The Economic Contribution of High-Growth Firms: Do Policy Implications Depend on the Choice of Growth Indicator?

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Abstract Prior studies have defined high-growth firms (HGFs) in terms of growth in firm employment or firm sales, and primarily analyzed their contribution to overall employment growth. In this paper we define HGFs using the commonly applied growth indicators (employment and sales), but also add definitions based on growth in value added and productivity. Our results indicate that HGFs in terms of employment are not the same firms as HGFs in terms of productivity, and that their economic contributions differ significantly. Economic policy promoting fast growth in employment may therefore come at the cost of reduced productivity growth. Although HGFs of different definitions may not be the same firms, young firms are more likely to be HGFs irrespective of definition. This suggests that economic policy should focus on the conditions for new firm formation and early growth of firms, rather than target a particular type of HGFs.

1 Introduction

In recent years, a small number of *high-growth firms* (henceforth HGFs) have received increasing attention from policymakers, arguably because they create most new jobs (Birch

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and Medoff 1994; Storey 1994; Henrekson and Johansson 2010; Hölzl 2010). The *Europe 2020* strategy, for example, explicitly mentions support of high growth SMEs as a political objective (European Commission 2010), and a country's share of fast-growing innovative firms has been proposed as a top indicator to measure the progress of the strategy. A report from OECD meanwhile explicitly asks the question of what governments can do to promote high-growth enterprises (OECD 2010a).

Researchers have also begun to argue that policies should be re-directed towards targeting potential HGFs. Shane (2009), for example, argues that the importance of a small number of HGFs suggests that policies should be re-directed from subsidizing the typical start-up company towards encouraging high-growth start-ups. Mason and Brown (2013) support the idea of targeting high-growth start-ups, and present a number of initiatives that policymakers can implement to actually generate and promote HGFs.

The recent focus on HGFs is, however, not unproblematic. One question of importance is whether policymakers should target firms that experience high growth in terms of employment, sales, value added or productivity. There may for example be large societal costs to targeting HGFs in terms of employment by economic policy if the policy at the same time disfavors HGFs in terms of productivity (cf. Aiginger 2006; 2007).

Theoretical predictions on the relationship between employment and productivity growth are contradictory (Penrose 1959; McCombie 1987; Metcalfe 1994), and empirical studies (Foster et al. 1998) have in most cases failed to find any significant relationship. One exception is Coad and Broekel (2012), who found that an increase in employment growth in general was associated with a decrease in productivity. On the other hand, their results also indicated that an increase in productivity had a positive effect on employment growth for the fastest growing firms.

Another concern is whether HGFs will repeat their high growth rates in coming periods. If not, this seriously challenges the notion that policymakers can target high-growth firms in order to promote future firm growth. In addition, a more extensive targeting of firms may also result in more unproductive entrepreneurship since the return to such activities increase. Firm managers may perceive that they are better off applying for government subsidies than producing goods and services demanded by consumers (Baumol 1990).

The purpose of this paper is to examine whether the results of supporting HGFs depend on which growth indicators are used to identify these firms. More specifically, we are interested in

– whether HGFs defined in different ways are equally important to the growth in different economic output variables
– if HGFs are the same firms irrespective of definition
– if the growth persistence of HGFs depend on the chosen definition, and
– whether firm age and size have the same influence on the probability of a firm being a HGF irrespective of how we choose to identify these firms.

Our analysis is based on a comprehensive dataset covering all limited liability companies in Sweden from 1997 to 2010. While prior research analyzing the economic contribution of HGFs has identified them as fast growers in terms of firm employment or firm sales, we also identify HGFs by growth in firm labor productivity and firm value added. We thus employ four different indicators of firm growth. We measure firm growth in both absolute and relative (percentage) terms. When employment is the growth indicator, growth is also measured using a combination of absolute and relative numbers, the so-called Birch Index. In total, this results in nine types of growth. The one percent of firms exhibiting the highest growth rates are defined as HGFs in each of these nine groups.

Correlation analysis is used to determine to what extent the nine definitions of HGFs overlap. Following Capasso et al (2009) and Daunfeldt and Halvarsson (2012), we also estimate transition probabilities in order to analyze the growth persistence for the different

types of HGFs. The contribution of each group of HGFs to the output variables aggregate economic growth, employment growth, productivity growth, and sales growth is then analyzed. To study whether firm age and size influence the probability of being a HGF, probit regression models are estimated.

The results indicate a trade-off between fast growers in employment and fast growers in productivity, implying that policies targeted towards employment HGFs will disfavor productivity HGFs (and vice versa). Estimated transition probabilities also show that HGFs that are defined in terms of relative change are unlikely to repeat their high growth rates in coming periods, whereas HGFs that are measured in absolute numbers show a high degree of growth persistence. Regression results show that young firms are more likely to be HGFs irrespective of how HGFs are defined. Hence, the conditions for new firm formation and early growth of firms appear to be crucial for the prevalence of HGFs and for economic development.

We begin with a theoretical discussion on firm growth in Section 2. Thereafter, we review the empirical literature on HGFs in Section 3. The data and the descriptive statistics are presented in Section 4. In Section 5 we undertake our transition probability analysis. In Section 6, the contribution of HGFs to different output variables is investigated. The influence of firm age and size on the likelihood of being a HGF is studied in Section 7. In Section 8, we summarize and draw conclusions.

2 Theoretical discussion

The growth in per capita income over the past two centuries has been spectacular (Maddison 2001). The Austrian economist Joseph Schumpeter credited this development to creative destruction—the process of transformation that accompanies innovation, caused by the discovery and use of novel ideas. In the market, firms are established to exploit and commercialize these ideas. The question whether some firms—small, large, young, old, or fast-growing—serve this purpose better than others is still central in the discourse of firm growth, and the cause of a longstanding discussion (Davidsson et al. 2010).[1]

The early Schumpeter (1934/1912)—Mark I—emphasized entrepreneurship and the role of new (small) ventures for introducing novel ideas into the economic system. The later Schumpeter (1943)—Mark II—was of another opinion, arguing that innovation was a routinized process best performed by large firms able to reap the benefits of economies of scale in production and in R&D (Malerba and Orsenigo 1995). Granted, the answer may differ across time and space, as the characteristics of HGFs may be shaped by a country's economic development. Audretsch and Thurik (2000) argue that highly developed economies have experienced a general shift from a managed to an entrepreneurial economy, and van Stel et al. (2005) relate Mark I and II to 'entrepreneurial' and 'managed' economies, respectively. They point to cross-country differences, distinguishing between 'core economies', rich/developed countries where growth is powered by firms' capacity to innovate, and 'non-core economies', poor/developing countries where growth is achieved by the absorption of technology and capital of core economies, in a catching-up process.

The dichotomy characterized above can be related to the literature on 'technological regimes' pioneered by Winter (1984), which argues that the industry-specific technological regime has a major influence on firm competitiveness (Audretsch 1995). An entrepreneurial regime applies in early stages of creative destruction and a product or industry life cycle,

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[1] Recently, endogenous growth theory has emerged arguing that new knowledge drives economic growth (Romer 1986). This literature was preceded by Hayek who early on forcefully emphasized the role of knowledge (e.g. 1937, 1945, 1984).

where knowledge is new and dispersed and scale economies are of minor importance. At this entrepreneurial stage, small and new firms are most likely to drive development and economic growth. By contrast, a routinized regime pertains to later stages of the industry or product life cycle, when technologies have been exploited and products and knowledge have become more standardized. In this regime, scale economies and process innovation hold center stage, the industry has probably undergone a period of shakeout, and a small number of large incumbent firms predominate (cf. Klepper and Simons 2005).[2]

Many findings emphasize the complementary roles of firms of different sizes. Large established firms appear to succeed in traditional technological fields already based on large innovative activities, while new firms explore new technological areas. Especially, small entrepreneurial firms introduce many of the radically new innovations, 'revolutionary break-throughs', while risk-averse large firms provide 'cumulative incremental improvements' whose revolutionary consequences should not be underestimated (Acs and Audretsch 2005). Baumol (2004, p.13) writes: "Of course, that initial invention was an indispensable necessity for all of the later improvements. But it is only the combined work of the two together that made possible the powerful and inexpensive apparatus that serves us so effectively today". Even in mature industries dominated by economies of scale, new and small firms can compete successfully due to the bureaucratic inertia that often plagues old and large firms (Hannan and Freeman 1977).

Lately, research has focused on the growth ambitions of the entrepreneur as a necessary condition for firm growth (Davidsson 1991; Wiklund and Shepherd 2003).[3] Yet, many entrepreneurs hold only modest growth aspirations (Davidsson et al. 2010). Hence, entrepreneurial capacity is a major constraint on firm growth, and scarce and unevenly distributed among the population (Penrose 1959; Peneder 2009). Jovanovic (1982) assumes that individuals have different innate abilities but imperfect information about them when they start a business, only learning about their abilities as their business survives and grows. Dosi (2007) assesses that heterogeneity in degrees of innovativeness and production efficiencies is what should be expected to be the outcome of idiosyncratic capabilities, mistake-ridden learning and forms of path-dependent adaptation. It is hence plausible that requirements of managerial ability differ depending on industry, firm size, technology, and life cycles of firms.

Firm growth is most frequently measured as changes in sales or employment (Delmar 1997), although a number of theoretical studies have argued that there exists a strong relationship between productivity and employment growth. Already Penrose (1959) emphasized that managers were forced to devote resources to less productive domains following increases in the number of employees, suggesting a negative trade-off between employment and productivity growth. Growing fast in terms of employees will thus be associated with a decrease in productivity. This also implies that targeting firms with high employment growth might come at a cost of lower productivity growth. Evolutionary theories and studies (Alchian 1950; Metcalfe 1994; Caballero 2007; Bartelsman et al. 2004, 2013) on entrepreneurship and creative destruction, on the other hand, emphasize the "growth of the fitter"; where industrial development

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[2] Audretsch and Fritsch (2002) and Fritsch and Mueller (2006) have extended the use of the regimes concept to geographical units, notably regions, the idea being that the mode of production in a certain region may be distinct from the dominant modes of production in other regions.
[3] The measures of ambitious entrepreneurship, provided by the Global Entrepreneurship Monitor, echo this. Stam et al. (2008) find that ambitious entrepreneurship contributes more strongly to country-scale economic growth than entrepreneurship in general. According to Wong et al. (2005), high-growth potential Total Entrepreneurial Activity (TEA) is the sole form of entrepreneurship that has any explanatory effect on differing rates of economic growth across nations. Based on this and similar studies, Sternberg and Wennekers (2005, p.200) conclude: "These findings may have important implications for entrepreneurship policy in highly developed economies. At least from an economic growth perspective, policy should focus primarily on potentially fast-growing new firms and not on new enterprises in general."

implies that resources will be allocated towards firms with higher productivity. Thus, firms that are growing fast in terms of productivity will in general increase their number of employees more than firms with lower productivity.

While the above theories do not provide us with many guidelines as to how much faster fast-growing firms will grow, nor what can be expected to be the contribution of HGFs compared to non-HGFs, the empirical literature of firm growth suggests what Dosi (2007) labels an "extremely robust stylized fact" (p.11): that distributions of growth rates are at least exponential (Laplace) or even fatter in their tails (Bottazzi et al. 2001; Bottazzi and Secchi 2003). This finding contradicts the implications of Gibrat's Law, proposed by Robert Gibrat (1931) after he observed that the size distribution of French manufacturing firms closely resembled the lognormal distribution. Gibrat's law predicts that firm growth is a purely random effect and therefore should be independent of firm size. The law has received a huge interest in the literature, as attested by two authoritative surveys in the Journal of Economic Literature (Sutton 1997; Caves 1998), and often forms the null hypothesis for empirical analyses of firm growth.

Dosi (2007 p. 20) assesses that the fat-tale distribution is one of the familiar signs of all complex system dynamics, and that "in most respects, the statistical evidence on industrial change corroborates the exciting conjecture that evolutionary phenomena tend to generically undergo 'non-Gaussian' lives". This implies that the importance of the fastest-growing firms to aggregate growth should be greater than would be suggested from a standard Gaussian distribution. In fact, anything besides a disproportionate contribution from the fastest-growing firms would be surprising.

To sum up, as growth ambitions and entrepreneurial competence are scarce and unevenly distributed resources, some firms should grow faster and make a larger economic contribution, but by how much is an open question which we wish to examine further. Since, according to theory, the growth that should be the result of successful entrepreneurship can take many shapes, and since it might exist a trade-off between employment and productivity growth, we also wish to examine whether the same firms become HGFs when growth is defined in various ways.

3 Previous empirical research

Birch (1979) is generally considered to have provided the igniting spark to the area of small business research (Landström 2005). He did so by empirically demonstrating that small firms generated most new jobs in the US economy, a finding that went against the prevailing view at that time. The interest in HGFs originates from this research, as further investigations showed that most small firms did not grow at all, and that job growth emanates from a small number of fast-growing firms. In an analogy with the animal kingdom, Birch labeled the fast-growing firms "gazelles", the majority of small firms that did not grow "mice", and the big firms with a large employment share but generating little new employment, "elephants" (Birch and Medoff 1994).

Delmar and Davidsson (1998) and Delmar et al. (2003) systematize the literature on rapid firm growth, concluding that measuring firm growth requires addressing four issues: the indicator of growth, the measurement of growth, the period studied, and the process of growth. Growth indicator refers to the variable over which growth is observed, and the measurement of growth concerns a choice between absolute and relative numbers. The process of growth concerns organic and acquired growth.[4]

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[4] Organic growth is growth through new appointments in a firm, while acquired growth is growth through acquisitions and/or mergers. Organic growth and acquired growth may also be denoted internal growth and external growth, respectively. McKelvie and Wiklund (2010) also suggest that different hybrids of organic and acquired growth should be considered.

Henrekson and Johansson (2010) survey the empirical literature on HGFs as job creators. They find that employment and sales are always used as growth indicators, and that growth is measured in absolute numbers and/or relative numbers. Employment growth is also sometimes measured using a combination of absolute and relative numbers. Growth is usually measured over three- or four-year periods. With few exceptions, total growth (the sum of organic and acquired growth) is studied, due to lack of data. HGFs are identified in either of two ways. First, as the share of firms in a population which see the highest growth during a particular period, for instance the one or five percent of firms with the highest growth rate in the period studied. Second, as firms growing at or above a particular pace, measured either in terms of growth between a start and end year, or as annualized growth over a specific number of years. The studied population is either continuing firms (firms existing throughout the period studied), new firms (one or several cohorts of new firms established during the period studied), or all firms (continuing firms as well as new firms established during the period studied).

Despite the apparent heterogeneity across studies, Henrekson and Johansson (2010) ascertain that some general findings emerge. Small firms are overrepresented among HGFs, something which suggests the existence of a regression to the mean. Nevertheless HGFs do come in all sizes, and large firms are important job creators in absolute terms. Furthermore, HGFs appear to always be younger on average than the general population. Lastly, they seem to exist in all industries.

The discussion concerning the importance of age and size as determinants of growth also has a long tradition, going back at least to the formulation of Gibrat's law (Coad 2010). In general, little support has been found for the hypothesis that the growth of a firm is independent of its size, with most studies seeing a negative relationship between size and growth; see Sutton (1997) for a review. A number of studies also suggest that firm age is negatively related to growth (Haltiwanger et al. 2013).

We update Henrekson and Johansson's survey, extending its scope to examine the contribution of HGFs to other output variables as well. Nine additional studies are found (Moreno and Casillas 2007; Hölzl 2009; Anyadike-Danes et al. 2009; López-Garcia and Puente 2012; Bjuggren et al. 2013; Bravo-Biosca 2010; Coad and Hölzl 2010; Hölzl and Friesenbichler 2010; Stangler 2010; Woodward et al 2011). In total, 30 studies are identified (Table 1).[5] The output variables studied are stated in the last column.

The table reveals that all studies have used employment and sales as growth indicators. No previous study has used productivity growth or growth in value added as growth indicators to define HGFs when their economic contribution has been analyzed.[6] Employment is the by far most studied output variable. Sales, wages, and revenue are also used.

Productivity has been discussed in the literature on HGFs prior to this paper (Littunen and Tohmo 2003; Fritsch and Mueller 2004; Acs et al. 2008). For example, Fritsch and Mueller (2004) find that the employment effect from new entry follows a "wave pattern": entry initially increases employment, but after a while employment declines as a result of exits and the crowding out of low-productivity entrants and incumbents: "In this case, the surviving firms will provide a given amount of output more efficiently than before and, insofar as

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[5] Stam et al. (2011) investigate whether the rate of HGFs has an effect on subsequent macroeconomic performance in a sample of low- and high-income countries during the period 2002–2005. Teruel and de Wit (2011) analyze the determinants of HGFs in different countries. As they do not concern themselves directly with the contribution of HGFs, we do not include their studies in our overview.

[6] López-Garcia and Puente (2012) use growth in value added to identify HGFs. However, this is only as a test of robustness of their regression model with HGFs defined by growth in employment. As their study does not consider the contribution of HGFs defined by value added, we do not include their use of value added as a growth indicator in our survey of the previous literature.

Table 1 Growth indicators and growth measurements used in previous studies to identify HGFs, and outcome variables considered

Study	Employment			Sales		Process of growth[a]	Period studied	Output variables[b]
	Absolute	Relative	Composite	Absolute	Relative			
Birch and Medoff (1994)	0	0	0	1	1	T	1988–1992	Emp
Kirchhoff (1994)	0	1	0	0	0	T	1977/78–1984	Emp
Storey (1994)	1	1	0	0	0	T	Various	Emp
Birch et al.(1995)	0	0	0	1	1	T	1990–1994	Emp
Picot and Dupuy (1998)	1	1	0	0	0	T	1978–1992, 1983–1986	Emp
Autio et al.(2000)	0	0	0	1	1	T	1994–1997	Emp
Brüderl and Preisendörfer (2000)	1	1	0	0	0	T	1985/86–1990	Emp
Schreyer (2000), Canada	0	0	1	0	0	T	1990–1996	Emp
Schreyer (2000), France	0	0	1	0	0	T	1985–1994	Emp
Schreyer (2000), Germany	0	1[c]	0	0	0	T	1992–1995	Emp
Schreyer (2000), Italy	0	0	1	0	0	T	1990–1995	Emp
Schreyer (2000), Netherlands	0	0	1	0	0	T	1989–1994	Emp
Schreyer (2000), Spain	0	0	1	0	0	T	1990–1994	Emp
Delmar et al. (2003)[d]	1	1	0	1	1	T, O, A	1987–1996	Emp
Littunen and Thomo (2003)	0	0	0	1	1	T	1990–1997	Emp
Fritsch and Weyh (2006)	1	0	0	0	0	T	1984–2002	Emp
Halabisky et al. (2006)	0	1	1	0	0	T	1985–1999	Emp, W
Moreno and Casillas (2007)	0	0	0	0	1	T	1998–2001	Sales
Acs and Mueller (2008)	0	1	0	0	0	T	1990–2003	Emp
Acs et al. (2008)	1	1	0	0	1	T	1994–2006	Emp, Rev
Deschryvere (2008)	1	1	0	0	0	T, O	2003–2006	Emp
Anyadike-Danes et al (2009)	1	1	0	0	0	T	2002–2008	Emp
Hölzl (2009)	0	0	1	0	0	O	1995	Emp
Bravo-Biosca (2010)	0	1	0	0	0	T	2002–2005	Emp, Prod

Table 1 (continued)

Study	Employment			Sales		Process of growth[a]	Period studied	Output variables[b]
	Absolute	Relative	Composite	Absolute	Relative			
Coad and Hölzl (2010)	0	1	0	0	0	T	1995–2005	Emp
Hölzl and Friesenbichler (2010)	0	0	1	0	0	O	1998–2000	Emp
Stangler (2010)	0	1	0	0	0	T	2007	Emp
Woodward et al (2011)	0	0	1	0	1	T	1995–2008	Emp
López-Garcia and Puente (2012)	0	0	1	0	0	T	1996–2003	Emp
Bjuggren et al. (2013)	1	1	0	0	0	T	1993–2006	Emp
Total	9	15	9	5	7			

[a] T total, O organic, A acquired

[b] Emp employment, W wages, Rev revenue, $Prod$ productivity

[c] Schreyer (2000), Germany used the logarithmic annual average rate of growth (AARG)

[d] Schreyer presents seven studies on HGFs. The Swedish study in Schreyer, Davidsson and Delmar (2003, 2006) and Delmar et al. (2003) use similar data and draw similar conclusions; we therefore report on them jointly. The composite index is calculated as the Birch Index $m=(x_{t1}-x_{t0})*(x_{t1}/x_{t0})$, where x_{t1} and x_{t0} denote employment size at the beginning and end of the period

Henrekson and Johansson (2010, Table 1), updated. This table only reproduces elements of Henrekson and Johansson's table that are directly relevant to our paper

labour productivity rises, this implies less employment" (p.963). This suggests that there is a complicated relationship between productivity and employment growth.[7]

Fritsch and Mueller (2004) stress the difficulties in gathering data on productivity, which can partly explain why just one study, the report by Bravo-Biosca (2010),[8] has explicitly addressed this issue. According to Bravo-Biosca (2010, p. 16), policymakers should not only focus on HGFs since "they are not on their own sufficient to address the wider failure to thrive and failure to shrink that hampers Europe's productivity performance."

4 Data and descriptive statistics

All limited firms in Sweden are legally bound to submit an annual report to the Swedish Patent and Registration Office (PRV). This study uses data collected from PAR, a Swedish consulting firm that gathers economic information from PRV. This information is primarily used by decision makers and stakeholders in Swedish commercial life. Our data comprise all Swedish limited companies active at some point between 1997 and 2010, in total 503,756 firms and 3,814,217 firm-year observations, and include all variables that can be found in the annual reports, such as profits, number of employees, salaries, fixed costs, and liquidity.

To allow for feasible comparisons, we define HGFs as the one percent of firms with the highest growth over three different periods, three, five, and seven years.[9] Following previous researchers (Storey 1996, 1997, 1998, 1999; Delmar et al. 2003), we also considered other shares of the firm population, such as the five or ten percent of firms with the highest growth. Besides the one percent definition however, it was not possible to apply precise cut-off levels, since a great many firms showed the growth required to enter as the last firm using other thresholds. This would necessitate including some of these firms among HGFs arbitrarily and excluding the rest of them. Furthermore, growth fell off rapidly when the span was widened. For example, when applying the ten-percent definition over a seven-year period, firms that had only added four employees over the entire period were classified as HGFs.[10]

Eurostat and the OECD have recommended that HGFs should be defined as firms with at least ten employees in the start-year and annualized employment (or sales) growth exceeding 20 % during a 3-year period. Yet to apply this cut-off level means that a very large number of firms would be excluded from the analysis. Daunfeldt et al. (2012), for example, showed that the OECD-definition excluded almost 95 % of surviving firms in Sweden, and about 40 % of

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[7] Although they do not directly focus on HGFs, this is supported by Coad and Broekel (2012). Their results indicate that the relationship between employment and productivity growth is dependent on where the firm is located at the firm growth rate distribution. An increase in productivity growth seems to be associated with a decrease in employment growth for most firms, while it stimulates further employment growth for fast growing firms.

[8] The report investigates the growth dynamics of firms in 11 countries for the period 2002 to 2005. It covers the non-agricultural business sector, ISIC Rev3 Sectors 10–74. In general, firms with ten or more employees are analyzed.

[9] Shepherd and Wiklund (2009) investigate correlations between firm growth measured over one- and three-year time spans, finding them to be rather high in the case of employment and sales growth. They see average correlations of 0.582 for absolute employment growth measured over these two time spans, and 0.580 for absolute sales growth, while correlations for relative employment growth were 0.556 and for relative sales growth 0.678.

[10] We also identified HGFs as the firms with the 3 % highest growth rates during the studied periods in order to test whether our results are sensitive to the chosen cut-off level. All results remain qualitatively similar, and are available from the authors upon request.

new private jobs during 2005–2008. We have therefore chosen not to use the Eurostat-OECD definition of HGFs in this paper.[11]

In the following, all tables present the results for HGFs identified over 7 years. Relevant differences with regard to the groups based on the two other time periods are also reported. The population is continuing firms in these periods. Since we cannot distinguish organic from acquired growth, we study total growth. Nonetheless, Davidsson and Delmar (2006) find that among fast-growers, small and young firms to a larger extent grow organically.

In order to relate our results to the previous literature, we use employment and sales as growth indicators, yet in addition we introduce productivity and value added. Productivity growth is defined as growth in value-added-based labor productivity, which is the single most frequently used productivity statistic (OECD 2001, p.12). Labor productivity is a key determinant of living standards and of significant policy relevance. Numerous studies also suggest widespread and persistent differences in productivity across firms (Bartelsman and Doms 2000). Labor productivity is also a good starting point for productivity analysis, which later can be extended to multifactor productivity measures (OECD 2001, pp.15, 20). Nonetheless, Dosi (2007) advocates the use of labor productivity rather than total factor productivity, stressing that due to the complementary nature of inputs in a production function, it makes little sense to separate their contribution to final output. In cross-country comparisons, the OECD defines labor productivity as GDP in constant prices per hour worked (OECD 2010b). Since our data do not report the number of hours worked, we define labor productivity as firm value added divided by the number of employees.

The four indicators are closely interrelated. Productivity growth is defined by growth in value added per employee, which implies that the same number of employees can "produce" more sales. In line with Schumpeter, this can, for instance, be the result of the discovery and introduction of labor saving innovations. Therefore, there may be a trade-off between productivity and employment.

It has long been realized that while the use of absolute measures of firm growth lead to a bias towards large firms, relative growth measures lead to a bias towards small firms (Delmar et al. 2003). Due to the widespread 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 Birch Index, which is the combination of employment growth measured in absolute and relative numbers, as growth measurement in order to relate to previous literature (Table 1).

To summarize, we use three definitions of growth for employment, two definitions for sales, two for productivity, and two for value added. We thus arrive at a total of nine groups of HGFs: absolute employment HGFs, relative employment HGFs, composite employment HGFs, absolute sales HGFs, relative sales HGFs, absolute productivity HGFs, relative productivity HGFs, absolute value added HGFs and relative value added HGFs.[12] These

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[11] A descriptive analysis also shows that HGFs are significantly larger and older when the Eurostat-OECD definition of HGFs is used (see Table A1 in the Appendix).

[12] 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; absolute sales HGFs are defined measuring the growth in sales in absolute numbers; relative sales HGFs are defined measuring the growth in sales in relative numbers; absolute value added HGFs are defined measuring the growth in value added in absolute numbers; relative value added HGFs are defined measuring the growth in value added in relative numbers; absolute productivity HGFs are defined measuring the growth in labor productivity in absolute numbers; relative productivity HGFs are defined measuring the growth in labor productivity in relative numbers.

types are defined over three distinct periods (3, 5, and 7 years), resulting in 27 different groups of HGFs.

In the econometric analysis, firm age and size are included as independent variables, the goal being to investigate their influence on the probability of a firm being a HGF and whether these results are sensitive to the choice of growth indicator, growth measurement, or period. Firm size is measured as the two-period lag of the number of employees, and firm age is defined as the year of observation minus the registered start year. Note, however, that the data on the start year are truncated. The earliest registered start year is 1972, implying that firms in the dataset cannot be over 33 years of age. We remedy this shortcoming by including a dummy variable ($D72$) that controls for all registered startups in 1972. To control whether firms in an enterprise group are more likely to be HGFs, a dummy variable taking the value one if the firm belongs to an enterprise group is included in the analysis. Means and standard deviations of all variables included in the empirical analysis are given in Table 2, while descriptive statistics for HGFs defined over a seven-year period are presented in Table 3, with respect to age, size, productivity, value added and sales. [13]

Tables 4 and 5 present differences in mean values for number of employees and firm age for different HGFs defined over a seven-year period. The tables indicate, for example, that HGFs identified in terms of absolute employment growth on average have 550 more employees and are almost 6 years older than productivity HGFs. There are significant differences in mean values between most growth indicators, the most pronounced being those between HGFs defined in absolute and relative terms. HGFs defined in relative terms are always younger than HGFs defined in absolute terms. HGFs defined in absolute terms are larger than HGFs defined in relative terms, with the exception of absolute productivity HGFs. HGFs based on absolute growth in sales are on average oldest, whereas HGFs based on absolute growth in value added are on average largest. HGFs based on relative productivity are on average youngest, while relative value added HGFs are on average smallest. This indicates that the characteristics of HGFs differ depending on the choice of growth indicator and growth measurement.

To further examine how well the different types of HGFs correspond to each other, correlations are presented in Table 6. We follow the categorization by Shepherd and Wiklund (2009, p.110), when classifying correlations. Two measures are considered to have high concurrent validity when the correlation coefficient is 0.5 or greater, moderate concurrent validity when the correlation coefficient is between 0.3 and 0.5, low concurrent validity when the correlation coefficient is between 0.1 and 0.3, and no concurrent validity when the correlation coefficient is below 0.1.

In general, a significant positive correlation between the different groups of HGFs can be found. In most cases it is rather high. The correlation is highest between the HGFs based on absolute measurements, with the exception of absolute productivity HGFs. For example, the correlation between absolute employment and absolute sales HGFs is 0.477—which can be contrasted with Shepherd and Wiklund's (2009) average correlation between absolute employment and sales growth (using a one-year timespan) of 0.340. There is less correlation between HGFs based on relative measurements (except between relative value added and relative productivity HGFs). For example, that between relative employment and relative sales HGFs is 0.319, which is still larger than that between relative employment and sales growth (over a one-year time span) of 0.127 reported by Shepherd and Wiklund (2009).

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[13] How the Eurostat-OECD definition and the choice of growth cut-offs influence the average size and age of different types of HGFs are presented in Table 13 in the appendix.

Table 2 Means and standard deviations for independent variables and growth indicators in the dataset used to define HGFs

Variable	Mean	Std. Dev.	Min	Max	Observations
Firm age	11.4	9.92	0	37	1,779,860
Firm size[a]	12.9	148.62	1	32,681	1,779,860
Sales[b]	30,064	519,699	1	108,000,000	1,779,860
Value added[b]	8,289	135,601	1	58,900,000	1,779,860
Value added/employee	55	141	1	9,881	1,779,860
Dgroup	0.42	0,49	0	1	1,779,860
D71	0.02	0,13	0	1	1,779,860

[a] Number of employees

[b] 1000s of SEK

Furthermore, the correlations between HGFs based on absolute and relative measurements of the same growth indicators are rather small, confirming previous findings (Delmar et al. 2003). For example, the correlation between absolute and relative employment HGFs is 0.207, while that between absolute and relative sales HGFs is 0.092. In comparison, Shepherd and Wiklund find that while absolute sales growth and relative sales growth have a rather low correlation (0.095), absolute and relative employment growth have as high a correlation as 0.45 on average (again over a one-year time span).

Table 3 Descriptive statistics for HGFs defined over a 7-year period

HGFs defined in terms of		Age	Size	Valueadded	Productivity	Sales	Observations
Absolute employment	Mean	21.6	558.2	419,418	781	1,533,506	4,508
	Std. Dev.	10.9	1493.9	1,524,232	1870	6,097,976	
Relative employment	Mean	14.0	119.2	71,962	696	219,837	4,465
	Std. Dev.	8.8	775.5	371,306	1957	1,252,504	
Birch employment	Mean	18.5	490.6	361,657	739	1,333,588	4,379
	Std. Dev.	10.8	1521.0	1,531,990	1847	6,110,275	
Absolute sales	Mean	24.2	618.4	553,056	1860	2,434,456	4,527
	Std. Dev.	10.9	1611.2	1,665,137	4892	6,611,091	
Relative sales	Mean	14.0	71.3	42,321	1089	160,655	4,377
	Std. Dev.	8.7	689.2	297,784	3079	959,569	
Absolute productivity	Mean	19.3	29.7	137,179	6398	362,505	5,042
	Std. Dev.	10.6	377.4	1,012,587	9634	2,357,890	
Relative productivity	Mean	15.6	7.1	21,134	2570	54,888	4,487
	Std. Dev.	9.2	48.6	229,585	6767	523,906	
Absolute value added	Mean	23.7	613.2	581,488	2448	1,973,886	4,652
	Std. Dev.	10.9	1558.1	1,670,475	6659	6,080,585	
Relative value added	Mean	14.0	60.4	40,840	1292	126,424	4,430
	Std. Dev.	8.6	555.3	306,208	4410	1,077,145	

Table 4 Differences in mean age between HGFs based on different growth indicators and measurements. HGFs are defined over a growth period of seven years

Mean diff	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Absolute employment	–	7.59***	3.15***	-2.58***	7.56***	2.24***	5.93***	-2.09***	7.51***
(2) Relative employment	-7.59***	–	-4.43***	-10.16***	-0.03	-5.34***	-1.66***	-9.68***	-0.08
(3) Composite index	-3.15***	4.43***	–	-5.73***	4.40***	-0.91***	2.78***	-5.25***	4.35***
(4) Absolute sales	2.58***	10.16***	5.73***	–	10.14***	4.82***	8.51***	0.49***	10.09***
(5) Relative sales	-7.56***	0.03	-4.40***	-10.14***	–	-5.31***	-1.63***	-9.65***	-0.05
(6) Absolute value added	-2.24***	5.34***	0.91***	-4.82***	5.31***	–	3.69***	-4.34***	5.26***
(7) Relative value added	-5.93***	1.66***	-2.78***	-8.51***	1.63***	-3.69***	–	-8.02***	1.58***
(8) Absolute productivity	2.09***	9.68***	5.25***	-0.49***	9.65***	4.34***	8.02***	–	9.60***
(9) Relative productivity	-7.51***	0.08	-4.35***	-10.09***	0.05	-5.26***	-1.58***	-9.60***	–

***, **, *denote differences that are statistically significant at the 1 %, 5 %, and 10 % level, respectively

Table 5 Differences in mean size (number of employees) between HGFs based on different growth indicators and measurements. HGFs are defined over a growth period of seven years

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Absolute employment	–	439.87***	69.03***	−54.21***	489.40***	528.37***	550.73***	−53.75***	498.48***
(2) Relative employment	−439.87***	–	−370.85***	−494.08***	49.53***	88.50***	110.86***	−493.62***	58.61***
(3) Composite index	−69.03***	370.85***	–	−123.24***	420.38***	459.34***	481.71***	−122.77***	429.45***
(4) Absolute sales	54.21***	494.08***	123.24***	–	543.61***	582.58***	604.94***	0.46	552.69***
(5) Relative sales	−489.40***	−49.53***	−420.38***	−543.61***	–	38.97***	61.33***	−543.14***	9.08
(6) Absolute valueadded	−528.37***	−88.50***	−459.34***	−582.58***	−38.97***	–	22.36***	−582.12***	−29.89***
(7) Relative valueadded	−550.73***	−110.86***	−481.71***	−604.94***	−61.33***	−22.36***	–	−604.48***	−52.26***
(8) Absolute productivity	53.75***	493.62***	122.77***	−0.46	543.15***	582.12***	604.48***	–	552.23***
(9) Relative productivity	−498.48***	−58.61***	−429.45***	−552.69***	−9.08	29.89***	52.26***	−552.23***	–

***, **, *denote differences that are statistically significant at the 1 %, 5 %, and 10 % level, respectively

Table 6 Correlations between HGFs of different definitions over a seven-year period, N=442,973

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Absolute employment	1								
(2) Relative employment	0.2073*	1							
(3) Composite index	0.6874*	0.4726*	1						
(4) Absolute sales	0.4772*	0.1066*	0.3750*	1					
(5) Relative sales	0.0891*	0.3186*	0.2002*	0.0919*	1				
(6) Absolute value added	0.5822*	0.1278*	0.4526*	0.6084*	0.0804*	1			
(7) Relative value added	0.0803*	0.3191*	0.1853*	0.0553*	0.3911*	0.0700*	1		
(8) Absolute productivity	0.0059*	0.0183*	0.0135*	0.0826*	0.0815*	0.1327*	0.0720*	1	
(9) Relative productivity	−0.0041*	0.0220*	0.0043*	0.0130*	0.1588*	0.0197*	0.5171*	0.2113*	1

*denotes that the correlation is significant at the 1 % level

The findings suggest that HGFs defined by growth in absolute and composite employment, absolute sales and absolute value added to a rather large extent tend to be the same firms (high concurrent validity), and that there is also a fairly large correspondence between firms defined as HGFs in terms of growth in relative and composite employment, relative sales, and relative value added (mostly moderate concurrent validity). Absolute productivity HGFs meanwhile seem to have little in common with the other groups, while relative productivity HGFs only correlate highly with relative value added HGFs. Finally, correlations between HGFs based on the same growth indicator but measured in different ways (absolute or relative) are generally low (generally no concurrent validity).

5 The persistence of HGFs

One question that has received increasing attention in recent years is whether the high growth rates of HGFs are sustainable over time. Following Capasso et al (2009), Hölzl (2011), and Daunfeldt and Halvarsson (2012), we estimate transition probabilities to analyze this question. The results are presented in Table 7 and show the probability that a HGF (=1) in period t (vertical-axis) will remain a HGF, or become a non-HGF (=0) in period $t+3$ (horizontal-axis).

Previous studies (Hölzl 2011; Daunfeldt and Halvarsson 2012) have indicated that HGFs essentially are 'one-hit wonders', implying that it is very unlikely that they will repeat their high growth rates in coming periods. These studies have identified HGFs as those firms with the highest percentage change in employment during a 3-year period. The results presented in Table 7 support these finding. A HGF defined in terms of relative employment has a very low probability (1.49) of remaining a HGF in the next coming period. The same result holds for all growth indicators that are

Table 7 Transition probabilities for different HGF definitions from period t (vertical axis) to period $t+3$, where 0=non-HGFs, and 1= HGFs

Growth indicator	$t/t+3$	0	1
Absolute employment	0	99.33	0.67
	1	68.33	31.67
Relative employment	0	99.58	0.42
	1	98.51	1.49
Birch employment	0	99.36	0.64
	1	78.68	21.32
Absolute sales	0	99.42	0.58
	1	52.98	47.02
Relative sales	0	99.48	0.52
	1	98.71	1.29
Absolute productivity	0	99.20	0.80
	1	90.55	9.45
Relative productivity	0	99.29	0.71
	1	99.43	0.57
Absolute value added	0	99.35	0.65
	1	61.31	38.69
Relative value added	0	99.41	0.59
	1	99.78	0.22

measured in relative terms. The fastest growers in percentage (irrespective of choice of growth indicator) are thus not able to repeat their high growth rates in coming periods.

A higher degree of growth persistence is found for the fastest growers in absolute terms. Almost one-third of the 1 % fastest growing firms in terms of number of employees, for example, will remain HGFs in the coming period. We find similar results for those firms that have the 1 % highest growth rate in absolute sales (47 %) and absolute value added (38.69 %), whereas the persistence is lower when it comes to absolute productivity (9.45 %).

Another question to take into consideration is whether being a HGF in one period increases the probability of being some other type of HGF in the following period. We examine this in Table 8 which shows results for estimating transition probabilities for all HGFs, all HGFs defined by absolute measurements, and all HGFs defined by relative measurements. We observe that the probability of remaining some type of HGF in the following period is 25.80 %, while that of remaining some type of HGF

Table 8 Transition probabilities for different HGF definitions from period t (vertical axis) to period $t+3$, where 0=non-HGFs, and 1= HGFs

	$t/t+3$	0	1
Any HGF (4.73 %)	0	97.20	2.80
	1	74.20	25.80
Any absolute HGF (2.64 %)	0	98.37	1.63
	1	61.68	38.32
Any relative HGF (2.48 %)	0	98.54	1.46
	1	95.93	4.07

defined in absolute terms is as high as 38.32 %. The probability of remaining some type of relative HGF is considerably lower, 4.07 %.

6 The economic contribution of HGFs

Table 9 presents the contribution of different groups of HGFs to economic growth (measured as percentage change in aggregate value added), employment growth (measured as percentage change in aggregate employment), productivity growth (measured as percentage change in aggregate value added per employee) and sales growth (measured as percentage change in aggregate sales). By aggregate, we refer to the totals of our population of firms. The contribution during a seven-year period is measured by comparing the total growth in the output variable in question to the total contribution to the output variable made by the group of HGFs in question. The same computations were undertaken for growth periods of five and three years. The results rarely differ, apart from those discrepancies reported below. Shepherd and Wiklund (2009) also found that the results were robust over different time spans.

The contributions of HGFs can be both positive and negative and amount to more than 100 % of the aggregated numbers (which are always positive). The magnitudes of many of these contributions are large. For example, the one percent fastest-growing firms in terms of absolute employment growth, absolute sales growth, and absolute value added growth contribute to more than 100 % of the net growth in total employment.

HGFs based on the same growth indicator have the same sign on their contributions, with the exception of the contribution of productivity HGFs to sales. The three types of employment HGFs contribute to the bulk of or more than all of the total net job growth in the population. They also give substantial contributions to the total economic growth and sales growth of the firm population during the study period. But the contribution to productivity growth is negative or close to zero.

The productivity HGFs, on the other hand, make disproportionately large contributions to total productivity growth and economic growth. Both absolute and relative productivity HGFs give negative contributions to employment growth, while relative productivity HGFs also give a slightly negative contribution to sales growth. This is in line with previous

Table 9 The contribution of seven-year-HGFs to economic growth, employment, productivity and sales

	Percentage contribution to			
	Economic growth	Employment growth	Productivity growth	Sales growth
Absolute employment	61,0	149,1	−1,6	55,3
Relative employment	17,4	61,9	−2,2	12,3
Composite index	51,3	122,9	−2,4	46,1
Absolute sales	70,7	106,2	6,7	84,2
Relative sales	10,7	35,5	8,3	11,1
Absolute productivity	24,0	−13,4	60,5	11,2
Relative productivity	3,3	−7,1	23,5	1,5
Absolute value added	89,1	112,4	14,6	64,7
Relative value added	10,5	30,4	10,1	7,5

research; for instance, Dosi (2007, pp.180–181) writes that data reveal: "a weak or non-existent relationship between growth however measured (e.g. in terms of Value Added, Employment or Sales) and relative productivities."

The two types of sales HGFs make large positive contributions to all four output variables, but more to employment, sales, and value added than to productivity. The value added HGFs also give disproportionately positive contributions to all four outputs. Hence, all HGFs give disproportionately positive contributions to economic growth.

7 Firm age, firm size, and HGFs

Following recent studies (López-Garcia and Puente 2012; Bjuggren et al. 2013), a probit regression model is estimated to study the influence of firm age and size on the probability of a firm being a HGF. The estimated model is specified as

$$Pr(HGF_{it} = 1) = F\left(a_1 SIZE_{it-2} + a_2 SIZE_{it-2}^2 + a_3 AGE_{it} + a_4 AGE_{it}^2 + a_5 D72_{it} + a_6 DGROUP_{it} + a_I + \varepsilon_i\right) \quad (1)$$

where the dependent variable HGF_{it} takes the value 1 if firm i can be classified into the 1 % fastest-growing firms in the population in period t; $SIZE_{it-2}$ is firm size measured as absolute employment in year $t-2$[14]; AGE_{it} is firm age; squares of both size and age are included to control for nonlinearity; $D72_{it}$ is a dummy variable that takes the value one if the start year for firm i is classified as 1972; $DGROUP_{it}$ is a dummy variable indicating whether the firm belongs to an enterprise group or not; a_I is an industry-specific fixed effect,[15] and ε_i is a random error term. The marginal effects acquired from the estimation of Eq. (1) are presented in Tables 10, 11 and 12.[16] [17]

The results for the three different time periods we investigated are largely quite similar. With growth measured in absolute terms, firm size always has a positive impact on the probability of a firm becoming an HGF. This finding also holds for composite employment HGFs. The opposite relationship holds when HGFs are defined in relative terms. In this case, the results indicate that smaller firms are more likely to be HGFs. The results regarding size are firmly established in previous research on firm growth in general and on HGFs (Delmar 1997; Delmar and Davidsson 1998; Delmar et al. 2003; Coad and Hölzl 2009; Shepherd and Wiklund 2009). Firm age has a negative impact on the likelihood of

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[14] Firm size is lagged two periods to avoid endogeneity problems.

[15] All the firms in the database are denoted by five-digit SNI codes. Based on these, the firms have been sorted using three-digit SNI codes into 213 different industries to control for industry-specific heterogeneity in the presence of HGFs. The estimated coefficients for each of these industry dummies are not presented in this paper in order to save space, but are available from the authors upon request.

[16] Note that the variables D72 and DGROUP are not presented in Table 7 in order to save space, but are available from the authors upon request. The enterprise group dummy is always positive and significant (in line with previous research), except in the regressions where HGFs based on productivity function as a basis for the dependent variable, where it is insignificant. The dummy for being registered as a startup in 1972 is only occasionally significant.

[17] All estimations were also done with a 3 % cut-off point to test the robustness of our results. The results are qualitatively very similar to the results we obtain when we use the 1 % cut-off point, and they are available from the authors upon request.

Table 10 Results from probit regressions on HGF$_{it}$. Marginal effects coefficients and z-values for independent variables, 7-year growth period (n=332,614)

Dependent variable HGF$_{it}$=1 if firm is HGFln terms of:	Firm size	Firm size^2	Firm age	Firm age^2	d71	dgroup
Absolute employment	1.28e−05*** (17.65)	−1.22e−09***(−16.47)	−0.000191***(−5.33)	5.35e−06*** (6.46)	−0.000266 (−1.03)	0.0181*** (47.89)
Relative employment	−4.03e−05***(−6.77)	2.01e−09*** (5.62)	−0.000810***(−10.27)	1.37e−05*** (7.18)	0.00337*** (2.77)	0.00956*** (28.73)
Composite index	1.54e−05*** (23.09)	−1.36e−09***(−18.27)	−0.000458***(−8.40)	9.71e−06*** (7.70)	0.000685 (1.26)	0.0169*** (44.08)
Absolute sales	1.11e−05*** (11.71)	−9.64e−10***(−11.52)	−0.000163***(−6.32)	5.06e−06*** (7.89)	−9.41e−05 (−0.63)	0.0162*** (45.03)
Relative sales	−0.000175***(−18.90)	8.75e−09*** (16.96)	−0.000472***(−7.06)	8.18e−06*** (5.08)	−0.000540 (−0.70)	0.00645*** (22.99)
Absolute value added	3.52e−06*** (4.36)	−1.20e−10* (−1.86)	−0.000494***(−5.91)	1.31e−05*** (6.80)	0.000104 (0.14)	0.0175*** (42.12)
Relative value added	4.41e−08 (0.03)	9.85e−11 (0.95)	−0.000187* (−1.94)	1.96e−06 (0.85)	−0.000769 (−0.72)	0.00270*** (7.96)
Absolute productivity	7.00e−06*** (8.41)	−4.78e−10***(−8.37)	−9.76e−05***(−4.92)	3.19e−06*** (6.15)	−0.000192* (−1.86)	0.0174*** (46.98)
Relative productivity	−9.94e−05***(−13.24)	5.00e−09*** (12.58)	−0.000470***(−5.79)	7.39e−06*** (3.77)	0.000953 (0.88)	0.00487*** (16.12)

***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively

Table 11 Results from probit regressions on HGF_{it}. Marginal effects coefficients and z-values for independent variables, 5-year growth period (n=590,736)

Dependent variable HGF_{it}=1 if firm is HGF ln terms of:	Firm size	Firm size^2	Firm age	Firm age^2	d71	dgroup
Absolute employment	1.24e−05*** (25.91)	−1.05e−09***(−24.81)	−0.000187***(−7.15)	5.63e−06*** (8.85)	0.000132 (0.54)	0.0178*** (63.61)
Relative employment	−4.47e−05***(−11.08)	1.32e−09*** (9.888)	−0.000750***(−15.08)	1.40e−05*** (11.02)	0.00239*** (2.87)	0.00861*** (36.52)
Composite index	1.33e−05*** (31.54)	−9.64e−10***(−26.54)	−0.000473***(−12.77)	1.09e−05*** (12.05)	0.000147 (0.38)	0.0166*** (58.07)
Absolute sales	8.71e−06*** (18.73)	−4.46e−10***(−18.78)	−0.000164***(−8.35)	5.91e−06*** (11.57)	−1.23e−05 (−0.08)	0.0176*** (63.07)
Relative sales	−0.000181***(−25.01)	5.37e−09*** (22.21)	−0.000317***(−7.12)	5.42e−06*** (4.77)	−0.000587 (−1.00)	0.00569*** (27.95)
Absolute value added	2.48e−06*** (4.03)	−7.74e−11*(−1.82)	−0.000228***(−3.95)	7.43e−06*** (5.29)	0.00124* (1.84)	0.0181*** (57.14)
Relative value added	3.47e−07 (0.20)	−1.06e−10 (−0.38)	−0.000221**(−3.37)	3.06e−06* (1.85)	−0.000356 (−0.42)	0.00235*** (9.214)
Absolute productivity	6.54e−06*** (13.18)	−3.47e−10***(−13.15)	−9.99e−05***(−6.78)	3.60e−06*** (9.02)	3.07e−05 (0.28)	0.0184*** (64.99)
Relative productivity	−0.000269***(−41.74)	7.97e−09*** (32.45)	−0.000204***(−5.45)	2.90e−06*** (3.04)	0.00104* (1.67)	0.00343*** (20.78)

***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively

Table 12 Results from probit regressions on HGF$_{it}$. Marginal effects coefficients and z-values for independent variables, 3-year growth period (n=942,506)

Dependent variable HGF$_{it}$=1 if firm is HGF In terms of:	Firm size	Firm size^2	Firm age	Firm age^2	d71	dgroup
Absolute employment	1.49e−05*** (35.95)	−1.28e−09***(−34.16)	−0.000176***(−8.92)	5.61e−06*** (11.05)	0.000301 (1.29)	0.0175*** (79.63)
Relative employment	−1.83e−05***(−7.49)	5.41e−10*** (6.04)	−0.000655***(−20.14)	1.32e−05*** (14.88)	0.000602 (1.07)	0.00702*** (40.46)
Composite index	1.58e−05*** (42.32)	−1.19e−09***(−36.15)	−0.000380***(−14.46)	9.15e−06*** (13.42)	0.000584* (1.65)	0.0156*** (70.35)
Absolute sales	9.48e−06*** (24.35)	−5.02e−10***(−24.31)	−0.000110***(−8.26)	4.89e−06*** (13.47)	0.000198 (1.48)	0.0170*** (78.82)
Relative sales	−0.000227***(−52.19)	6.75e−09*** (51.19)	−0.000208***(−7.95)	3.98e−06*** (5.58)	−0.00140***(−4.09)	0.00442*** (32.08)
Absolute value added	2.04e−06*** (4.18)	−5.31e−11* (−1.89)	−0.000115***(−2.85)	4.50e−06*** (4.30)	0.000959* (1.71)	0.0175*** (70.85)
Relative value added	−1.73e−06 (−1.60)	7.88e−11* (1.94)	−0.000154***(−3.35)	2.16e−06* (1.75)	−0.000939 (−1.40)	0.00205*** (10.18)
Absolute productivity	7.93e−06*** (19.84)	−4.06e−10***(−19.80)	−8.31e−05***(−7.42)	3.64e−06*** (11.61)	7.79e−05 (0.71)	0.0181*** (81.90)
Relative productivity	−4.01e−05***(−18.15)	1.25e−09*** (17.66)	−0.000244***(−5.92)	2.90e−06** (2.569)	−0.000581 (−0.87)	0.00249*** (13.65)

***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively

being a HGF, indicating that young firms are more likely to be HGFs irrespective of how HGFs are defined, and also holding firm size constant—hence effectively excluding the possibility of the results being driven by regression to the mean.

Our study confirms the findings of Delmar et al. (2003), who conclude that firm age, rather than firm size, determines rapid growth and hence that firm age is crucial for net employment growth. Recent research concerning firm growth in general arrives at this conclusion as well (Haltiwanger et al. 2013). It is also an indication that the type of innovative activity envisaged by Schumpeter Mark I, where small and young firms challenge the status quo, is important. In accordance with, among others, Davidsson and Delmar (2006), our findings suggest that economic renewal is critical for firm growth as well as for growth in the whole economy.

8 Discussion and conclusions

Previous studies have generally used growth in firm employment or in firm sales as growth indicators when defining HGFs, while less attention has been paid to HGFs growing in terms of value added or productivity. This may be troublesome since a policy targeting firms that grow fast in terms of employment risks having counterproductive results on other growth indicators.

The purpose of this paper was to examine whether the implications of supporting HGFs depend on which growth indicators are used to identify these firms. In accordance with previous studies, we used both employment and sales as growth indicators, but also introduced growth in value added and in productivity as additional indicators. These four growth indicators were then measured in both absolute and relative (percentage) terms. For employment, a combination of absolute and relative measurements labeled the composite index was also applied. In total, this resulted in nine different types of HGFs.

In our analysis, we asked the following questions:

i)   Are the same firms defined as HGFs irrespective of definition?
ii) What is the magnitude of their contribution, and, in particular, do HGFs contribute as much to aggregate economic growth, productivity growth, and sales growth as they have previously been shown to do to aggregate employment growth, and is the contribution the same irrespective of definition?
iii) Does the persistence of high growth rates depend on the definition of HGFs?
iv) Does firm age and size have the same influence on the likelihood of being a HGF irrespective of definition?

We found a very low correlation between employment HGFs and productivity HGFs, implying that HGFs identified using employment and productivity growth will not be the same firms. The magnitude of the contribution of HGFs to aggregate employment growth, economic growth, productivity growth, and sales growth are also different for employment HGFs and productivity HGFs. All HGFs, except productivity HGFs give a positive contribution to employment growth and sales growth. In most cases, the magnitudes of these contributions are large. The 1 % fastest growers, both in terms of employment and value added, contribute to more than 100 % of the total growth in employment, whereas productivity HGFs give negative contributions to employment growth. In addition, besides employment HGFs, all HGFs are

associated with a disproportionately positive contribution to productivity growth. Economic policy promoting fast growth in employment may therefore come at the cost of reduced productivity growth.

The sustainability of high growth rates has recently received an increasing amount of attention. The reason is that policies directed towards HGFs can be questioned if HGFs in one period are not HGFs in coming periods. Previous studies have used relative measures of employment to identify HGFs, and found that HGFs are unlikely to repeat their high growth rates in coming periods. We found that all HGFs, irrespective of growth indicator, show a low degree of growth persistence when growth was measured in relative terms. When growth was measured in absolute terms, HGFs had a higher probability of remaining HGFs in the coming period.

Our probit model showed that firm age and size affected the probability of a firm becoming any type of HGF. Firm size had a positive effect on the probability of a firm becoming a HGF based on absolute measurement, while it had a negative effect on the probability of a firm becoming a HGF based on relative measurement. Irrespective of how HGFs were defined, younger firms were more likely to experience rapid growth. These results hold for all periods studied. It is an indication that the type of innovative activity envisaged by Schumpeter Mark I, where small and young firms challenge the status quo, is a main driver of aggregate economic performance.

Many policies for promoting HGFs are today targeted towards innovative industries (Shane 2009; Mason and Brown 2013), and high-tech industries are often considered as the main generators of HGFs (OECD 2010a). But our results question the efficiency of implementing policies aimed at targeting HGFs, supporting studies that have argued that it is virtually impossible for policymakers to identify which firms will become HGFs ex-ante (Birch 2006). Targeting of potential HGFs is highly likely to be inefficient, and in a worst-case-scenario even counterproductive to the goal of a growing dynamic economy generating new jobs. Our results suggest that policymakers should focus on the general conditions for new firm formation and early growth of firms, rather than target a particular type of HGFs.

In addition, firms that have been targeted by venture capitalist usually receive great attention from policymakers. Yet as noted by Kenney (2012), so called nice-growth companies, defined as firms that are knowledge intensive but do not have the scalability features that are necessary for attracting venture capitalists, may be more important in creating job opportunities. Bornhäll et al (2013) also notes that there seem to be an untapped potential of many firms that choose not to grow, despite high profits.

Several other avenues of further research on HGFs can certainly be taken. Very few studies have, for example, analyzed whether HGFs hire certain employees to a larger extent than other firms (Coad et al. 2013). There is also little research on the spatial distribution of HGFs within a country and its influence on regional development. It could also be fruitful to focus future research on identifying growth barriers for firms with growth potential in general, since removal of such barriers might generate faster economic development than targeting a small number of HGFs.

Appendix

Table 13 Average age and size of HGFs for different growth cut-offs and the Eurostat-OECD definition, growth calculated over a 3-year period

	1 % Mean	1 % Std. Dev.	3 % Mean	3 % Std. Dev.	5 % Mean	5 % Std. Dev.	10 % Mean	10 % Std. Dev.	OECD-definition Mean	OECD-definition Std. Dev.
Absolute sales										
Firm age	20.59587	11.58103	18.88205	11.42433	17.76788	11.28853	16.46249	10.99905	N/A	N/A
Firm size	466.4642	1308.239	211.0246	828.636	141.7129	648.4591	93.74472	516.3121	N/A	N/A
Observations	11974		35016		58358		93368		7724	
Relative sales										
Firm age	10.91875	9.001762	10.57948	8.758001	10.54248	8.639836	10.94478	8.719908	14.05606	10.83786
Firm size	26.77868	383.8057	20.74674	259.4428	18.89424	214.8642	17.98144	188.3863	153.2171	687.3289
Observations	12136		35016		58360		93377		7724	
Absolute employment										
Firm age	17.55151	11.39333	15.92251	11.01355	15.23278	10.77009	14.56988	10.50889	N/A	N/A
Firm size	411.3231	1119.576	181.4593	681.3865	122.7679	537.6458	87.99268	447.4817	N/A	N/A
Observations	11911		34599		56801		83116			
Relative emplyment										
Firm age	10.37096	8.948212	10.08971	8.42957	10.34095	8.535389	10.84425	8.486751	14.20337	10.75858
Firm size	62.95775	471.5985	36.42098	298.6295	37.28402	283.6696	20.26208	219.5161	273.2941	937.7212
Observations	10082		33118		46846		103133		3206	
Composite employment										
Firm age	14.86426	11.07364	14.24194	10.67353	14.03817	10.4939	13.5391	10.14488	N/A	N/A
Firm size	362.717	1140.929	163.8031	683.2216	117.7046	550.514	76.41606	434.0616	N/A	N/A
Observations	11235		33790		53031		86486			
Absolute productivity										
Firm age	15.57624	10.58522	18.17347	11.37645	17.15398	11.2165	13.5619	9.779518	N/A	N/A
Firm size	19.41848	325.1509	204.8949	757.6181	136.991	593.5328	14.34213	211.5522	N/A	N/A
Observations	13635		35015		58353		93360			

Table 13 (continued)

Table 13 (continued)

	1 %		3 %		5 %		10 %		OECD-definition	
Relative productivity	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Firm age	12.51407	9.465066	10.91757	8.83005	10.89104	8.733839	12.54224	9.337444	16.6578	11.34517
Firm size	6.181708	160.7402	17.61456	204.2543	17.1201	192.0268	7.57643	106.8461	49.27935	350.1376
Observations	12366		35012		58353		93373		6841	
Absolute value added	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Firm age	20.04799	11.53575	14.31704	10.15488	13.87126	9.946871	16.0523	10.85869	N/A	
Firm size	459.0152	1224.95	17.05489	283.3977	15.35387	237.49	89.84922	473.0293	N/A	
Observations	12169		34999		58295		93363			
Relative value added	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Firm age	11.11414	8.906119	12.41558	9.3791	12.35093	9.298867	11.24335	8.794252	14.55325	10.7832
Firm size	22.84939	304.6346	6.497458	120.5028	6.697118	118.4987	16.93337	181.8998	146.8891	613.7076
Observations	11845		35016		58356		93366		7812	

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