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**Conference Paper**

# Industrial Variation of High-Growth Firms

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# Industrial variation of high-growth firms

Sven-Olov Daunfeldt, Niklas Elert, Dan Johansson

June 11, 2010

*Abstract*: Previous examinations of the literature suggests that high-growth firms (HGFs) exist in all or most industries, are not overrepresented in high-tech, and if anything appear to be slightly overrepresented in services. In an updated overview, we find that more recent studies, employing better statistical methods, show a clear link between technological sophistication and HGFs. In a tobit model we examine what factors explain the presence of HGFs across 5-digit-NACE-industries in Sweden 1997-2005. We find that technological sophistication is crucial for the prevalence of HGFs in an industry, particularly in services. These results are in line with both current research and previous research concerning Sweden. We conclude that innovation is crucial for firm growth.

*Keywords*: Entrepreneurship; Firm growth; Gazelles; High-growth firms; High-impact firms; Industry

## 1. Introduction

The last decades have seen an increased interest in high-growth firms (henceforth HGFs). The interest emanates from empirical results identifying HGFs as major drivers behind net job creation (e.g., Birch and Medoff, 1994; Henrekson and Johansson, 2010; Storey, 1994). Recent results also suggest that they are equally important to economic growth (Daunfeldt et al, 2010). Yet the question of where in the economy HGFs can be found has not been sufficiently addressed.

In an overview of the previous research, focusing on the contribution of HGFs to employment growth, Henrekson and Johansson (2010) conclude that HGFs appear to exist in all or most industries. Furthermore, they are not overrepresented in high-tech. If anything, there appears to be some overrepresentation in services (Henrekson & Johansson, 2010, p. 14). The results indicating that HGFs are evenly distributed among industries are puzzling. Since HGFs have been empirically demonstrated to generate the bulk of new jobs and economic growth, shouldn't growing industries exhibit an overrepresentation of HGFs (cf. Acs et al. 2008)?

Drawing on Henrekson and Johansson, we perform an overview of all studies examining the industrial distribution of HGFs. Older studies have generally been based on a limited number of industries, a high level of aggregation, applied a firm size threshold, and sometimes been vague about the meaning of over- or underrepresentation. Meanwhile, more recent studies, based on more sophisticated statistical methods than prior work, suggest a clear link between the degree of technological sophistication of industries and the presence of HGFs.

Most previous research has limited itself to exploring in which industries HGFs can be found and sometimes whether certain industries have an overrepresentation of HGFs. After assessing that some industries are in fact over- and underrepresented in HGFs, this paper goes one step further. Tobit and probit regression models are estimated to establish what industry-specific factors influence the presence of HGFs. The analysis is based on a comprehensive data-set covering all limited firms in Sweden during the period 1997-2005. The population is continuing firms, i.e., firms existing throughout a particular time period. The unit of analysis is the 5-digit NACE-level.

HGFs are identified as the one percent of firms with the highest growth in either absolute, relative or composite employment growth, resulting in three types of HGFs. In the regression model, industry share of HGFs, or a dummy variable assigning whether an industry has an overrepresentation of HGFs, serve as dependent variables. We examine the influence from

sector size and age, research and development spending, and the eight different technology classifications for service and manufacturing industries provided by Eurostat.

The regression results indicate that no matter how defined, HGFs have a higher presence in high innovation industries. This connection between technological sophistication and the industry share of, or overrepresentation of HGF is particularly pronounced for the service industries. The results are in line with previous research on Sweden and also with recent evidence from other studies.

The remainder of the paper is organized as follows: The contribution from previous literature is discussed in Section 2. The data are introduced in Section 3 while the econometric choices and measurements are presented in Section 4. The econometric model and the results are reported in Section 5. This is followed by a discussion in Section 6.

## 2. Previous literature on HGFs and industry

Following Henrekson and Johansson (2010), we identify the studies in our survey by searching the following databases: the American Economic Association's electronic bibliography of economic literature (Econlit), Google Scholar, Journal Storage (JSTOR), Research Papers in Economics (RePEc), and Social Science Research Network (SSRN). We first searched for ''Gazelle'', ''high growth firm'', ''rapidly growing firm'', and similar words and phrases in titles, abstracts, keywords, and, when possible (Econlit, JSTOR, and RePEc), in the main text. In total, there were hundreds of hits. We browsed the hits and selected the papers that relate HGFs to industry. The identified studies were complemented by references found in the identified studies and previously known work.

Table 1 summarizes the findings. 25 studies were found that discuss either the distribution of HGFs across industries or the relationship of HGFs to industry specific characteristics. A summary was not a straightforward manner, for starters because, as previously noted (Henrekson and Johansson, 2010) there is no coherent definition of HGF in the literature. The level of aggregation and the scope, in terms of what time periods, countries and industries are studied, also varies substantially. No article primarily focuses on the distribution of HGFs across industries. There is furthermore no coherent idea in the literature regarding the definition of over- or underrepresentation. As a result, the conclusions are often a matter of debate.

Many, particularly the earlier studies, are descriptive in character. For these studies it is usually rather easy to assess a fairly straightforward notion of the "representation" of HGFs

across industries, whether the author(s) has (have) done so or not. By this notion, industry j can be said to have a proportionate share of HGFs relative to the rest of the economy if

$$\text{N of HGFs}_j \text{ /N of firms}_j = \text{N of HGFs}_{pop}\text{/N of firms}_{pop,}$$

that is, if the share of HGFs in industry j is equal to the share of HGFs in the entire population of firms. If this share exceeds (falls short of) the share of HGFs in the overall population, the sector has an over- (under-) representation. This notion is applicable with all studies of HGFs providing information on the share of HGFs in industries and the share of HGFs in the total population. It is not applicable for studies that employ econometric modeling rather than descriptive analysis, but these studies of course have other advantages.

**Table 1.** The overrepresentation of HGFs. An overview of previous literature.

| Study | Time period | Industries studied | Type of firms | Process of growth | Definition of HGF | Where are HGFs found? | Industry level of aggregation. | Possible to assess representation? | Link technology and HGFs? | Econometric analysis? |
|---|---|---|---|---|---|---|---|---|---|---|
| Birch and Medoff (1994) | 1988-1992 | All. | Ongoing firms. | Total. | A business establishment >20% sales growth each year over the interval, and base-year revenue>$100,000. | All industries. | High, the economy is divided into five sectors: Manufacturing (20-39), Trade (50-59), FIRE (60-67), Services (70-89), Other (0-17, 40-42, 44-49). | No, "if there is a pattern, it is that every industry has roughly the same proportion of its firms innovating and growing at a rapid rate." | No, only 2.5% of gazelles in high tech. | No. |
| Kirchhoff (1994) | 1977/78-1984 | Nonagricultural, private sector. | New single establishments with <500 employees established in 1977/1978. | Total. | The 10% fastest growing firms (relative employment growth) in the investigated population, 1977-1984. | All innovative sectors. | High, all industries are divided into high-, medium-, or low-innovativeness. | Yes, the economy share of HGFs is 10%. High-innovative sectors have a share of 16,8% of HGFs. | Yes, overrepresentation in high innovation industries. | No. |
| Storey (1994) | Different | Mainly manufacturing (survey). | Different | Different. | Different. | Varies. | Varies. | No, yet "significant differences between sectors in terms of the typical growth rates of firms". | Yes, link to technological sophistication. | No. |
| Birch et al. (1995) | 1990-1994 | All. | Continuing firms. | Total. | A business establishment >20% sales growth each year over the interval, and base-year revenue>$100,000. | All industries. | High, the economy is divided into five sectors: Manufacturing (20-39), Trade (50-59), FIRE (60-67), Services (70-89), Other (0-17, 40-42, 44-49). | Yes, (Fig 8, p.7), services are underrepresented while manufacturing and trade are overrepresented. | No, only 1.8% of gazelles in high tech. | No. |
| Autio et al. (2000) | 1994-1997 | All. | Independent continuing single establishments. | Total. | A firm >50% sales growth three consecutive years 1994–1997 and >FIM 1 million in sales at end of period. | No answer. | Medium, the economy is divided according to 3-digit SNI-sectors. | Yes, the economy share of HGFs is about 0,2%. Most of the large sectors with a high absolute number of gazelles (Table 1) also have an overrepresentation relative to their size. Trade, services and construction are overrepresented.. | No. | No. |
| Brüderl and Preisendörfer (2000) | 1985/86-1990 | All, but crafts, agricultural businesses, physicians, architects, and lawyers. | New firms founded in 1985–1986. | Total. | Surviving firms, growing more than 100% and growing by >5 employees in the studied period. | Not applicable. | High, as firms are characterized by their founders' assessment of such aspects such as market competition, concentration, dynamics, and company innovativeness. | Yes, the economy share of HGFs is about 4,3% of startups. Small differences in the share of HGFs in industries with different market competition, concentration or dynamics. Clear overrepresentation (9,2%) of HGFs among firms offering an innovative product. | Yes, firms grow faster if they offer an innovative product. | No. |

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| Schreyer (2000), Canada | 1990-1996 | Manufacturing. | Permanent firms employing >20 people at the beginning of the period. | Total. | The 5% fastest growing firms in the investigated population. | All industries. | Rather high, in total 22 industries on the 2-digit SNI-level are studied, although some are combined whereas others are further disaggregated. | Yes, the economy share of HGFs is about 2,2%. Transport equipment, a medium tech industry, has a share of 10,7%. The other industries with overrepresentation have no particular technological sophistication. | No. | No. |
| Schreyer (2000), France | 1985-1994 | Manufacturing and other non-service industries such as mining. | Permanent firms employing >20 people at the beginning of the period. | Total. | The 10% fastest growing firms in the investigated population. | All industries. | Rather high, in total 15 industries on the 2-digit SNI-level are studied, although some are combined. | Yes, the economy share of HGFs is about 4,7%. Several medium tech-industries have a clear overrepresentation of HGFs. Pharmaceutical, electronics, and rubber are overrepresented. | Yes. | No. |
| Schreyer (2000), Germany | 1992-1995 | The entire private sector | Permanent firms. | Total. | The 10% fastest growing firms in the investigated population. | All industries? | High, as in a probit model the probability of a HGF of belonging to manufacturing or services is examined. | No, probit regression is used. The probability of a HGF belonging to the service sector is significantly higher than to the manufacturing sector. The share of firms that qualify as high-growers rises with the intensity of R&D activity. | Yes, The share of firms that qualify as high-growers rises with the R&D activity. | No. |
| Schreyer (2000), Italy | 1990-1995 | Manufacturing and business services. | Permanent firms employing>20 people at the beginning of the period. | Total. | The 5% fastest growing firms in the investigated population. | All industries. | Rather high, in total 26 industries on the 2-digit SNI-level are studied, although some are combined whereas others are further disaggregated. | Yes, the economy share of HGFs is about 1,4%. Manufacturing is underrepresented (1,1%) while business services is overrepresented (4,2%). All knowledge intensive business services have a high overrepresentation, and some high- and medium tech manufacturing industries. | Yes, overrepresentation in other business services, computer services, R&D . | No. |
| Schreyer (2000), Netherlands | 1989-1994 | Manufacturing and services. | Permanent firms employing >20 people at the end of the period. | Total. | The 5% fastest growing firms in the investigated population. | All industries. | Rather high, in total 15 industries on the 1- and 2-digit level are studied. Manufacturing and business services are further broken down. | Yes, the economy share of HGFs is 5,2%. Business services, in particular software services, stands out for high overrepresentation. Manufacturing as a whole is underrepresented. | Unclear. | No. |
| Schreyer (2000), Spain | 1990-1994 | Manufacturing. | Permanent firms employing >10 people at the end of the period. | Total. | The 10% fastest growing firms in the investigated population. | All industries. | Rather high, in total 17 industries on the 2-digit level are studied, although some are combined whereas others are further broken down. | Yes, the economy share of HGFs is 10,1%. Three medium tech-manufacturing industries stand out as particularly overrepresented: chemicals, electronics, and rubber and plastics. | Unclear. | No. |

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| Almus (2002) | 1990-1998 | Sample of all industries. | Startups 1990-1993. | Total? | The 10% fastest growing firms in the investigated population, either in terms of relative employment or by the Birch Index. | All industries. | High, the economy is divided into 8 different sectors. | No, probit regression is used. In West Germany, no significant industry differences are found. In East Germany, firms operating in Construction and less technologically sophisticated sectors have a higher probability of growth. | No, in East Germany the opposite seems to hold. | Yes, probit regression. |
| Delmar et al. (2003) | 1987-1996 | Private commercially active firms. | All firms employing >20 people by 1996. | | Super absolute growers in employment and sales, and Super relative growers in employment and sales. | All industries. | Unclear, but rather high. Probably the same division as Davidsson and Delmar (2006)?? | Yes, the economy share of Super absolute growers is 13,5%. They are overrepresented in knowledge intensive manufacturing industries. The share of Super relative growers is 16,3%. They are overrepresented in knowledge intensive service industries. | Yes, overrepresentation in knowledge intensive sectors. | No. |
| Davidsson and Delmar (2003) | 1987-1996 | Private commercially active firms. | All firms employing >20 people by 1996. | Total. | The 10% fastest growing firms in absolute employment. | All industries. | High, the economy is divided into five sectors: High-tech Manufacturing, Other manufacturing, Professional Services, Trade, Other, and Non-classified. | Yes, the economy share of HGFs is 10%. Services is highly overrepresented of HGFs, and high-tech manufacturing is also overrepresented. Other manufacturing and Trade are underrepresented. | Yes, overrepresentation in knowledge intensive sectors. | No. |
| Davidsson and Delmar (2006) | 1987-1996 | Private commercially active firms | All firms employing >20 people by 1996. | Organic. | The 10% fastest growing firms in absolute employment. | All industries. | Rather high, in total 15 industries on the 2-digit SNI-level are studied, although most are combined. Manufacturing and Services are grouped according to Eurostat's definition of high-tech and knowledge intensity. | Yes, the economy share of HGFs is 10%. High-tech manufacturing and all types of knowledge intensive services are overrepresented. | Yes, overrepresentation in knowledge intensive sectors. | No. |
| Halabisky (2006) | 1985-1999 | All, except health, education, and government. | All continuing employer firms. | Total. | Firms growing by more than 50% in employment between 1985 and 1999. | All industries. | Rather high, in total 70 industries are studied. | No, but business services is said to be the leading industry among hyper- and strong-growth firms. | Unclear. | No. |
| Acs et al. (2008) | 1994-2006 | All. | Continuing firms. | Total | Enterprises that double sales over the 4-year period between 1998 and 2002 and have an employment growth quantifier of at least 2. | All industries. | Medium, in total 73 industries on the two-digit level are studied. | No, a comparable economy share of HGFs is not given, but it is possible to rank industries according to their share of HGFs. High-technology industries do not appear to be overrepresented. Manufacturing has a share comparable to sectors such as finance, insurance, and real estate; transportation; and services. Over time, 2-6% of firms in each industry are gazelles. | No. | No. |

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| Deschryvere (2008) | 2003-2006 | All. | Continuing firms. | Total and organic | High-growth firms defined as firms with an average growth in employees>20% p.a. over a 3-year period, and with >10 employees initially. | About 75% of industries. | Medium, the economy is divided into 42 2-digit SNI-sectors. Sometimes they are further disaggregated to the 3-digit level. | Yes, when total growth considered, economy share of HGF is 5,4%, when organic is studied, the share is 4,6%. Knowledge intensive services are highly overrepresented in both cases. | Yes, knowledge intensive industries are overrepresented. | No. |
| de Wit and Timmermans (2008) | 2005-2008 | A sample of all firms, except mining, public utilities, healthcare and government. | Firms with less than 100 employees in the base year. | Total. | A business establishment >20% employment growth each year over the interval, and >10 employees in base year. | All industries. | High, in total the economy is divided into 9 different sectors: Manufacturing, Construction, Trade, Hotels and Restaurants, Transport and Communication, Banking and Insurance, Other Commercial Services, Personal Services, Non-Private. | Yes, the economy share of HGFs is either 10% or 12%. Transport and Communication, Other commercial services, and Personal Services are overrepresented in HGFs irrespective of baseline. | Yes, Other commercial services, and Personal Services overrepresented in HGFs. | Yes, logit regression. |
| Hölzl (2008) | 1998-2000. | A sample of manufacturing firms in 16 countries. | Continuing firms. | Organic. | Firms that are in the top 10 (5) % measured by growth in the Birch Index, and which had a firm size in 1998 of less or equal to 250 employees. | Not specified. | No sector disaggregation. Instead, countries are divided into three groups: 1. Continental (EU Cont): Austria, Germany, Luxembourg, Belgium, Sweden, Finland 2. Southern Europe (EU South): Italy, Portugal, Greece, Spain 3. New Member States (NMS): Slovenia, Slovakia, Estonia, Hungary, Czech Republic, Lithuania, Latvia | No, the focus is to compare R&D activity between HGFs in three different country groups, and between HGFs and non-HGFs within country groups. HGFs operating in countries closer to the technical frontier will have higher R&D activity than both non-HGFs in their own country group and than HGFs in countries further form the technical frontier, where there is no difference in R&D intensity between HGFs and non-HGFs. | Yes, in countries close to the technological frontier, HGFs have a higher R&D intensity than non-HGFs. | Yes, matching results and quintile regression. |
| Wyrwich (2009) | 1991-2005 | A sample of West and East German firms. | Original, non-subsidiary start-ups of at least five years of age with at the most 30 employees in the start year. | Total? | The ten percent of firms with the highest growth in composite employment between start year and fifth year. | Not specified. | In probit regression model, 7 industry dummies where included (Retailing served as base case): Raw Material Manufacturing, Investment Good Manufacturing, Consumption good Manufacturing, Construction, Transportation, Business Services, Consumer Services. | No, but dummies are included in probit model. In East Germany, raw material manufacturing is the only sector that has a significant dummy coefficient, which is positive. In West Germany, Overall manufacturing, Business services and Computer services turn out to have both positive and significant coefficients. | No. The strategic dummy determining whether the firm employs state of the art technology turns insignificant. | Yes, probit. |

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| López-Garcia and Puente (2009) | 1996-2003 | All | All. | Total. | The ten percent of firms with the highest growth in composite employment between start year and fifth year. | All industries. | Economy is divided into the overall sectors of manufacturing, construction and market services, but also into seven more disaggregated sectors based on technological intensity. | Yes, HGFs are overrepresented in manufacturing, construction and Information and Communications Technology-producing (ICT) services have an overrepresentation of HGFs. Applying probit regression, it is found that firms operating in construction, services and non-ICT manufacturing have a higher probability of experiencing fast growth when compared to firms operating in ICT-manufacturing. | Yes, in services industries. However in manufacturing high tech is irrelevant or even detrimental to presence of HGFs. | Yes, probit. |
| Stam and Wennberg (2009) | 1994-2000 | A sample of all industries. | Continuing firms that were startups in 1994. | Total? | The 10 % of the population with the greatest percentage growth in employment over a six-year period. | Not specified. | No sector disaggregation. | No. OLS results show R&D activities to have no effect on overall firm growth, but a significant and positive effect on HGFs, defined as the 10 % of the population with the greatest percentage growth in employment. Furthermore, R&D activities are shown to have an effect on the growth of high-tech firms but not on low-tech firms. | Yes. | Yes, OLS. |
| Anyadike-Danes et al (2010) | 2002-2005, 2005-2008 | All. | Firms with at least 10 employees at the start of each period. | Total. | Firms with ten or more employees at the start of the period and an average employment growth exceeding 20 percent per annum over three consecutive years. | All industries. | High, economy is divided into seven industries based on 2-digit sectors combined: Manufacturing (15-37), Construction (45), Wholesale and retail trade (50-52), Hotels and restaurants (55), Transport, storage and communication (60-64), Financial intermediation (65-67) and Real estate, renting and business activities (70-74). | Yes, the share of HGFs amounts to 6,4% (2002-2005) and 5,8% (2005-2008) of firms with more than 10 employees in each base year. manufacturing (SNI 15-37) has the lowest proportion of HGFs (around 4%) whilst Financial (65-67) and Business Services (70-74) have the highest overrepresentation (8-9%). | Yes, clear overrepresentation in knowledge intensive business services. | No. |

*Source*: Henrekson and Johansson (2010, Table 1), updated. This table only reproduces the parts of Henrekson and Johansson's table that are relevant for our paper.

Storey (1994) surveys 14 studies that examine the influence of firm characteristics on firm growth. One characteristics is the sector or market in which the firm operates. The bulk of studies found significant differences between sectors in terms of the typical growth rates of firms, but the level of disaggregation varies markedly across studies (Storey, 1994, p. 138-140, Table 5.8 p.138). Storey finds five studies that examined the relationship between technological sophistication as a firm strategy and growth. Three indicate a positive association between technological sophistication and rapid growth of firms. The only one of these that especially discussed sector degree of technological sophistication is Kirchoff (1994) below. The other studies asked managers to state whether firms pursue a strategy of technological sophistication (Storey, 1994, p. 146-147, Table 5.9 p.144).

Kirchoff (1994) studies the development of startups in 1977 or 1978 in the US nonagricultural private sector. All 4-digit SIC-industries are classified as high-, medium- or low-innovation. Industry innovativeness is measured as average spending on R&D and average number of researchers and engineers employed. HGFs are the ten percent of firms with the highest organic growth in employment until 1984. They are overrepresented in the high-innovative sector, as 16,2% of these firms are HGFs, compared to only 9,8% and 9,0% of medium- and low-innovation firms, respectively (Kirchoff, 1994, p. 172-183).

Birch and Medoff (1994) and Birch et al (1995) study all industries 1988-1992 and 1990-1994. HGFs had a base-year revenue of above $100’000 and more than 20% sales growth each year over the intervals. They are found in roughly the same proportion in virtually all sectors of the economy. ‘High tech’ accounts for only 2.5 percent (Birch and Medoff, 1994) and 1,8 percent (Birch et al, 1995) of firms, respectively but we are not told what share of the economy these industries occupy. An aggregated juxtaposition (Birch et al, 1995, Figure 8, p.7) shows manufacturing and trade to have an overrepresentation of HGFs relative to their size, while services has a clear underrepresentation.

Autio et al (2000) study all industries in Finland 1994-1997. HGFs had at least 50% sales growth for three consecutive years and at least FIM 1 million in sales at the end of the period. There are 387 HGFs among 184,931 firms, an overall share of 0.2%. In absolute numbers, most are found in the aggregated sectors of trade, services and construction, while manufacturing lags behind. Autio et al apply a lower limit for overrepresentation of a 1% share, and an upper limit for underrepresentation of a 0,.% share of HGFs. Extreme overrepresentation is naturally found in small sectors with few active firms. Yet relative to the overall share of 0.2%, most sectors with a high absolute number of HGFs also have an overrepresentation relative to their size. For example Construction of Buildings, land and

water projects has a HGF share of 0.46%. High-tech firms are not over-represented among HGFs, which the authors consider surprising given the success of Nokia (Autio et al, 2000, p.8-10, and appendix Tables 1-3).

Brüderl and Preisendörfer (2000) study a sample of startups in Upper Bavaria, covering most industries. HGFs grew by more than 100% and more than 5 employees in the period 1985/86-1990. They amount to 4.3% of all startups. Some characteristics assessed by the founders attributable to the industry level are investigated. Little difference is found in the share of HGFs in industries characterized by differing level of market competition, concentration or dynamics. However, there is a clear overrepresentation (9.2%) of HGFs among firms offering an innovative product.

Schreyer (2000) covers six European countries and the Canadian province Quebec. HGFs are defined differently in different countries. For example, in France, HGFs are the top 10% of all growing firms, whereas in Spain they are the top 10% of all firms. When the shares of HGFs are estimated (Annex Tables 1 to 5) it is always relative to the permanent population. In the studies that cover the entire economy, HGFs are found in all industries, but with overrepresentation in a few sectors. HGFs appear to be more technology intensive than the average firm. This is however only examined in four studies (France, Netherlands, Spain, Germany), and the methodology differs.

In France, the whole population of non-service industries is studied. The share of HGFs in the economy is 4,7%. HGFs are overrepresented in the chemicals industry (13.3%), Rubber and plastics (9.2%), Transport equipment (8.5%), Electrical machinery and apparatus (8.3%) and Electricity, gas and water supply (6.6%). While 13% of all firms in the sample carry out formal R&D efforts, 33% of HGFs do.

In Quebec, a sample of manufacturing firms is studied. The share of HGFs in the economy is 2.2%. HGFs are highly overrepresented in the transport equipment producing industry (share 10.7%), but also overrepresented in Rubber (4.8%), Textiles (4.2%), and Paper (3.2%), Petroleum (3.1%), Beverages (3.1%) and Chemicals (2.5%).

In Italy, the whole population of manufacturing and business services firms is studied. HGFs account for 1.4% of the permanent population. Manufacturing is overall underrepresented in HGFs (1.1%) while Business services is overrepresented (4.2%). The small sectors Tobacco (7.7%) and R&D services (4.0%) both have high overrepresentation of HGFs. Among sectors of significant size, Other business services (4.5%) and Computer services (3.1%) have the highest overrepresentation. Some manufacturing sectors, such as Office machinery & computers (2.7%), Coke, refined petroleum & nuclear (2.6%), Electric

machinery (2.3%), Precision instruments (2.2%) and Radio & TV communication equipment (2.1%) are overrepresented as well.

In the Netherlands, a sample of manufacturing, services and other industries is studied. 15 industries are covered, but Manufacturing and Business services are further broken down into sub-industries. The share of HGFs in the economy is 5.2%. Overall, Manufacturing has a slight underrepresentation of HGFs, while Business services has almost twice the overall share (10.2%). Within this category, Software services stands (16.8%). Among the 15 aggregate industries, Renting of movables (11.2%), Cleaning services (10.3%), Banking and insurance (10.1%), Retail trade (7.8%), and even Horticulture and fishery (6.2%) are overrepresented in HGFs. HGFs focus more frequently than other firms on product and market innovation, and devote considerable attention to positioning their products and product lines.

In Spain, a sample of 17 manufacturing industries on a 2-digit NACE-level are studied. The share of HGFs in the economy is 10.1%. HGFs are most over-represented in Motor vehicles (18.5%), Chemicals (15.1%), Electronics (15.0%), but also in Rubber and plastics (13.8%), Non-metal, mineral products (12.7%) and Food, beverage and tobacco (12.6%). While half of all firms undertake R&D, more than 70% of HGFs do. For given R&D intensities, HGFs always have the highest share of R&D firms.

In Germany, a sample of all sectors in the economy is studied. The assessment of the industry effects is based on results from a (probit) regression model that simultaneously examines the effects of age, size, industry, etc. on the probability of being a high-growth firm and therefore of a different nature from the partial analysis in Schreyer's (2000) other studies. A HGF is much more probable to belong to the service sector than to the manufacturing sector. The share of firms that qualify as HGFs rises with the intensity of R&D activity.

In a probit regression model, Almus (2002) examines what influences the probability of fast growth in East and West Germany. The sample is firms founded 1990 – 1993. Growth is measured by relative employment and by the Birch index. HGFs are defined as the ten percent fastest growers according to each of these indicators. The economy is divided into eight different sectors (trade serves as base case in the regression). No sector related differences for probability of fast growth is found in West Germany. In East Germany, Construction and Less knowledge-based business related services increase the probability of both types of growth. In addition, Transport and communication increase the probability of fast relative growth while Low technology manufacturing increase the probability of fast growth in the Birch index. It thus appears that firms operating in less technologically sophisticated sectors in East Germany

have a higher probability of growth than those operating on more technologically sophisticated sectors.

Delmar et al, 2003, and Davidsson and Delmar (2003, 2006) use the same dataset of all private commercially active firms as Schreyer (2000) did in his Swedish study. Therefore, we report the results jointly here.

Delmar et al. (2003) apply 19 different measures of firm growth. Super absolute growers are defined as firms exhibiting very high absolute growth in employment (total and organic) and sales, representing 13.5% (n = 202) of cases. Super relative growers exhibit very high relative growth in employment (total and organic) and in sales, and account for 16.3% (n = 244) of cases. The two groups of HGFs are found in knowledge intensive industries. Super absolute growers are overrepresented in high-technology and technology-oriented manufacturing industries. Super relative growers are more dominated by professional services. Davidsson and Delmar (2003, 2006) define HGFs as the 10% of firms with the highest average annual increase in absolute employment among all firms in the population. Studying total growth, Davidsson and Delmar (2003) find that while HGFs exist in all industries, service industries are overrepresented with twice as high a representation (32.4%) among the top 10% firms compared with its share of the entire population (16.5%). High-tech manufacturing is also strongly over-represented (4.9% of HGFs for a total sector size of 3.2%). Older industries such as Other manufacturing and Retail/wholesale are substantially underrepresented. When Davidsson and Delmar (2006) distinguish between organic and acquired growth, and disaggregate their material further, the results confirm the general picture. High-tech manufacturing and all types of knowledge intensive services are overrepresented. Thus, the overall picture given by these studies is that knowledge intensive and high tech industries generally have an overrepresentation of HGFs. Whether in services or manufacturing, these industries are new or growing, and the outcome of newly created markets like information technology, or deregulated state monopolies.

Halabisky et al (2006) examine most private continuing firms in Canada 1985-1999. HGFs grew by more than 50 percent in employment 1985-1999. The industry dispersion of HGFs is briefly discussed. No single industry is predominantly responsible for employment creation. The leading industry among HGFs, Business Services, accounted for only 15% of net employment creation, and 26 out of 70 industries account for 80% of employment creation. High-tech industries are not among the top-ten job creating industries (Halabisky et al, 2006, p.262-263).

Acs et al (2008) study continuing firms in USA 1994-2006. High-impact firms (HIFs) doubled their sales over four years and had an employment growth quantifier of at least 2[1]. Three time periods, 1994-1998, 1998-2002 and 2002-2006, are studied. It is not possible to exactly assess what industries have an overrepresentation, as table 6 (providing data on the share of HIFs in each 2-digit SIC-industry in the economy for the years 1998, 2002, 2006) and table 2 (presenting the number of HIFs relative to all other continuing firms) are not comparable. It is however stated that HIFs in general represent between 2 and 3 percent of all firms (Acs et al, 2008, p.2). HIFs exist in all industries, the industry share generally being between two and six percent. High-technology industries do not appear to be overrepresented. Manufacturing has a share of gazelles comparable to sectors such as Finance, insurance, and real estate, Transportation, and Services (Acs et al, 2008, p.32).

Deschryvere (2008) studies all industries in Finland 2003-2006. The OECD-definition of HGF applies: a firm with at least ten employees initially and an average annual employment growth above 20% over a 3-year period. When total growth is considered this results in 750 HGFs or 5.4% of firms with at least 10 employees. When only organic growth is considered there are 642 HGFs, or roughly 4.6% of firms with at least 10 employees. HGFs are found in about 75% of 2-digit industries, and those with the highest share of HGFs are also top-performers in terms of employment growth. Disregarding the really small sectors, the sectors with the highest overrepresentation of both types of HGFs are Computer and related activities, Other business activities, and Health and social work. Manufacturing is generally outdone by services, in particular knowledge intensive services. Yet some large high- or medium tech manufacturing industries have a pronounced overrepresentation as well (Deschryvere, 2008, p.19-20).

de Wit and Timmermans (2008) cover a Dutch firm sample 2005-2008. Following the OECD definition, a HGF had on average at least 20% employment growth over three consecutive years, and had at least 10 employees in the base year. Two ways of measuring this process are employed. The first, “perception” method results in a 10% share of HGFs in the economy. The second, “objective” method results in 12% share of HGFs in the economy. Table 3 enables us to calculate that 4 of the 9 sectors of the economy had a clear overrepresentation of HGFs. Regardless of method, Transport & communication, Other commercial services and Personal services have overrepresentations of HGFs, whilst Manufacturing trails far behind. In a multivariate logit regression, the results that there are

[1] Note: the employment growth quantifier is equivalent to what in this paper is labelled the composite employment index: a combination of relative and absolute measurements of employment growth.

relatively few gazelles in manufacturing and relatively many in transport and communication are further corroborated.

Hölzl (2008) performs a study of 16 countries divided into three groups: Continental Europe, Southern Europe and new member states of the European Union. The sample covers manufacturing firms 1998-2000. HGFs are the ten (five) percent fastest growers in the Birch Index that had an initial size of at the most 250 employees. Employing both a matching results method and a quantile regression approach, the degree of innovativeness (quantified by various R&D measures) is examined between HGFs in the country groups and between HGFs and non-HGFs in each country group. HGFs in countries closer to the technological frontier are more innovative than both non-HGFs and HGFs in countries further from the technological frontier. In countries far from the technological frontier, there is no difference in innovativeness between HGFs and non-HGFs.

Wyrwhich (2009) employs a probit regression model to establish what influences the probability of high-growth in West and East German firms founded between 1991 and 2000. The sample contains 813 East German and 529 West German firms. HGFs are the ten percent of firms with the highest growth in composite employment between start year and the fifth year. Seven industry dummies are included in the regression. In East Germany, raw material manufacturing is the only sector that with a significant dummy coefficient, which is positive. In West Germany, Overall manufacturing, Business services and Computer services turn out to have both positive and significant coefficients. The strategic dummy determining whether the firm employs state of the art technology is insignificant.

Lopéz-Garcia and Puente (2009) study all Spanish firms 1996-2003. Firm growth is measured as composite employment. HGFs are classified as the ten percent of firms with the highest growth. HGFs are overrepresented in manufacturing, and, above all, construction. As compared to slow growers, they are more concentrated in all manufacturing industries independently of degree of technology. There are differences among service industries of varying technological intensity. Information and Communications Technology-producing (ICT) services (basically telecommunications and computer services) have an overrepresentation of HGFs. ICT-users in service (Retail) and non-ICT services (for example Hotels and restaurants) have an underrepresentation (Lopéz-Garcia & Puente, 2009, p.21-22). A probit model is estimated to determine what influences the probability of being a HGF. Coefficients are reported for the effect of five sector dummies grouping manufacturing and service industries according to their technology intensity. It is found that firms operating in

construction, services and non-ICT manufacturing have a higher probability of experiencing fast growth compared to firms operating in ICT-manufacturing.

Stam and Wennberg (2009) do not focus explicitly on industry. Instead, the role of R&D in new firm growth is studied, by establishing an OLS regression model. Their sample consists of 647 firms that started in 1994 and survived for at least six years. HGFs are defined as the 10% of the population with the greatest percentage growth in employment. The results show R&D activities to have no effect on overall firm growth, but a significant and positive effect on HGFs. Furthermore, R&D activities have an effect on the growth of high-tech firms but not on low-tech firms.

Anyadike-Danes et al (2010) mainly study HGFs in the United Kingdom. The OECD definition of a HGF is employed, whereby HGFs had ten or more employees at the start of the period and an average employment growth exceeding 20 percent per annum over three consecutive years. Two different time periods are studied: 2002-2005 and 2005-2008. There were 11,369 HGFs in the first period and 11,530 HGFs in the latter, representing less than one percent of all firms in each case, and 6.4% and 5.8% of firms with more than 10 employees in each base year. HGFs exist in all sectors of the economy, but the proportion varies quite markedly by sector. The results are similar in both periods. Among the seven sectors, manufacturing has the lowest proportion of HGFs (around 4%) whilst Financial and Business Services have the highest overrepresentation (8-9%). Remaining sectors have shares close to the economy average. The numbers for 2002-2005 are compared to numbers from the United States, where the overall share of HGFs is only around 5%. US HGFs have a higher overrepresentation in construction than UK HGFs, and no underrepresentation in manufacturing. Like UK HGFs, they are overrepresented in Transport, storage and communication, Real estate, renting and business activities, and also in Financial intermediation, but in the last case to a far lesser extent. Meanwhile, US HGFs are far more underrepresented in Hotels and restaurants and Wholesale and retail trade than their UK counterparts. In sum, there appears to be a clear overrepresentation in knowledge intensive business services in both countries.

To summarize, many studies find HGFs to exist in all or most industries studied, perhaps with a disproportionately high share in some (Birch and Medoff, 1994; Birch et al, 1995; Storey 1996, 1997, 1998, 1999; Schreyer, 2000; Delmar et al, 2003 and Davidsson and Delmar, 2003, 2006; Halabisky et al; Acs et al, 2008; Deschryvere, 2008; Léopez-Garcia and Puente, 2009). Some studies point to a tendency towards an overrepresentation of gazelles in

service industries relative to other sectors such as manufacturing (Autio et al, 2000; Schreyer, Germany, 2000; Halabisky, 2006).

Early research concerning HGFs found some evidence for a link between technology and firm growth in general terms (cf. Storey 1991 and Kirchoff 1994). The bulk of studies, in particular the most recent studies, also find indications of a positive association between some measure of industry innovation, such as high tech or knowledge intensity, and HGF overrepresentation (Brüderl and Preisendörfer, 2000; Schreyer 2000 (4 out of 6 studies) Delmar et al, 2003, Davidsson and Delmar, 2003, 2006; Deschryvere, 2000; de Wit and Timmermans, 2008; Hölzl, 2008; López-Garcia and Puente, 2009; Stam and Wennberg, 2009; Anyadine-Danes et al, 2010). It should be noted that this link is established in several different ways across studies, and the results should thus be interpreted with care. Others (Birch & Medoff, 1994; Birch et al, 1995; Autio et al, 2000; Almus, 2002; Halabisky et al, 2006; Acs et al, 2008) find either an absence of, or a negative link, between innovation and HGFs. It should be noted however, that the latest empirical evidence, more often based on statistical regression techniques than earlier studies, generally confirms a link between technological sophistication and HGFs, particularly in the service sector.

In the following sections, we elaborate the empirical model that we employ to examine this relationship in Sweden.

## 3. Data

All limited firms in Sweden are legally bound to submit their annual report to the Swedish Patent and Registration Office (PRV). The data used in this study are collected from MM (Market Manager)-Partner, now merged with PAR, a Swedish consulting firm that gathers economic information from PRV, to be used foremost by decision-makers in Swedish commercial life. Our data comprise all Swedish limited companies active at some point between 1997 and 2005, in total 288,757 firms, and include all variables that can be found in the annual reports, e.g., profits, number of employees, salaries, fixed costs and liquidity.

## 4. HGFs – definition

The industry share of HGFs is one of the independent variables of concern in this study. As has been suggested in the literature, a high number of HGFs could drive the growth of industries (c.f. Acs et al, 2008; Deschryvere, 2008).

To allow for feasible comparisons, we follow Daunfeldt et al (2010) and define HGFs as the one percent of firms with the highest growth over three different time periods, three, five and seven years. We considered other shares of the firm population, such as the five or ten

percent of firms with the highest growth. However, besides the one percent definition, it was not possible to apply precise cut-off levels, since a larger share of firms showed the growth required to enter as the last firm using other thresholds. This would necessitate arbitrarily including some of these firms among HGFs, while arbitrarily excluding the rest of them. Also, growth fell off rapidly when the span was widened. For instance, applying the ten-percent definition over a seven-year period would include firms that had grown by only four employees over the entire time period.

The population is continuing firms in these time periods. Since we cannot distinguish organic from acquired growth, we study total growth. In order to relate to previous literature, we use employment as growth indicator. It has long been realized that while absolute measures of firm growth lead to a bias towards large firms, relative growth measures lead to a bias towards small firms (c.f. Acs et al., 2008; Schreyer, 2000). Due to the wide-spread use of the absolute and relative measures, we use these two measures for all growth indicators in the empirical analysis. We also apply the so-called composite index, i.e., the combination of employment growth measured in absolute and relative numbers, as growth measurement to relate to previous literature (cf. Schreyer, 2000; Lopez-Garcia and Puente, 2009).

To summarize, we use three definitions of growth for employment and thus arrive at three groups of HGFs: absolute employment-HGFs, relative employment HGFs, composite employment-HGFs[2]. These types are defined over three different time periods (three, five and seven years), resulting in 27 different ways of defining HGFs. Unless otherwise stated, in the following all results will refer to HGFs based on a time period of three years.

Table 2 shows correlations between these three groups of HGFs. A significant positive, correlation between the different groups of HGFs can be found. The correlation is highest between the absolute employment-HGFs and the composite employment-HGFs, and lowest between absolute employment-HGFs and relative employment-HGFs. That the correlation between HGFs based on absolute and relative measures of the same growth indicator is rather small confirms previous findings (Delmar et al., 2003).

[2] Absolute employment-HGFs are defined measuring the growth in employment in absolute numbers; relative employment-HGFs are defined measuring the growth in employment in relative numbers; composite employment-HGFs are defined measuring the growth in employment using a combination of relative and absolute numbers.

**Table 2.** Correlations between HGFs of different definitions over a three-year time period, N=796794.

| | Absolute employment-HGFs | Relative employment-HGFs | Composite employment-HGFs |
|---|---|---|---|
| Absolute employment-HGFs | 1 | 0.210*** | 0.723*** |
| Relative employment-HGFs | 0.210*** | 1 | 0.453*** |
| Composite employment-HGFs | 0.723*** | 0.453*** | 1 |

Note: *** denotes that the correlation is significant at the 1%-level.

## 5. Industry distribution – descriptive analysis

As a first step in our descriptive analysis, we compute the shares of each type of HGFs to the total number of firms in that same 2-digit NACE-industry in each year. In 2000, for example, fast growers over the time period 1997-2000 are compared against continuing firms over the same time period. The annual numbers 2000-2005 are averaged over the entire time period. The results appear in table 3. Column 2-4 presents the share of absolute employment-, relative employment- and composite employment-HGFs of each sector.

In each column the ten sectors with the greatest share of HGFs, and therefore the highest overrepresentation, have numbers marked in bold. All industries with a share of HGFs above the economy share of 1 percent can be said to have an overrepresentation of HGFs. The variation around this mean value is quite substantial, although smaller in the case of the share of relative employment-HGFs than for the other two.

Some sectors appear as overrepresented mainly due to their small size, and, conversely, some sectors with a high absolute number of HGFs have a small share by virtue of being large. Column 5 therefore provides information about sector size, measured as the average number of firms across the time period. Column 6 states whether the sector is classified as a high- or medium-tech manufacturing industry or a knowledge intensive services industry according to Eurostat (see table A1). 22 of the 56 industries are technologically sophisticated according to this definition.

Five industries are among the top ten industries in terms of all three types of HGFs. The smallest, (66) *Insurance, pension, not social security*, consists of a handful of companies, while the others have a few hundred employees. All five have a high level of technological sophistication. Two of them are high tech manufacturing and three knowledge intensive services.

The bottom-ten industries, the sectors with the smallest shares, are the same for absolute and composite employment-HGFs. Six of these are also among the bottom-ten in terms of relative-employment-HGFs. One of these, (70) *Real Estate activities*, is a knowledge intensive service industry. Another one, (71) *Renting machinery, personal, household goods*, is in the bottom ten in terms of absolute employment- and composite employment-HGFs. These two service industries are the only technologically sophisticated industries in the bottom-ten.

14 of 29 industries with on average overrepresentation of absolute employment-HGFs over the entire time period are sectors with technical sophistication. Of the five sectors with the highest overrepresentation, four were technologically sophisticated. Of the 25 sectors with an average underrepresentation in absolute employment-HGFs, six have a high degree of technological sophistication.

The picture is similar when composite employment-HGFs are concerned. 14 of 27 industries with on average overrepresentation of composite employment-HGFs over the entire time period were technologically sophisticated. Of the top-five, four were technologically sophisticated. Among the 29 sectors with on average underrepresentation in composite employment-HGFs, six had a high degree of technological sophistication.

By contrast, only 11 sectors had on average overrepresentation of relative employment-HGFs, seven of which were technologically sophisticated. 3 three of the five sectors with the highest overrepresentation were technologically sophisticated. Of the 43 sectors with on average underrepresentation in relative employment-HGFs, twelve had a high degree of technological sophistication.

A basic descriptive analysis thus seems to imply that sectors with a higher degree of technological sophistication are overrepresented in HGFs. To dig deeper into this subject, on a greater level of disaggregation, and controlling for factors that could influence the results, regression analysis is required.

Table 3. Average share of high-growth firms by industry (2000-2005).

| | 2-digit SNI sector | Industry mean percentage share of absolute employment-HGFs | relative employment-HGFs | composite employment-HGFs | Mean sector size (N of firms) | Technological sophistication? |
|---|---|---|---|---|---|---|
| 1 | Agriculture, hunting | 0.1 | 0.3 | 0.1 | 3 625.8 | 0 |
| 2 | Forestry, logging | 0.1 | 0.4 | 0.1 | 1 434.3 | 0 |
| 5 | Fishing | 0.0 | 0.1 | 0.0 | 145.7 | 0 |
| 10 | Mining of coal and lignite | 0.8 | **2.4** | 0.8 | 61.3 | 0 |
| 11 | Extraction petroleum, natural gas | 0.0 | 0.0 | 0.0 | 2.8 | 0 |
| 13 | Mining of metal ores | 2.2 | 0.0 | 1.1 | 17.6 | 0 |
| 14 | Other mining, quarrying | 0.5 | 0.4 | 0.4 | 230.7 | 0 |
| 15 | Manu: food, beverages | 1.8 | 1.1 | 1.4 | 1 276.3 | 0 |
| 16 | Manu: tobacco | **11.7** | 0.0 | **11.7** | 5.5 | 0 |
| 17 | Manu: textiles | 0.4 | 0.5 | 0.5 | 423.5 | 0 |
| 18 | Manu: wearing apparel | 0.2 | 0.5 | 0.2 | 154.5 | 0 |
| 19 | Manu: leather | 0.0 | 0.0 | 0.0 | 91.8 | 0 |
| 20 | Manu: wood | 1.1 | 0.5 | 0.8 | 1 572.0 | 0 |
| 21 | Manu: pulp, paper | 2.5 | 0.8 | 1.6 | 251.8 | 0 |
| 22 | Manu: Publishing, printing, recordings | 0.7 | 0.5 | 0.5 | 3 097.5 | 0 |
| 23 | Manu: coke, refined petroleum, nuclear fuel | **3.2** | 0.7 | 0.7 | 23.4 | 0 |
| 24 | Manu: chemicals | **2.8** | 0.9 | **2.1** | 419.7 | 1 |
| 25 | Manu: rubber, plastic | 1.8 | 0.9 | 1.4 | 878.0 | 0 |
| 26 | Manu: other non-metallic mineral | 1.6 | 0.7 | 1.0 | 482.7 | 0 |
| 27 | Manu: basic metals | **3.6** | 0.6 | 1.9 | 219.9 | 0 |
| 28 | Manu: fabricated metal, not machinery, equip | 0.6 | 0.7 | 0.5 | 4 701.7 | 0 |
| 29 | Manu: machinery, equipment | 1.5 | 0.6 | 1.1 | 2 172.4 | 1 |
| 30 | Manu: office machinery, computers | 2.7 | 0.8 | **2.0** | 146.0 | 1 |
| 31 | Manu: electrical machinery, apparatus | 1.6 | 0.8 | 1.2 | 590.4 | 1 |
| 32 | Manu: radio, television, communication | **2.9** | **1.2** | **3.0** | 282.0 | 1 |
| 33 | Manu: medical, precision, optical | 1.7 | 0.7 | 1.2 | 1 028.3 | 1 |
| 34 | Manu: motor vehicles | **5.2** | **1.4** | **3.6** | 444.8 | 1 |
| 35 | Manu: other transport | 1.6 | 1.0 | 1.5 | 504.0 | 1 |
| 36 | Manu: furniture | 1.2 | 0.4 | 0.5 | 1 150.8 | 0 |
| 37 | Manu: Recycling | 2.0 | **1.9** | 1.6 | 139.3 | 0 |
| 40 | Electricity, gas, steam, hot water supply | 2.2 | 0.8 | 1.6 | 608.2 | 0 |
| 41 | Water collection, purification, distribution | **3.5** | 0.0 | **1.9** | 18.2 | 0 |
| 45 | Construction | 0.4 | 0.7 | 0.4 | 16210.7 | 0 |
| 50 | Motor vehicles sale, maintenance, repair | 0.6 | 0.6 | 0.4 | 6 460.2 | 0 |
| 51 | Wholesale/commission trade, not motor vehicles | 0.4 | 0.5 | 0.4 | 15680.3 | 0 |
| 52 | Retail trade, not motor vehicles | 0.4 | 0.5 | 0.5 | 14950.5 | 0 |
| 55 | Hotels and restaurants | 0.4 | 0.9 | 0.6 | 5662.0 | 0 |
| 60 | Land transport; transport via pipelines | 0.4 | 0.8 | 0.5 | 6812.1 | 0 |
| 61 | Water transport | 2.6 | 1.0 | **2.0** | 396.2 | 1 |
| 62 | Air transport | **5.1** | **1.3** | **4.6** | 84.8 | 1 |
| 63 | Supporting, auxiliary transport | 1.6 | **1.1** | 1.5 | 1953.3 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 64 | Post and telecommunications | **5.8** | **2.3** | **5.0** | 212.6 | 1 |
| 65 | Financial intermediation, not insurance, pension | 1.0 | 0.5 | 0.8 | 774.1 | 1 |
| 66 | Insurance, pension, not social security | **11.7** | **11.7** | **11.7** | 3.4 | 1 |
| 67 | Activities auxiliary to finance | 0.4 | 0.6 | 0.4 | 1731.4 | 1 |
| 70 | Real estate activities | 0.2 | 0.3 | 0.3 | 12477.3 | 1 |
| 71 | Renting machinery, personal, household goods | 0.2 | 0.5 | 0.2 | 1837.2 | 1 |
| 72 | Computer and related activities | 1.2 | **1.2** | 1.4 | 6991.3 | 1 |
| 73 | Research and development | 1.2 | **1.1** | 1.2 | 881.0 | 1 |
| 74 | Other business activities | 0.4 | 0.5 | 0.5 | 30258.6 | 1 |
| 75 | Public administration, defence; social security | 0.0 | 0.8 | 0.0 | 17.6 | 0 |
| 80 | Education | 1.0 | 1.0 | 1.0 | 2094.5 | 1 |
| 85 | Health and social work | 0.8 | 0.6 | 0.7 | 4588.9 | 1 |
| 90 | Sewage and refuse disposal etc | 2.1 | 0.8 | 1.3 | 321.0 | 0 |
| 91 | Activities of membership organizations | 1.6 | 0.7 | 1.2 | 183.0 | 0 |
| 92 | Recreational, cultural and sporting activities | 0.4 | 0.5 | 0.4 | 4262.3 | 1 |
| 93 | Other service activities | 0.3 | 0.5 | 0.3 | 1498.3 | 0 |

## 6. Regression model

In order to assess what industry-specific factors determine the industry distribution of HGFs, we estimate two sets of regressions: a tobit model and a probit model. To our knowledge, we are the first in this field to employ tobit regression analysis, and also to treat industry as the unit of analysis rather than firm.

The tobit method fits the dependent variable and the independent variables in a model where the censoring values are fixed. This serves our purpose as our dependent variable in the tobit model, the share of HGFs in an industry, can neither fall below zero nor exceed 1. The tobit model avoids the bias in the estimates that these lower and upper limits could otherwise cause. The dependent variable in this model is the industry's share of HGFs. While regressions are performed with industries on both the 3-, 4-, and 5-digit NACE-level serving as unit of analysis, the only results presented are those at the 5-digit level. The other results are however highly similar.

The probit model employs a dummy variable (1,0) as dependent variable. The dummy takes the value 1 if a 5-digit NACE industry has an overrepresentation (>1%) of HGFs relative to the economy average, 0 if not. Marginal effects coefficients in the probit model should be interpreted as increasing or decreasing the probability of an industry having an overrepresentation.

Descriptive statistics for the dependent variables are shown in table 4. While the economy share of HGFs is 1%, the mean values for the industry shares of HGFs do not have to be 0,01

since the size of the 5-digit industries, measured in numbers of firms, are not taken into account when computing this. The statistics imply that the dispersion around the mean is smaller for the shares of relative employment-HGFs than for the other two, and that fewer industries have an overrepresentation in relative employment-HGFs than in absolute employment-HGFs.

Table 4. Descriptive statistics for industry-specific dependent variables (2000-2005).

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| share of absolute employment-HGFs | 3,464 | 0.020 | 0.05 | 0 | 0.5 |
| share of relative employment-HGFs | 3,464 | 0.010 | 0.03 | 0 | 0.5 |
| share of composite employment-HGFs | 3,464 | 0.015 | 0.04 | 0 | 0.5 |
| overrepresentation of absolute employment-HGFs | 3,464 | 0.33 | 0.47 | 0 | 1 |
| overrepresentation of relative employment-HGFs | 3,464 | 0.26 | 0.44 | 0 | 1 |
| overrepresentation of composite employment-HGFs | 3,464 | 0.28 | 0.45 | 0 | 1 |

Turning to our independent variables, the growth of firms – and thereby the share of HGFs - is expected to vary across industries for several reasons. In the following, arguments are presented of what industry specific factors could affect the results. Their operationalization is also specified.

Firm age has been a subject of interest in the previous literature on HGFs. There is evidence that HGFs, regardless of definition, are on average younger than other firms (c.f. Daunfeldt et al 2010). A still larger number of studies in the general field of firm growth argue that firm age is an important determinant of firm growth. That a link should persist also on the industry-level is plausible. Firms in mature industries are likely to exhibit lower average growth rates, due to a lower level of opportunity in mature industries (Coad, 2007, p.40).

Two measures related to industry age are included in the empirical analysis. This industry-specific data is computed from individual firm age, specified as the current year of observation minus the registered start year of the firm in the data. Note, however, that the data on the start year is truncated. The oldest registered start year is 1971, implying that no firm can be older than 34. Since the industry's median age is included in the empirical analysis this truncation should not affect the results, as the great majority of firms are considerably younger. The sector's firm age variance is also included in the empirical analysis, in order to control for any effect of differences in the age distribution of firms across sectors.

The size of an industry could also potentially affect firm growth rates. There may also be a bias towards small (large) industries appearing to be overrepresented (underrepresented) in HGFs. Industry size, measured as the total number of firms, is included to capture this effect.

Because of the rapid pace of technological progress, firms in high-technology industries may have higher growth rates. Growth patterns across industries may also vary as innovation regimes differ considerably across sectors. Audretsch (1995) finds that while the likelihood of survival for new entrants is lower in innovative industries, those firms that do survive exhibit higher growth rates than firms in other industries. The most common ways to measure innovation is by using research and development (R&D) statistics or patents, albeit one should be wary of the drawbacks of each of these indicators (Coad, 2007, p.33).[3]

We employ two different measures of technological sophistication. First, we classify the 5-digit industries according to Eurostat's degree of technological sophistication in manufacturing and service industries. Manufacturing industries are classified as either high tech, medium tech, medium low tech or low tech. Services are classified as high tech knowledge intensive (kis), market knowledge intensive, other knowledge intensive or less knowledge intensive (see table A1 in appendix). Second, since our data contains information on the R&D expenditure of firms we include mean industry spending on this in the analysis as well. Both mean R&D expenditure and the Eurostat dummies are included in the models.

Descriptive statistics for the relevant industry specific independent variables are shown in table 5. We also include fixed effects for industry at the 1-digit NACE level (making sure they do not overlap with Eurostat's dummies), and year. For descriptive statistics on these variables, the reader is referred to the appendix.

Table 5. Descriptive statistics for the industry-specific independent variables (2000-2005).

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| median age | 3,464 | 12.2 | 4.8 | 1 | 32 |
| s.d. age | 3,464 | 8.9 | 2.1 | 0 | 17.0 |
| industry size | 3,464 | 263 | 751 | 2 | 11,888 |
| high tech manufacturing | 3,464 | 0.02 | 0.14 | 0 | 1 |
| medium tech manufacturing | 3,464 | 0.08 | 0.28 | 0 | 1 |
| medium low tech manufacturing | 3,464 | 0.11 | 0.31 | 0 | 1 |
| low tech manufacturing | 3,464 | 0.16 | 0.37 | 0 | 1 |
| high tech knowledge intensive services | 3,464 | 0.03 | 0.17 | 0 | 1 |
| market knowledge intensive services | 3,464 | 0.08 | 0.27 | 0 | 1 |
| other knowledge intensive services | 3,464 | 0.10 | 0.30 | 0 | 1 |
| less knowledge intensive services | 3,464 | 0.27 | 0.45 | 0 | 1 |

[3] As Coad (2007, p.33) explains, both patents and R&D statistics have their drawbacks: "R&D statistics are typically quite smoothed over time, which contrasts with the lack of persistence frequently observed in patent statistics. Furthermore, R&D expenditure is an innovative input and it gives only a poor indication of the value of the resulting innovative output that a firm can take to market. Patent statistics are very skewed in value, with many patents being practically worthless whilst a fraction of patents generate the lion's share of the economic value. Another limitation is that many previous studies have lumped together firms from all manufacturing sectors -- even though innovation regimes (and indeed appropriability regimes) vary dramatically across industries

| | | | | | |
|---|---|---|---|---|---|
| mean research and development spending | 3,464 | 426.1 | 2,121.1 | 0 | 35,106.4 |

## 7. Results

Tables 6-8 reports the results of the tobit and probit regression models. Marginal effect coefficients are presented for the probit regressions. To facilitate within-model comparisons, the industry and Eurostat dummies appear in italics and are ranked by order of magnitude.

Mean industry R&D spending has a small yet significant positive effect on both the share (tobit) and the overrepresentation (probit) of absolute and composite employment-HGFs, but no significant effect on the distribution of relative employment-HGFs. It thus appears that industries where firms grow fast in absolute (or quasi-absolute) numbers are more likely to invest in formal R&D. This is perhaps consistent with previous findings suggesting that these firms are on average larger – and thereby possess greater financial resources - than fast relative growers (c.f. Daunfeldt et al, 2010).

The industry median age of firms has a significant negative effect on both the share (tobit) and the overrepresentation (probit) of relative employment-HGFs. The effect is negative, but significant only in the probit model for composite employment-HGFs. The effect is negative, but insignificant on the overrepresentation of absolute employment-HGFs, yet positive and significant on the share of absolute employment-HGFs. This suggests that young industries are more likely than older industries to spawn a disproportionate number of relative employment-HGFs and composite-employment-HGFs. Industry age seems less important for the prevalence of absolute employment-HGFs.

The standard deviation of age in a sector has a significant positive effect on both the share (tobit) and the overrepresentation (probit) of absolute employment-HGFs and composite employment-HGFs, but a significant negative effect on the share of relative employment-HGFs. These results could be interpreted to mean that a greater age discrepancy across firms in an industry is more favorable for absolute and composite employment-HGFs than relative employment-HGFs.

While industry size has a significant negative effect on the overrepresentation (probits) of both absolute, composite and relative employment-HGFs, the effect is significant and positive on the share (tobit) of relative and composite employment-HGFs, but insignificant on the share of absolute employment-HGFs. The results appear to be sensitive to the choice of model.

In all six regressions, the coefficient for high tech knowledge intensive services ranks among the highest. It is always significantly different from the base case medium tech

manufacturing. Meanwhile, coefficients for sectors 0-9 (Agriculture and finishing) and 10-19 (Mining and manufacturing) always have the lowest value relative to the base case. They too are always significant. These results hold regardless of how HGFs are defined, and regardless of the choice of model.

Across both the manufacturing and service sectors, furthermore, there appears to be a hierarchy linking higher industry degree of technological sophistication to a higher impact on the prevalence or overrepresentation of HGFs, relative to the base case. Yet while the high tech manufacturing coefficient is always greater than the base case, it is smaller than the high tech knowledge intensive-dummy in five cases of six. Furthermore it is insignificant in the case of relative employment-HGFs. The medium low tech and low tech manufacturing coefficients are significantly smaller than zero, in all but one case. The service dummies are always structured with high tech knowledge intensive services on top, followed by other knowledge intensive services, market knowledge intensive services, and less knowledge intensive services. These coefficients are significantly different from the base case most of the time.

It thus appears reasonable to conclude that while the effect is more pronounced for service industries, a higher degree of technological sophistication will, ceteris paribus, result in a higher share of all types HGFs for both manufacturing and service industries.

In all, our results suggest that the relationship between technological sophistication and both the share and the overrepresentation of HGFs is clear, especially in service sectors. R&D spending only seems to have a positive impact on the prevalence or overrepresentation of absolute and composite employment-HGFs, while a young sector age has effect particularly on the share/overrepresentation of relative employment-HGFs.

Table 6. Regression model to estimate what effects the industry share (tobit) or industry overrepresentation (probit) of absolute employment-HGFs.

| Tobit (share of absemp-HGFs; 0-1) | | | | Mfx of Probit (overrep of absemp-HGFs; 0,1) | | | |
|---|---|---|---|---|---|---|---|
| Variable | Coef. | | t | Variable | dy/dx | | t |
| median age | 0,0012 | *** | ( 3,48 ) | median age | -0,0014 | | ( -0.72 ) |
| s.d. age | 0,0052 | *** | ( 6,35 ) | s.d. age | 0,0263 | *** | ( 5.59 ) |
| industry size | 2,4E-06 | | ( 1,42 ) | industry size | -0,0001 | *** | ( -6.28 ) |
| mean RnD | 3,3E-06 | *** | ( 5,25 ) | mean RnD | 2,0E-05 | *** | ( 4.24 ) |
| *high tech kis* | 0,049 | *** | ( 5,45 ) | *high tech manu* | 0,156 | ** | ( 2.14 ) |
| *other kis* | 0,019 | *** | ( 2,98 ) | *high tech kis* | 0,149 | ** | ( 2.38 ) |
| *high tech manu* | 0,019 | * | ( 1,95 ) | *other kis* | -0,077 | ** | ( -2.23 ) |
| *sni 40-49* | 0,003 | | ( 0,41 ) | *low tech manu* | -0,123 | *** | ( -3.96 ) |
| *market kis* | 0,000 | | ( -0,04 ) | *market kis* | -0,131 | *** | ( -4.03 ) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *low tech manu* | -0,015 | ** | ( | -2,24 | ) | *sni 40-49* | -0,168 | *** | ( | -5.16 | ) |
| *less kis* | -0,016 | *** | ( | -3,06 | ) | *medium low tech manu* | -0,183 | *** | ( | -7.21 | ) |
| *medium low tech manu* | -0,017 | *** | ( | -2,74 | ) | *less kis* | -0,227 | *** | ( | -8.99 | ) |
| *sni 10-19* | -0,037 | *** | ( | -5,71 | ) | *sni 10-19* | -0,234 | *** | ( | -11.10 | ) |
| *sni 0-9* | -0,083 | *** | ( | -9,48 | ) | *sni 0-9* | -0,334 | *** | ( | -26.88 | ) |
| yr_3 | -0,006 | | ( | -1,42 | ) | yr_3 | -0,047 | * | ( | -1.89 | ) |
| yr_4 | -0,004 | | ( | -0,97 | ) | yr_4 | -0,031 | | ( | -1.23 | ) |
| yr_5 | -0,001 | | ( | -0,25 | ) | yr_5 | 0,002 | | ( | 0.07 | ) |
| yr_6 | -0,001 | | ( | -0,34 | ) | yr_6 | -0,006 | | ( | -0.25 | ) |
| _cons | -0,060 | *** | ( | -5,88 | ) | | | | | | |

Note: ***, **, * denote significance at the 1-, 5- and 10-percent level. Industry specific dummies are sorted in order of magnitude to facilitate comparisons. Medium tech manufacturing serves as base case.

Table 7. Regression model to estimate what effects the industry share (tobit) or industry overrepresentation (probit) of relative employment-HGFs.

| Tobit (share of relemp-HGFs; 0-1) | | | | | | Mfx of Probit (overrep of relemp-HGFs; 0,1) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Coef. | | | t | | Variable | dy/dx | | | t | |
| median age | -0,0008 | *** | ( | -3,47 | ) | median age | -0,0122 | *** | ( | -6.04 | ) |
| s.d. age | -0,0021 | *** | ( | -4,01 | ) | s.d. age | -0,0020 | | ( | -0.47 | ) |
| industry size | 4,1E-06 | *** | ( | 3,69 | ) | industry size | -2,1E-05 | * | ( | -1.92 | ) |
| mean RnD | 2,5E-07 | | ( | 0,54 | ) | mean RnD | 2,9E-06 | | ( | 0.79 | ) |
| *high tech kis* | 0,025 | *** | ( | 4,16 | ) | *high tech kis* | 0,229 | *** | ( | 3,65 | ) |
| *other kis* | 0,012 | *** | ( | 2,82 | ) | *high tech manu* | 0,031 | | ( | 0,53 | ) |
| *sni 40-49* | 0,010 | ** | ( | 1,98 | ) | *sni 40-49* | 0,018 | | ( | 0,41 | ) |
| *market kis* | 0,009 | ** | ( | 1,99 | ) | *other kis* | 0,003 | | ( | 0,09 | ) |
| *high tech manu* | 0,007 | | ( | 0,99 | ) | *market kis* | -0,003 | | ( | -0,08 | ) |
| *less kis* | 0,006 | | ( | 1,53 | ) | *low tech manu* | -0,057 | * | ( | -1,69 | ) |
| *low tech manu* | 0,000 | | ( | 0,08 | ) | *less kis* | -0,062 | ** | ( | -2,22 | ) |
| *medium low tech manu* | -0,008 | * | ( | -1,74 | ) | *medium low tech manu* | -0,079 | ** | ( | -2,67 | ) |
| *sni 10-19* | -0,017 | *** | ( | -3,7 | ) | *sni 10-19* | -0,115 | *** | ( | -4,28 | ) |
| *sni 0-9* | -0,024 | *** | ( | -4,82 | ) | *sni 0-9* | -0,175 | *** | ( | -7,68 | ) |
| yr_3 | -0,003 | | ( | -1,05 | ) | yr_3 | 0,004 | | ( | 0.16 | ) |
| yr_4 | -0,007 | *** | ( | -2,59 | ) | yr_4 | -0,049 | ** | ( | -2.16 | ) |
| yr_5 | 0,001 | | ( | 0,27 | ) | yr_5 | 0,053 | ** | ( | 2.13 | ) |
| yr_6 | 0,000 | | ( | -0,14 | ) | yr_6 | 0,016 | | ( | 0.68 | ) |
| _cons | 0,016 | ** | ( | 2,46 | ) | | | | | | |

Note: ***, **, * denote significance at the 1-, 5- and 10-percent level. Industry specific dummies are sorted in order of magnitude to facilitate comparisons. Medium tech manufacturing serves as base case.

Table 8. Regression model to estimate what effects the industry share (tobit) or industry overrepresentation (probit) of composite employment-HGFs.

| Tobit (share of compemp-HGFs; 0-1) | | | | Mfx of Probit (overrep of compemp-HGFs; 0,1) | | | |
|---|---|---|---|---|---|---|---|
| Variable | Coef. | | t | Variable | dy/dx | | t |
| median age | -0,0002 | | ( -0,75 ) | median age | -0,006 | *** | ( -3,14 ) |
| s.d. age | 0,0031 | *** | ( 4,14 ) | s.d. age | 0,018 | *** | ( 3,91 ) |
| industry size | 3,5E-06 | ** | ( 2,3 ) | industry size | -9,2E-05 | *** | ( -5,37 ) |
| mean RnD | 3,0E-06 | *** | ( 5,26 ) | mean RnD | 1,9E-05 | *** | ( 4,59 ) |
| *high tech kis* | 0,052 | *** | ( 6,57 ) | *high tech kis* | 0,270 | *** | ( 4,27 ) |
| *high tech manu* | 0,023 | *** | ( 2,63 ) | *high tech manu* | 0,182 | *** | ( 2,61 ) |
| *other kis* | 0,018 | *** | ( 3,07 ) | *other kis* | -0,033 | | ( -0,97 ) |
| *market kis* | 0,006 | | ( 0,94 ) | *market kis* | -0,063 | * | ( -1,84 ) |
| *sni 40-49* | 0,001 | | ( 0,16 ) | *low tech manu* | -0,117 | *** | ( -4,16 ) |
| *less kis* | -0,010 | ** | ( -1,98 ) | *sni 40-49* | -0,127 | *** | ( -3,93 ) |
| *low tech manu* | -0,013 | ** | ( -2,19 ) | *less kis* | -0,152 | *** | ( -6,09 ) |
| *medium low tech manu* | -0,027 | *** | ( -4,59 ) | *medium low tech manu* | -0,154 | *** | ( -6,45 ) |
| *sni 10-19* | -0,029 | *** | ( -4,95 ) | *sni 10-19* | -0,163 | *** | ( -7,14 ) |
| *sni 0-9* | -0,052 | *** | ( -7,28 ) | *sni 0-9* | -0,256 | *** | ( -16,8 ) |
| yr_3 | -0,008 | ** | ( -2,1 ) | yr_3 | -0,062 | *** | ( -2,71 ) |
| yr_4 | -0,004 | | ( -1,09 ) | yr_4 | -0,042 | * | ( -1,8 ) |
| yr_5 | 0,000 | | ( -0,08 ) | yr_5 | -0,002 | | ( -0,06 ) |
| yr_6 | -0,002 | | ( -0,43 ) | yr_6 | -0,001 | | ( -0,03 ) |
| _cons | -0,031 | *** | ( -3,39 ) | | | | |

Note: ***, **, * denote significance at the 1-, 5- and 10-percent level. Industry specific dummies are sorted in order of magnitude to facilitate comparisons. Medium tech manufacturing serves as base case.

## 8. Concluding remarks

This study has examined the distribution of HGFs (defined by relative employment, absolute employment, and composite employment growth) across industries, and found substantial differences across industries concerning the representation of HGFs.

In a regression model, these discrepancies are found to be explained to a large extent by an industry's degree of technological sophistication. More technologically sophisticated industries, particularly high tech knowledge intensive service industries, spawn more HGFs, whether they are defined by absolute, relative or composite employment growth.

The results are in line with those presented for Sweden in the period 1987-1996 by Delmar et al (2003) and Delmar and Davidsson (2003, 2006). They also confirm the results from several recent studies that, applying statistical analysis, indicate a stronger relationship between innovation and high growth of firms than earlier literature did. We conclude that technological intensity appears crucial for firm growth, particularly in the service industries.

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Appendix 1

Aggregations of manufacturing based on NACE Rev 1.1

*High-technology*
24.4 Manufacture of pharmaceuticals, medicinal chemicals and botanical products;
30 Manufacture of office machinery and computers;
32 Manufacture of radio, television and communication equipment and apparatus;
33 Manufacture of medical, precision and optical instruments, watches and clocks;
35.3 Manufacture of aircraft and spacecraft

*Medium-high-technology*
24 Manufacture of chemicals and chemical product, excluding 24.4 Manufacture of pharmaceuticals, medicinal chemicals and botanical products;
29 Manufacture of machinery and equipment n.e.c.;
31 Manufacture of electrical machinery and apparatus n.e.c.;
34 Manufacture of motor vehicles, trailers and semi-trailers;
35 Manufacture of other transport equipment, excluding 35.1 Building and repairing of ships and boats and excluding 35.3 Manufacture of aircraft and spacecraft.

*Medium-low-technology*
23 Manufacture of coke, refined petroleum products and nuclear fuel;
25 to 28 Manufacture of rubber and plastic products; basic metals and fabricated metal products; other non-metallic mineral products;
35.1 Building and repairing of ships and boats.

*Low-technology*
15 to 22 Manufacture of food products, beverages and tobacco; textiles and textile products; leather and leather products; wood and wood products; pulp, paper and paper products, publishing and printing;
36 to 37 Manufacturing n.e.c.

Aggregations of services based on NACE Rev 1.1

Knowledge-intensive services (KIS)
61 Water transport;
62 Air transport;

64 Post and telecommunications;
65 to 67 Financial intermediation;
70 to 74 Real estate, renting and business activities;
80 Education;
85 Health and social work;
92 Recreational, cultural and sporting activities

High-tech KIS
64 Post and telecommunications;
72 Computer and related activities;
73 Research and development.

Market KIS (excl. financial intermediation and high-tech services)
61 Water transport;
62 Air transport;
70 Real estate activities;
71 Renting of machinery and equipment without operator and of personal and household goods;
74 Other business activities.

Less Knowledge-intensive Services (LKIS)
50 to 52 Motor trade;
55 Hotels and restaurants;
60 Land transport; transport via pipelines;
63 Supporting and auxiliary transport activities; activities of travel agencies;
75 Public administration and defence; compulsory social security;
90 Sewage and refuse disposal, sanitation and similar activities;
91 Activities of membership organization n.e.c.;
93 Other service activities;
95 to 97 Activities of households;
99 Extra-territorial organizations and bodies

Market services less KIS
50 to 52 Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods;
55 Hotels and restaurants;
60 Land transport; transport via pipelines;
63 Supporting and auxiliary transport activities; activities of travel agencies.