−0.1551	−0.1144	−0.0775	−0.0709	−0.1669	−0.1273	−0.0684	−0.0384
MCI	−0.2244	0.0136	1.0000	−0.0001	−0.1022	−0.0669	−0.0970	−0.0889	−0.1488	−0.0241	−0.1811	0.0215	−0.1709	−0.0745
RSG	−0.1346	−0.0107	−0.0001	1.0000	0.1264	0.0365	0.0477	−0.0283	−0.1112	−0.0883	0.0491	−0.1135	−0.0335	0.0904
Lss1	0.0103	−0.0636	−0.1022	0.1264	1.0000	0.0862	0.1153	0.0666	0.0632	0.1023	0.1316	0.0999	0.0734	0.1212
Lss2	0.0215	−0.0995	−0.0669	0.0365	0.0862	1.0000	0.1615	0.0992	0.1015	0.1691	0.1788	0.1738	0.1029	0.1653
Lss3	0.0531	−0.1551	−0.0970	0.0477	0.1153	0.1615	1.0000	0.1336	0.1362	0.2235	0.2399	0.2306	0.1381	0.2181
Lss4	0.0664	−0.1144	−0.0889	−0.0283	0.0666	0.0992	0.1336	1.0000	0.0945	0.1418	0.1506	0.1473	0.0916	0.1291
Lss5	0.0529	−0.0775	−0.1488	−0.1112	0.0632	0.1015	0.1362	0.0945	1.0000	0.1555	0.1582	0.1585	0.1062	0.1319
Lss6	−0.0406	−0.0709	−0.0241	−0.0883	0.1023	0.1691	0.2235	0.1418	0.1555	1.0000	0.2427	0.2775	0.1456	0.2346
Lss7	0.0736	−0.1669	−0.1811	0.0491	0.1316	0.1788	0.2399	0.1506	0.1582	0.2427	1.0000	0.2468	0.1618	0.2403
Lss8	0.0037	−0.1273	0.0215	−0.1135	0.0999	0.1738	0.2306	0.1473	0.1585	0.2775	0.2468	1.0000	0.1449	0.2354
Lss9	0.0392	−0.0684	−0.1709	−0.0335	0.0734	0.1029	0.1381	0.0916	0.1062	0.1456	0.1618	0.1449	1.0000	0.1375
Lss10	−0.0783	−0.0384	−0.0745	0.0904	0.1212	0.1653	0.2181	0.1291	0.1319	0.2346	0.2403	0.2354	0.1375	1.0000

Table 5. Variance inflation factors of heteroscedasticity corrected model (8739 Obs.)

	VIF
Intercept	0.00
Log(*Age*)	1.06
MCI	1.10
RSG	1.08
Log(*Size*)*Primary	1.06
Log(*Size*)*Supplier dominated	1.09
Log(*Size*)*Scale intensive	1.18
Log(*Size*)*Specialized suppliers	1.07
Log(*Size*)*Science based	1.10
Log(*Size*)*Construction	1.20
Log(*Size*)*Wholesale	1.24
Log(*Size*)*Specialised services	1.24
Log(*Size*)*Scale intensive services	1.09
Log(*Size*)*ICT intensive services	1.18

In respect to the other variables the significance concerning RSG and MCI is still very strong and positive. The log(*Size*)**industry* variable exhibits rather mixed results. The turnover growth regression has no significance left at all, but the employment growth regression still has some significant negative estimates. The primary industry, the supplier-dominated industry, the construction industry and the scale-intensive services all exhibit the negative convex relationship between firm growth and firm size. Still we may put our faith in the mean reversion explanation and the Gibrat's Law depending on the industry in question.

All in all we are able to confirm our initial expectations on the included variables. Considering the significant estimations of specific variables we may conclude that the stylised facts summarised in the introduction should be reviewed. The firm growth process cannot be categorised as a stochastic process without any significant relationship to firm specific conditions. However, it is important to keep in mind that the regressions only explain a marginal part of the total variation in the growth rates. One might argue that what we have found are the industry specific patterns and not firm specific. Consequently we have also made the regressions separately on all the industries.

Tables 6 and 7 summarise the results of the regressions on industry level. While Table 6 refers to the regressions on all firms in the dataset, Table 7 refers to regressions done on firms with more than ten employees in 1994. The upper half of the tables refers to the regression in which turnover growth is the dependent variable while the lower half refers to the case where employment growth is the dependent variable.

With respect to the log(*Size*) variable, Table 6 shows a less distinct picture. Only a limited number of the estimates are significant. Only the construction industry shows the expected negative significant estimate in both regressions. In the employment growth regression the primary industries and the supplier-dominated industry also have the expected results, but they are not supported by the turnover growth regression. Here three of the service industries rather surprisingly

Table 6. Industry wise regression results (all firms)

	Intercept	Log(*Size*)	Log(*Age*)	RSG	MCI	R^2	Adj. R^2	*N*
Dependent variable=AAG(*Tur*)								
Primary industry	**0.2221	0.0050	*–0.0596	0.1848	–0.0085	0.0243	0.0090	261
Manufacturing								
Supplier dominated	*0.0926	0.0057	–0.0254	0.0583	–0.0022	0.0078	–0.0011	449
Scale intensive	**0.1075	0.0015	*–0.0253	0.1026	0.0045	0.0044	0.0002	950
Specialised suppliers	–0.0234	–0.0007	0.0232	0.0031	0.0065	0.0060	–0.0088	272
Science based	0.0522	0.0070	–0.0138	**0.2545	0.0010	0.0194	0.0077	341
Construction	***0.1051	**–0.0086	*–0.0226	0.1280	**0.0160	0.0097	0.0070	1488
Services								
Wholesale trade	***0.1821	*0.0077	***–0.0428	0.0099	*–0.0153	0.0091	0.0060	1297
Specialised services	***0.1267	0.0035	**–0.0262	–0.0352	–0.0080	0.0048	0.0025	1760
Scale intensive services	–0.0039	*0.0112	–0.0181	0.2824	0.0094	0.0315	0.0204	352
ICT intensive services	***0.1425	*0.0083	***–0.0528	0.0489	*0.0157	0.0104	0.0079	1569
Dependent variable=AAG(*Emp*)								
Primary industry	0.1094	***–0.0221	–0.0168	**0.2551	0.0023	0.0702	0.0557	261
Manufacturing								
Supplier dominated	0.0009	**–0.0081	0.0129	0.1038	0.0013	0.0145	0.0056	449
Scale intensive	0.0392	–0.0001	–0.0140	**0.3214	0.0049	0.0095	0.0053	950
Specialised suppliers	0.0243	–0.0019	–0.0048	0.1272	0.0079	0.0144	–0.0004	272
Science based	*0.1091	–0.0051	–0.0260	**0.2047	0.0030	0.0221	0.0104	341
Construction	***0.1137	***–0.0143	**–0.0273	0.0590	0.0090	0.0142	0.0116	1488
Services								
Wholesale trade	***0.1460	0.0027	***–0.0457	0.0271	–0.0014	0.0135	0.0104	1297
Specialised services	***0.1338	–0.0013	***–0.0486	*0.0700	***0.0137	0.0230	0.0208	1760
Scale intensive services	0.0869	–0.0043	–0.0195	*0.1773	–0.064	0.0147	0.0034	352
ICT intensive services	**0.0789	–0.0003	***–0.0305	0.0245	0.0113	0.0061	0.0036	1569

Source: NewBiz Database, Version 98,4—Plus X.
*Significant at a 10% level; **Significant at a 5% level; ***Significant at a 1% level.

Table 7. Industry wise regression results (more than 10 employees)

	Intercept	Log(*Size*)	Log(*Age*)	RSG	MCI	R^2	Adj. R^2	*N*
Dependent variable=AAG(*Tur*)								
Primary industry	0.2213	0.0197	–0.0917	*0.3650	–0.0002	0.0753	0.0291	85
Manufacturing								
Supplier dominated	*0.1270	0.0009	–0.0350	0.0970	0.0041	0.0146	0.0022	321
Scale intensive	**0.1123	**–0.0166	–0.0042	0.2338	0.0083	0.0234	0.0159	526
Specialised suppliers	–0.0357	–0.0095	0.0411	0.1314	0.0016	0.0148	–0.0059	195
Science based	0.1468	–0.0078	–0.0250	0.1888	0.0077	0.0231	0.0038	207
Construction	0.0255	–0.0063	–0.0003	**0.3176	0.0145	0.0113	0.0030	481
Services								
Wholesale trade	**0.1271	–0.0067	–0.0140	0.1638	–0.0068	0.0071	–0.0000	559
Specialised services	–0.0348	0.0072	0.0183	–0.0339	0.0074	0.0065	–0.0008	546
Scale intensive services	–0.0197	0.0077	–0.0148	0.2929	*0.0177	0.0566	0.0329	164
ICT intensive services	*0.1361	0.0073	–0.0403	–0.1143	0.0085	0.0086	–0.0007	428
Dependent variable=AAG(*Emp*)								
Primary industry	–0.0404	0.0033	0.0136	0.1920	–0.0090	0.0527	0.0054	85
Manufacturing								
Supplier dominated	–0.0330	–0.0048	0.0143	***0.2214	0.0057	0.0348	0.0226	321
Scale intensive	0.0140	*–0.0088	0.0102	***0.4205	–0.0001	0.0251	0.0177	526
Specialised suppliers	0.0059	–0.0096	0.0141	**0.2543	0.0032	0.0395	0.0193	195
Science based	0.0583	–0.0118	0.0006	**0.2354	0.0051	0.0343	0.0152	207
Construction	–0.0096	–0.0017	–0.0030	0.1946	0.0150	0.0088	0.0005	207
Services								
Wholesale trade	*0.0880	–0.0092	–0.0188	**0.2652	0.0064	0.0198	0.0127	559
Specialised services	–0.0135	0.0047	0.0007	*0.1160	0.0066	0.0108	0.0034	546
Scale intensive services	–0.0779	–0.0110	0.0329	*0.2775	0.0067	0.0295	0.0051	164
ICT intensive services	0.0921	0.0037	*–0.0340	*–0.0775	0.0091	0.0100	–0.0006	428

Source: NewBiz Database, Version 98,4—Plus X.*Significant at a 10% level; **Significant at a 5% level ***Significant at a 1% level.

have positive significant estimates. That the science-based, specialised-suppliers and scale-intensive firms do not exhibit the expected negative estimates could be explained by the growth ambitions of these types of firms. In order to be able to compete in these industries, firms need specific kinds of employees no matter the size of the firm. The firms that are categorised as specialised suppliers or science based have to compete on knowledge. Knowledge is to some extent embodied in employees. In order to reach their goals they have to employ highly qualified labour and improve their skills. The apparent negative relationship between firm size and firm growth seems to be less obvious in high technology industries. With respect to the scale-intensive industry one would be inclined to highlight the fact that economies of scale play an important role in their competitiveness.

This explanation far from corresponds to the points summarised by Geroski concerning the firm growth process. Looking at the *adj.*–R^2 values of the industry-wise regressions also indicate otherwise. The level of overall explanatory power has increased considerably in some of the regressions. The primary industry and the scale-intensive services particularly show a higher level of explanatory power (3%). The increase in the *adj.*–R^2 values points at the necessity for further studies on the subject. Additional variables should be included. Considerations on the composite of the firm in terms of employee skills and competences as well as the technological level of the firm/product may prove to be important. Also it seems that the level of explanatory power increases as the level of investigation becomes more detailed. In other words an even higher overall fit may be found if the regressions are disaggregated even more.

Considering Tables 6 and 7 again, we may point to another explanation for the lack of significant negative correlation between firm size and growth. Many of the industries categorised as scale intensive, specialised suppliers or science based could be characterised as an industry in which the role of large firms and formal R&D activities are important, in which case we would expect a positive correlation. These two explanations are forces pulling in each direction leaving us with an insignificant estimate. If this is the explanation for these results, it is surprising that the estimation of the concentration index is only significant for the science-based industries in both regressions and significant for the scale-intensive industries in the employment growth regression only. Again we may attribute this to the composition of the Pavitt taxonomy. A further analysis, like the one of Malerba and Orsenigo (1997), would clarify these questions.

The log(*Size*) estimates of the service industries are rather weak in relation to employment growth. Some significant positive correlations do emerge in the turnover growth regression in wholesale trade, scale-intensive services and ICT intensive services. The explanation for this pattern may be found in the production structure of the service industries. These industries are relatively employee intensive and may have a different employee policy than manufacturing. The costs of firms in this industry are relatively more concentrated on wages than in traditional manufacturing industries. Hence strong competition may drive the service firms to cutback on employees earlier than manufacturing firms would no matter the size of the firm. The large discrepancy between the estimates of the log(*Size*) variable across industries confirms the operation implemented in order to take the heteroscedasticity into account.

The log(*Age*) variable shows the expected negative significant estimates especially for the service industries, but to some degree the construction industry also shows a negative convex correlation between firm growth and firm age.

The RSG variable shows some rather interesting results as well. Those of the estimates that are significant are also positive. Looking at the two regressions in Table 6, only the science-based industry shows supporting results. This would indicate that it is an advantage to be located in a region, which is increasing its share of science-based firms more than the average region. The significant estimates of the science-based industry can be explained by the clustering of these firms in regions, where there are other firms of the same industry located. This gives the firms access to specially localised capabilities and knowledge spillovers.

Table 7 shows some rather weak results. One should note though that the scale-intensive industry shows the expected negative estimates in both regressions with respect to log(*Size*). Also when considering the employment growth regressions, one cannot ignore the highly significant positive estimates of the RSG variable. Only one of the significant estimates is negative—namely the ICT intensive service estimate. Only two industries, primary and construction, have insignificant estimates. Surprisingly enough these two industries have a significant estimate in the turnover growth regressions.

Concluding Remarks

By using Danish data, several variables are found significant when regressing them against average firm growth. Applying the proposed regression analysis on a lower level of aggregation exhibit a higher level of overall explanatory power. This suggests that growth patterns of firms, apart from being firm specific, also have industry dependencies. In all fairness it should be emphasised that the regressions only explain a marginal part of the variation in the growth rates, which leaves much for randomness. Nevertheless, we are able to confirm some of the existing empirical studies in terms of firm size and firm age. Additional explanatory variables were tested against firm growth. The geographical variable, in particular, showed significant positive estimates.

Our remedy for the heteroscedasticity problem suggest that the heteroscedasticity of parametric. Size seems to have significant different effects from industry to industry and may be used to correct similar models so that they may become homoscedastic and hence more trustworthy.

We abolish the idea of firm growth being a random walk. We do not acknowledge the properties of the random walk as being the right functional form to describe firm growth. We find several interesting closely related variables that may be linked to firm growth, which suggests that there are deterministic elements, but to what degree is still uncertain. We suggest further studies in which additional and more sophisticated variables are taken into account and in which the level of aggregation is somewhat lower.

Acknowledgements

The authors would like to thank Keld Laursen, Bent Dalum, Esben Sloth Andersen, Bjarne Højgaard, and the anonymous referees from this journal for their valuable comments and discussions. Furthermore, we would like to thank Lars Anderson for his help with the construction of this dataset. Drafts of this paper was presented at the DRUID Summer Conference 2000 and at the LEM Seminar Series, Sant' Anna School of Advanced Studies in November 2001.

Notes

1. The original index was first introduced by Balassa (1965). It was used to measure a country's international trade specialisation in specific industries. The index was called the Revealed Comparative Advantage (RCA).
2. The rather high level of aggregation is needed to avoid the increase in each variable being due to the single firm in the specific region and hence cause a 100% fit in the specific case.
3. The criteria concerns which observations, that may be categorised as outliers, are at a growth rate higher than 100% or lower than –100% yearly. Normally it is not possible to have a lower growth rate than –100%, but using the equation (4) approximation allows for such values to appear.
4. For an analysis of the ICT intensive services of Denmark, see Dahl and Dalum (2001).

References

Acs, Z. J. & Audretsch, D. B. (1998) Testing the Schumpeterian hypothesis, *Eastern Economic Journal,* 14, pp. 129–140.

Balassa, B. (1965) Trade liberalization and 'revealed' comparative advantage, *Manchester School of Economics and Social Studies,* 32, pp. 99–123.

Dahl, M. S. & Dalum, B. (2001) The ICT cluster in Denmark, in E. M. Bergman, D. Charles & P. den Hertog (Eds) *Innovative Clusters: Drivers of National Innovation Systems* (Paris: OECD).

Dunne, P. & Hughes, A. (1994) Age, size, growth and survival: UK companies in the 1980s. *Journal of Industrial Economics,* 42, pp. 115–141.

Evans, D. S. (1987a) The relationship between firm growth, size and age: estimating for 100 manufacturing industries, *Journal of Industrial Economics,* 35, pp. 567–581.

Evans, D. S. (1987b) Tests of alternative theories of firm growth, *Journal of Political Economy,* 95, pp. 657–674.

Geroski, P. (1994) *Market Structure, Corporate Performance and Innovative Activity* (Oxford: Clarendon Press).

Geroski, P. (2000) The growth of firms in theory and practice, in N. Foss & V. Mahnke (Eds) *Governance, Competence and Entrepreneurship* (Oxford: Oxford University Press).

Hall, B. H. (1987) The relationship between firm size and firm growth in the US manufacturing sector, *Journal of Industrial Economics,* 35, pp. 583–606.

Hart, P. E. & Oulton, N. (1996) Growth and size of firms, *Economic Journal,* 106, pp. 1242–1252.

Hart, P. E. & Prais, S. J. (1956) The analysis of business concentration: a statistical approach, *Journal of the Royal Statistical Society,* 119, pp. 150–191.

Jovanovic, B. (1982) Selection and the evolution of industry, *Econometrica,* 50, pp. 649–670.

Krugman, P. (1991a) *Geography and Trade* (Cambridge, MA: The MIT Press).

Krugman, P. (1991b) Increasing returns and economic geography, *Journal of Political Economy,* 99, pp. 483–499.

Krugman, P. (1998) Space: the final frontier, *Journal of Economic Perspectives,* 12, pp. 161–174.

Laursen, K. & Christensen, J. L. (1996) *The Creation, Distribution and Use of Knowledge–A Pilot Study of the Danish Innovation System* (Copenhagen: Danish Agency for Trade and Industry).

Malerba, F. & Orsenigo, L. (1997) Technological regimes and sectoral patterns of innovative activities, *Industrial and Corporate Change,* 6, pp. 83–117.

Maskell, P. Eskelinen, H. Hannibalsson, I. Malmberg, A. & Vatne, E. (1998) *Competive Localised Learning and Regional Development* (London: Routledge).

Nelson, R. R. & Winter, S. G. (1982) *An Evolutionary Theory of Economic Change* (Cambridge, MA: Belknap Press).

OECD (1996) Innovation, firm size and market structure: Schumpeterian hypothesis and some new themes, Economic Department Working Papers, No. 161.

Pavitt, K. (1984) Sectoral patterns of technological change: towards a taxonomy and theory, *Research Policy,* 13, pp. 343–373.

Porter, M. E. (1990) *The Competitive Advantage of Nations* (New York: The Free Press).

Salter, W. (1969) *Productivity and Technological Change* (London: Cambridge University Press).

Sawyer, M. C. (1971) Concentration in British manufacturing industry, *Oxford Economic Papers,* 23, pp. 352–383.

Schumpeter, J. A. (1942) *Capitalism, Socialism and Democracy* (London: Unwin).

White, L. J. (2002) Trends in aggregate concentration in the United States, *Journal of Economic Perspectives,* 16, pp. 137–160.