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**Conference Paper**

## Does high growth persist? A focus on growth formulas and the influence of firm exits

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2018: Digitale Wirtschaft - Session: Business Economics II, No. E07-V3

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Erhardt, Eva (2018) : Does high growth persist? A focus on growth formulas and the influence of firm exits, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2018: Digitale Wirtschaft - Session: Business Economics II, No. E07-V3, ZBW - Leibniz-Informationszentrum Wirtschaft, Kiel, Hamburg

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# Does high growth persist? A focus on growth formulas and the influence of firm exits

## Abstract

This study investigates the development of firms after high-growth. We argue that the formula used for measuring growth determines results. Implications from different formulas are tested with data from Amadeus on Bulgarian firms for the years 2001-2010. We provide first evidence for an absolute growth formula and its systematic comparison to alternative choices. The focus is on growth in employees, but we offer additional evidence for sales and profits. Using a two-part regression model with separate equations for survival and growth, we find that high-growth does not persist when size of exits is accounted for. Losses by exiting high-growth firms outweigh further gains in size by survivors. This result equally holds for the 1 percent fastest growers in absolute terms, the top 1 percent in terms of log growth and high-growth firms defined according to Eurostat-OECD. Implications for the future study of high-growth firms and policies focused at them are discussed.

Keywords: high-growth firms, persistence, growth formulas, firm size, firm exit

JEL Classification Number: L11, L25, D22, C18, P23

## 1 INTRODUCTION

A small number of high-growth firms create a large share of jobs (Birch and Medoff, 1994; Brüderl and Preisendörfer, 2000; Davidsson and Henrekson, 2002; Delmar et al., 2003; Littunen and Tohmo, 2003; Halabisky et al., 2006; Acs and Mueller, 2008; Schreyer, 2000). More specifically, about 4-6% of firms have been found to be responsible for around 50% of employment growth during their high-growth period (see Henrekson and Johansson, 2010; Storey, 1994 for surveys of related evidence).

Accordingly, most OECD countries and the European Union have adopted policies to support highly growing firms (Autio et al., 2007; EU, 2010; Mason and Brown, 2013; OECD, 2013). The important role of high-growth firms has also triggered a large amount of research on their characteristics and determinants (e. g. Bjuggren et al., 2013; Bos and Stam, 2013; Bravo-Biosca et al., 2016; Delmar et al., 2003) resulting in stylized facts such as that high-growth firms are not necessarily small but of all sizes, tend to be younger than other firms, and originate from all industries, not only high-tech (Henrekson and Johansson, 2010; Coad et al., 2014).

More recently, it has however been rightly argued that any evidence limited to the period of high growth is of little importance if firm growth is purely random or, even worse, if high-growth firms display a disappointing performance after having achieved high-growth (Coad et al., 2014). The research focus has therefore been lately shifted towards investigating the persistence of high growth over time. Two types of research questions are examined in this context. One focuses on whether high-growth can be repeated in subsequent periods. Evidence quite clearly demonstrates that high rates of growth are unsustainable over time (Daunfeldt and Halvarsson, 2015; Dillen et al., 2014; Gabrielsson et al., 2014; Moschella et al., 2018). We consider another question as more pertinent from a policy perspective. It is whether high growth firms further expand in size or not, i. e. the serial correlation of growth for high-growth firms. Policy support for high-growth firms would be justifiable, if they continued to subsequently grow, but largely questionable, if they declined after having achieved high-growth. In this respect, the existing evidence is yet very inconclusive even pointing into contradictory directions: Whereas some studies show that high-growth firms continue to grow in the period following high-growth (Acs, 2013; Du and Temouri, 2015; Hölzl, 2013; Satterthwaite and Hamilton, 2016; Senderovitz et al., 2016), others find negative future growth (Capasso et al., 2013; Coad, 2007; Coad and Hölzl, 2009; Daunfeldt and Halvarsson, 2015).

Theory predicts both random (Gibrat, 1931), positive (Barney, 1991 and Peteraf, 1993; Greiner, 1972) and negative (Penrose-effect in Penrose, 1959) correlation of firm growth over time and therefore provides little guidance for interpreting the diverging empirical findings. Building on predictions of the learning model developed by Jovanovic (1982), one finding has however emerged as largely undisputed in the firm growth literature: survival and growth depend on firm size and age. The probability of survival tends to increase with size and age, whereas the rate of growth conditional on survival decreases (see T. Dunne et al., 1989; Evans, 1987; Hall, 1987 for early empirical evidence).

This size-dependence of survival and growth suggests that the existing evidence on the persistence of high growth might be inconclusive, because different methodological choices have been made to measure growth, which in turn strongly influence firm size. A similar argument for the inconsistency of findings across firm growth studies has been brought forward previously (Davidsson and Wiklund, 2000; Delmar et al., 2003; Shepherd and Wiklund, 2009; Weinzimmer et al., 1998). Among the typical choices to be made for measuring growth, growth formulas are particularly important for size. The basic distinction is between absolute and relative formulas. Absolute growth is measured as the raw difference in size between two points in time, whereas relative growth measures percentage changes in size or log differences. A definition of high-growth based on an absolute formula therefore tends to select larger firms, while high-growth firms selected on the basis of a relative formula will be largely composed of very small firms. While implications from the use of different growth formulas have been well-demonstrated for the high-growth period (Almus, 2002; Daunfeldt et al., 2014; Delmar et al., 2003), the influence of growth formulas on their development after high-growth including survival has not been explored to date. Previous evidence for persistence of high-growth has either focused on using a relative growth formula based on log differences or on composite formulas such as the one recommended by Eurostat-OECD (2007), i. e. annualized growth in employees of at least 20% over a 3-year period limited to firms with an initial size of 10+ employees, and modified versions of the formula proposed by Birch and Medoff (1994), which in its original form multiplies absolute and relative growth.

The lack of evidence for an absolute growth formula as well as a systematic comparison of effects from different formulas is an important research gap for another reason: the role which different growth formulas attribute to firm exit. A relative growth formula is left-censored at -1 and disregards how small or large a firm is at the time of exit. For anyone concerned with the longer-term contribution of high-growth firms to for instance the labor market, firm size of exits should however be of large interest. Size of subsequently exiting high-growth firms is particularly relevant because it will be much larger than that of exiting average firms. The losses by exiting high-growth firms are only reflected when choosing an absolute growth formula. Therefore – even though a definition of high-growth firms according to an absolute formula might typically not be used, because policy tends to focus on support of small firms - insights from the choice of an absolute formula to measure future growth of high-growth firms should very well be of high interest to policy.

Against this background, the research question of this study is as follows: How does the use of different growth formulas, in particular an absolute formula, affect results for the persistence of high-growth? To answer our research question we investigate performance after the high-growth event for high-growth firms defined according to three different growth formulas – absolute, relative and the composite formula proposed by Eurostat-OECD. Using firm-level data from Amadeus on 369,294 private firms in Bulgaria for three consecutive 3-year periods (2001-2004, 2004-2007, and 2007-2010) we analyze growth three and six years after the period of high growth. We focus on growth in the number of employees, but add evidence for a limited sample on sales and profits. Our empirical strategy combines non-parametric and parametric methods. We first compare transition probabilities between different growth states (exit, decline, stagnation, growth, high-growth) from one 3-year period ( $t$ ) to the next ( $t+3$ ) or upper next ( $t+6$ ) for each type of high-growth firm. We secondly estimate future growth conditional on a number of control variables by means of a two-part model. Following Huber et al. (2017) our model consists of separate probit regressions for firm survival and exit on the hand and linear regressions for growth of surviving and exiting firms on the other hand. The choice of a two-part

model is motivated by the different direction in which size affects survival and growth. It moreover allows for a decomposition of the specific contribution by firm exits to future growth of high-growth firms compared to non-high-growth firms depending on the growth formula used.

The main result of our study is that high-growth does not persist – neither in the number of employees, nor sales or profits – when absolute size of firm exits is taken into account. The use of an absolute growth formula to measure performance after high-growth reveals that subsequent losses by exiting high-growth firms outweigh further gains in size by surviving firms. Exit rates for high-growth firms are lower than for non-high growth firms. At the same time, high-growth firms which do exit are of much larger size than exiting non-high-growth firms. This finding holds for all three types of high-growth firms used in our analysis: the 1% fastest growers in absolute terms, the 1% fastest growers in terms of relative log differences as well as for high-growth firms defined according to Eurostat-OECD.

Our study offers several contributions to the literature. Most notably, we extend the literature by using an absolute formula to investigate the serial correlation of growth for high-growth firms. We demonstrate that measuring performance after high-growth by an absolute formula offers a clear answer to the debate if high-growth persists or not. Second, by reviewing existing empirical findings from the perspective of growth formulas and adding further evidence from this study, we are able to show that results for the persistence of high-growth are not as inconclusive as it had seemed so far, but that a distinct pattern emerges. Third, by using a dataset from Bulgaria, this study for the first time provides evidence apart from high-income countries. As our results compare closely, we are able to contribute to the external validity of previous findings for a different economic context.

We proceed as follows: Section 2 reviews the literature related to our research question and identifies important research gaps. Section 3 describes the data and Section 4 the method of analysis. Section 5 presents and discusses results from transition probability matrices and the two-part regression model before Section 6 concludes with implications for future research and policy.

## 2 THEORY AND PREVIOUS EVIDENCE ON PERSISTENT HIGH-GROWTH

Firm growth literature frequently uses Gibrat's law of proportionate (Gibrat, 1931) as theoretical starting point. It states that initial firm size and growth should be independent and therefore implies that growth rates are random and firm growth cannot persist. Apart from investigating Gibrat's law, firm growth research has not been strongly theory-driven (Caves, 1998). Among others, the following theories can be advanced to predict why high-growth firms continue to grow. The resource-based view suggests that firms can obtain a sustained competitive advantage which enables growth over a long time period. Barney (1991) for example argues that this is to be achieved if resources are valuable, rare, imperfectly imitable, and not substitutable. Peteraf (1993) proposes a similar framework for sustained growth. Repeated periods of positive growth would also be expected from life-cycle theories, although each growth phase, as e. g. suggested in the phase model of Greiner (1972), first ends with a management crisis that has to be resolved before growth can follow again. In contrast, Penrose (1959) proposes a theoretical prediction why high-growth firms subsequently decline. Unlike the previous theories referred to, she specifically addresses the phenomenon of fast growth. Notwithstanding her arguments in favor of a positive serial correlation of growth in general,<sup>1</sup> Penrose suggests that very fast growth is limited by the rate at which experienced managerial staff can plan and implement expansion projects. In particular, managers who strongly focus on a firm's expansion divert their attention from operating efficiency. High-growth firms hence start to experience higher operating costs than their slower-growing counterparts. Accordingly, a period of high-growth would be followed by a decline in profitability and productivity. This is commonly referred to as 'Penrose effect'.

Empirical evidence can be found to both support and reject each of these theoretical models. Some show that growth is indeed random (Almus, 2000; Lotti et al., 2003). Others detect either positive serial

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<sup>1</sup> Firms are faced with strong incentives to grow in order to create value from their unused resources, which in turn will create new resources to use for further expansion.

correlation of growth (Chesher, 1979; P. Dunne and Hughes, 1994; Geroski et al., 1997; Ijiri and Simon, 1964; Kumar, 1985; Singh and Whittington, 1975; Wagner, 1992) or negative one (Boeri and Cramer, 1992; Bottazzi et al., 2007; Bottazzi et al., 2011). Previous studies which specifically investigate the persistence of high-growth point into equally contradicting directions. As summarized in Table 1, four out of eight studies identify (moderately) positive growth after high growth (Acs, 2013; Hölzl, 2013; Satterthwaite and Hamilton, 2016; Senderovitz et al., 2016), whereas the other four find that high-growth is followed by decline (Capasso et al., 2013; Coad, 2007; Coad and Hölzl, 2009; Daunfeldt and Halvarsson, 2015).

A firm growth theory which has received large empirical support on the other hand (see T. Dunne et al., 1989; Evans, 1987 or Hall, 1987 for early evidence) is the model of passive learning developed by Jovanovic (1982). It emphasizes that firms have different efficiencies and hence different cost levels. A firm cannot observe its efficiency level and learns its cost only gradually through production. A firm that accumulates favorable information about its efficiency after entry grows and survives. Less efficient firms 'learn' of their relative inefficiency, and choose to exit. More in general, this implies that a firm's size and age positively affects its rate of survival while conditional on survival it negatively affect its rate of growth.

This size-dependence of survival and growth is closely related to arguments that the inconsistency of empirical findings across firm growth studies results from different methodological choices made for measuring firm growth (Davidsson and Wiklund, 2000; Delmar et al., 2003; Shepherd and Wiklund, 2009; Weinzimmer et al., 1998). Typical choices concern growth formulas, growth indicators, growth periods and modes of growth. Building on Jovanovic (1982), the growth formula clearly stands out, because it has particularly important implications for firm size and therefore growth and survival. The basic choice here is whether firm growth is measured by an absolute or relative formula. The influence of each formula on firm size can be illustrated by a simple example: We assume that firm X starts with 1 employee and has 5 employees three years later, while firm Y starts with 10 employees and has 14 employees after the same period. Although both would have achieved the same absolute growth (4 employees), relative growth would substantially differ (500 percent for firm X compared to 40 percent for firm Y). On the same note, we can add that it is much easier for a large firm to hire 1 additional employee, than it is for a very small firm. As a consequence, a definition of high-growth based on an absolute formula tends to select larger firms, while high-growth firms selected on the basis of a relative formula will be largely composed of very small firms. To reduce the impact of relative and absolute formulas on initial firm size, composite measures have been additionally suggested. The so-called Birch-index as originally used by Birch and Medoff (1994) multiplies absolute and relative growth. Another recently very common composite measure for high-growth is the one recommended by Eurostat-OECD (2007). It is based on a relative growth formula, but introduces an initial firm size threshold of 10 employees. Initial size of high-growth firms selected by composite indices hence ranges between that of firms selected by absolute and relative formulas, because both formulas are combined in case of the Birch-index or because of the required minimum size in the definition by Eurostat-OECD.

The literature has well-demonstrated the influence of growth formulas over the period of high-growth and shown that the correlation between different definitions of high-growth based on absolute versus relative formulas is rather low (Almus, 2002; Daunfeldt et al., 2014; Delmar et al., 2003). Their impact on the development of high-growth firms after high-growth including their survival has however not been systematically explored to date. Most notably, none of the studies investigating the persistence of high-growth has so far used an absolute formula. As indicated in Table 1, four studies use a relative growth formula based on log differences (Capasso et al., 2013; Coad, 2007; Coad and Hölzl, 2009; Daunfeldt and Halvarsson, 2015). The other five apply composite formulas. Acs (2013) modifies the Birch-index by an additional requirement of 100% increase in sales. Hölzl (2013) uses two different composite formulas, i. e. the definition by Eurostat-OECD and a Birch-index including a size threshold of 10 employees and minimum growth of 25%. Du and Temouri (2015) as well as Satterthwaite and Hamilton (2016) also use the definition by Eurostat-OECD, while Senderovitz et al. (2016) measure

high-growth based on percentage changes in sales or, if sales is not available, in profits including additional size thresholds for sales, equity and profits.

The lack of evidence for an absolute growth formula is considered as an important shortcoming for the following reasons: First, if growth decreases with size as predicted by Jovanovic (1982), the use of an absolute formula which selects larger firms would result in low or even negative subsequent growth. The use of a composite and in particular a relative formula in contrast should select firms which grow stronger. Second, the choice of growth formulas has further implications on the persistence of growth which have not been stressed in the previous literature focusing on high-growth periods. These implications are related to the influence of firm exits on subsequent growth. Two factors are at work here. On the one hand, if survival increases with firm size as theoretically predicted, exit rates should be lowest for high-growth firms selected according to an absolute growth formula, higher for those according to a composite formula and highest when choosing a relative formula. On the other hand, absolute growth formulas account for actual losses in size by exits, whereas relative growth formulas are left-censored in the sense that an exit is always accounted for by a decrease in size of -1 irrespective of how large a firm was at the time of exit. The same holds for composite formulas based on percentage changes. An absolute formula therefore accounts for both the first (differences in exit rates) and the second factor (actual size of exits). In the case of relative and composite formulas the influence of exits on overall growth is confined to the first factor. Since exiting high-growth firms are much larger in size after the period of high-growth than exits by other firms, which are on average small (Davidsson et al., 2010) and stagnate (Stanley et al., 1996), the economic contribution of both surviving and exiting high-growth firms after high-growth is incompletely reflected by relative and composite formulas. The following aggregate effects on the persistence of high-growth from different formulas are therefore expected: If losses in size by exits net out further gains in size by survivors and if at the same time differences in exit rates between high-growth firms and non-high growth firms are not large enough to compensate for these net losses, then high-growth measured by an absolute formula should not persist. In contrast, including exits should have positive effects on overall future growth based on relative and composite formulas because actual size of firm exits is disregarded.

We conclude this section with briefly outlining implications from additional methodological choices apart from growth formulas, which have been previously shown to matter as well. For the reasons outlined above, their influence is however expected to be of second-order compared to growth formulas for the question if high-growth persists or not. The most widely studied growth indicator for investigating persistent high-growth as shown in Table 1 is employment followed by sales. Sales is most likely the indicator favored by entrepreneurs themselves for whom growth in employees is rather a means to an end. From a more macro-economic interest in job creation on the other hand, measuring growth in employment seems the natural choice (Delmar et al., 2003). The use of different indicators matters because they are not necessarily related. Outsourcing of production e. g. would increase growth in sales, while growth in employment or assets would remain unaffected (Shepherd and Wiklund, 2009). Broadly spoken, the correlation between employment and sales indicators has been found to be moderate while the correlation with other growth indicators such as profits, assets, productivity, or value added is low (Daunfeldt et al., 2014; Markman and Gartner, 2002; Shepherd and Wiklund, 2009). Time spans over which high growth is calculated range between 1 and 4 years (Table 1). Choosing longer periods such as 3 years has the advantage that high-growth is less affected by measurement errors or short-term fluctuations in size due to transitory shocks (Davis et al., 1996; Haltiwanger et al., 2013). Compared to other methodological choices, Shepherd and Wiklund (2009) found that the correlation of growth over 1 year and 3 year periods was high (correlation coefficient of 0.5 or greater). Finally, the mode of growth, i.e. whether growth is organic and acquired is another choice to be made. McKelvie and Wiklund (2010) argue in favor of a differentiation between growth modes, because the characteristics of firms growing organically may well differ from those growing via acquisition. From a macro-perspective this distinction is also relevant, because there is no immediate additionality if one firm acquires employees of another firm. Over the course of time, acquired growth can however have economic significance if the acquiring firm makes more efficient use of the assets of the acquired business (Parker et al., 2010). It may also have a positive long-term impact on the overall

viability of both the acquired and acquiring firm in the face of strong domestic and international competition (McKelvie and Wiklund, 2010). The existing empirical evidence is largely confined to total growth as a combination of both organic and acquired growth. One exception is Capasso et al. (2013) showing that extreme acquisitive growth is not likely to be repeated, or at least not at the same magnitude, whereas extreme organic growth may persist. McKelvie et al. (2006) moreover find that smaller firms grow almost entirely by organic growth, while the opposite holds for the largest firms. High growth firms even shrank in terms of organic growth. Less support for the fact that high-growth is largely based on acquisition is brought forward by Delmar et al. (2003) finding that only 10% of high-growth firms in their sample of firms with at least 20 employees grew primarily via acquisition. The fact that modes of growth differ between firms of different size, additionally supports our proposition that growth formulas have a central role for the persistence of high-growth.

The remainder of this study therefore addresses the identified research gap regarding the use of an absolute growth formula to measure the persistence of high-growth and tests the suggested implications on empirical grounds.

Table 1. Results and methodological choices of previous studies on the persistence of high-growth

Study	Country	Observation period	Results <sup>a</sup>	Growth formula			Growth indicator	Growth period	Growth mode <sup>d</sup>	Exits included
				Absolute	Relative ( $\Delta \log$ )	Composite OECD Other				
Acs (2013)	United States	1998-2006	+			x	Employees, Sales	4-year	T	yes
Capasso et al. (2013)	Netherlands	1994-2004	-		x		Employees	1-year	O/A	no
Coad (2007)	France	1996-2002	-		x		Employees, Sales	1-year	O	no
Coad and Hözl (2009)	Austria	1975-2004	-		x		Employees	1-year	T	no
Daunfeldt and Halvarsson (2015)	Sweden	1997-2008	-		x		Employees	3-year	T	no
Du and Temouri (2015)	United Kingdom	2001-2010	+			x	Sales/Productivity <sup>b</sup>	3-year	T	no
Hözl (2013)	Austria	1985-2007	+			x	Employees	3-year	T	yes
Satterthwaite and Hamilton (2016)	New Zealand	2005-2014	+			x	Employees	3-year	T	yes
Senderovitz et al. (2016)	Denmark	2004-2010	+				various <sup>c</sup>	4-year	T	no

<sup>a</sup> Growth after high-growth period: + positive, - negative

<sup>b</sup> Sales used to define high-growth firms (explanatory variable), total factor productivity used as dependent variable

<sup>c</sup> Sales, profit and equity used to define high-growth firms, among which employees is used as explanatory variable and return on equity as dependent variable

<sup>d</sup> T total, O organic, A acquired



## 3 DATA

### 3.1 DATASET

This study uses administrative data on Bulgarian firms compiled in the Amadeus database by Bureau van Dijk. The available time period is the years 2001-2010. Amadeus draws on firms from the BULSTAT register, where all persons engaging in economic activity are required to register, assigned with a unique identification number (BULSTAT code)<sup>2</sup> and automatically recorded by the national social security institute as well as the national revenue agency. We consider private firms from all industries. Our main focus is on growth in the number of employees as reported to the social security institute at the end of a given year.<sup>3</sup> Other key variables included in the dataset are described below. The minimum firm size in our sample is 1 indicating self-employment. Firms employing salaried workers consequently have a size of 2 or more. We cannot distinguish between full-time and part-time employment, but the latter is very rare in Bulgaria (1.5-3.0% for 2001-2010).<sup>4</sup> Table A1 in the appendix shows how our sample from Amadeus compares to official data on firm demography reported by the national statistical institute (NSI) of Bulgaria.<sup>5</sup> The presented years correspond with the analyzed growth periods described below. It shows that about a third of all firms are included in our sample at the beginning of our observation period (2001). Coverage subsequently increases to about half of firms (2004) before effectively all firms are included in 2007 and 2010. Sample firms at the beginning of our observation period tend to be larger than those reported by NSI with 91.8% micro-sized firms in NSI compared to 75.8% for our sample in 2001. The difference is already much smaller in 2004 (90.2% in NSI compared to 81.1% in our sample). From 2007 onwards, our sample can be regarded as identical to the set of firms reported by NSI.

The main advantage of the dataset is that it captures not only medium and large firms, but also micro-sized ones including owner-only firms. It is therefore very well suited for addressing our research question if the use of different growth formulas - including a relative one selecting very small firms - affects the persistence of high growth. Another major advantage of the dataset is that it enables us to account for firm exit and its contribution to net employment growth. We use each firm's identification number to follow it over time. If no information on employment is reported in a specific year or in any following years until the end of our observation period, it is defined as exit. Given the considerable increase in reported firms over time in our dataset, we consider this approach as valid. Compared to other datasets which do not include owner-only firms, we can also rule out any cases where firms continue to exist without salaried workers. Nevertheless, two steps are added to limit the number of possibly falsely defined exits: We clean exits for firms which continue to report sales or profits. As this information originates from different sources (revenue agency) than that on employees (social security institute), it should provide an adequate cross-check for those firms which are obliged to report financials. In addition, firms with 1,000 employees or more before exit (around 0.4% of exits) are excluded from our definition of exit to avoid classifying large acquisitions as firm exit. The cut-off point was chosen based on evidence by Fackler et al. (2013) that establishments with more than 100 employees still accounted for around 1% of exits cleaned for acquisitions. Overall, the resulting average unconditional exit rate over 3-years of 32% in our sample (section 5.1) closely corresponds to the average annual exit rate of 11% for 2004-2010 reported by Eurostat.<sup>6</sup>

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<sup>2</sup> A firm can consist of several establishments. Job flows at the intra-firm level cannot be accounted for.

<sup>3</sup> Employment data was imputed for up to two missing values. Serial correlation for employment was above 0.8. See Delmar et al. (2003) for a very similar approach with regard to sales data.

<sup>4</sup> <https://data.oecd.org/emp/part-time-employment-rate.htm> (accessed 30 Oct 2017): Part-time employment defined as self-employed and employees working < 30 hours per week in their main job. Bulgaria had the lowest share among 48 surveyed countries.

<sup>5</sup> [https://infostat.nsi.bg/infostat/pages/module.jsf?x\\_2=219](https://infostat.nsi.bg/infostat/pages/module.jsf?x_2=219) (accessed 5 June 2018)

<sup>6</sup> <http://ec.europa.eu/eurostat/web/structural-business-statistics/entrepreneurship/business-demography> (accessed 23 Nov 2017).

### 3.2 CONTEXT

The country context of this study differs from previous research which has drawn on data from high-income countries (Austria, Denmark, France, Netherlands, New Zealand, Sweden, United Kingdom and United States as indicated in Table 1). Bulgaria is a middle-income country<sup>7</sup> in Eastern Europe, which became member of the European Union in 2007. There are both reasons why results for Bulgaria could be different as well as why they might be similar to high-income contexts. On the one hand, the transition to market-led economies in Eastern Europe in the 1990s introduced substantial changes to the environment for firms. In terms of firm demography, it typically resulted in the emergence of a large number of new small firms, a decline of old inefficient ones and large aggregate productivity gains (Hutchinson and Xavier, 2006). Moreover, the institutional environment for firm growth is much weaker in Eastern Europe compared to more developed countries and has been accordingly found to have detrimental effects on firm growth (Manolova and Yan, 2002; Manolova et al., 2008). Bulgaria's score in the economic freedom index by the Heritage Foundation<sup>8</sup> - a widely used indicator for the level of a country's institutional development - is accordingly below the regional average for Europe. With respect to high-growth specifically, it has moreover been shown that fast-growing firms in Eastern Europe rely more on internal sources to finance growth (Mateev and Anastasov, 2010) and that their contribution to employment is lower than in high-income countries in very extreme contexts such as Kosovo (Hoxha and Capelleras, 2010). The latter finding does not hold for Bulgaria. By measuring high-growth as relative increase in employees of 10% or more for firms with at least 10 employees, Eurostat<sup>9</sup> reports a share of high-growth-firms in Bulgaria in 2015 above the European average in terms of firms (11%) and even among the highest in Europe in terms of the number of employees (18%). Cuaresma et al. (2014) also show that Bulgaria ranks second highest among eleven countries in Eastern Europe concerning the share of high-growth firms (annualized employment growth of at least 20% over three years).

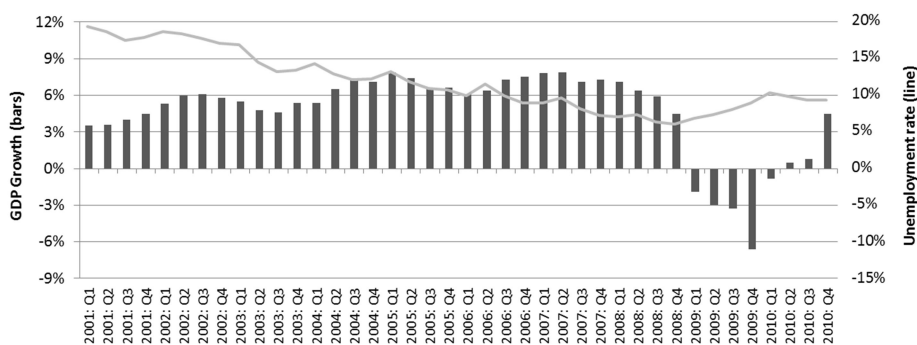


Figure 1. *Macro-economic country context, Bulgaria 2001-2010. Source: NSI<sup>10</sup>*

On the other hand, there are also important similarities to high-income countries with regard to the macro-economic and regulatory context. Figure 1 indicates the macro-economic environment during our observation period. After constant quarterly GDP growth (bars) at around 6-7% compared to the corresponding quarter of the previous year and steadily declining unemployment levels (line), GDP shrank in 2009 by up to -7% and unemployment sharply rose to 10%. As for most other countries, the macro-economic environment for firms in Bulgaria was therefore favorable in the years before 2008 and recessionary from 2008 onwards. In terms of regulatory environment for entrepreneurship, Bulgaria is ranked 50 out of 190 countries in the Doing Business Report 2018 by the Worldbank even before

<sup>7</sup> Classified as low-middle-income country until 2006 and upper-middle-income country afterwards.

<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups> (accessed 5 June 2018)

<sup>8</sup> <https://www.heritage.org/index/country/bulgaria> (accessed 19 Apr 2018)

<sup>9</sup> [http://ec.europa.eu/eurostat/statistics-explained/index.php/Business\\_demography\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php/Business_demography_statistics) (accessed 19 Apr 2018)

<sup>10</sup> <http://www.nsi.bg/en/content/5504/gdp-production-approach-%E2%80%93-total-economy> (accessed 29 Nov 2016)

some high-income countries such as Belgium and Luxembourg. In terms of labor market regulation such as redundancy rules to adjust employment levels, Bulgaria again shows similar framework conditions as high-income countries (e. g. 1 month of average notice period and severance pay for redundancy dismissal).<sup>11</sup> It remains to be tested in the empirical part whether differences or similarities prevail.

### 3.3 VARIABLES

The dependent variable in this study is future growth. As detailed in the method section, it is derived based on the probability to survive and exit as well as future growth of survivors and exits. The following methodological choices are made for measuring growth:

The choice of growth formulas is at the core of our research question. We use an absolute and a relative formula for measuring the dependent variable. Absolute growth refers to changes in size over the growth period. Relative growth is measured as average annualized percentage change in line with the definition of high-growth firms by Eurostat-OECD, which will be used for the explanatory variables. Log differences are also used for explanatory variables but not to measure the dependent variable, because they are less easy to interpret than percentage changes and, more important, not defined for exits indicated by a firm size of zero in this study.<sup>12</sup>

The main indicator for the dependent variable is employment. As Coad et al. (2014, p. 92) put it: 'Interest in high-growth firms can be explained in one word: jobs.' Not surprisingly, employment is the most studied growth indicator (Table 1). Employment gains and losses are measured at the individual firm level. We do not dispose of information on inter-firm job flows, which would be necessary to distinguish between the re-allocation of employment from one firm to another and job creation at the macro-economic level. As additional indicators, we use sales (net revenue from sales) and profits (net profit after taxes). Sales and profits are available for 14% of sample firms on average, but to a larger extent for high-growth firms (24 - 46%) due to reporting requirements for financial accounts depending on firm size. Results for profits are particularly interesting, because they allow testing for the suggested Penrose-effect, i. e. a decrease in profitability after high-growth.

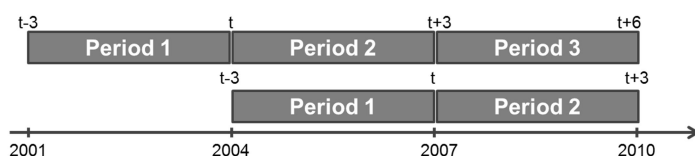


Figure 2. *Growth periods studied*

The growth period is measured over 3-years taking into account the discussion above on the influence of transitory shocks and measurement errors on shorter periods. A 3-year period is additionally in line with the definition of high-growth by Eurostat-OECD (2007). We accordingly divide our sample into three 3-year periods (2001-2004, 2004-2007 and 2007-2010).<sup>13</sup> As illustrated in Figure 2, our analysis of future growth in t+3 consequently comprises two periods (2004-2007 and 2007-2010) whereas the analysis of growth in t+6 is only based on a single period (2007-2010). In terms of macro-economic context, results for t+3 are derived by pooling both a period with favorable economic conditions (2004-2007) and a period with unfavorable ones (2007-2010). Results for t+6 in contrast are based on the recessionary period 2007-2010 and should hence be interpreted with adequate caution. Firms that newly appear in our dataset during the base year of each growth period (i. e. 2001, 2004, and 2007) are included in the analysis. Firms entering throughout a growth period are excluded based on our arguments above for measuring growth over 3-years. As a robustness check, we also re-estimated main results for a sample including these entrants.

<sup>11</sup> <http://www.doingbusiness.org/rankings>; <http://www.doingbusiness.org/data/ExploreTopics/labor-market-regulation> (accessed 1 May 2018)

<sup>12</sup> Re-estimation of results for surviving firms confirms similarity between percentage changes and log differences.

<sup>13</sup> Note that 53% of high-growth firms in our sample sustained growth in each year of the 3-year period.

The measured mode of growth captures total firm growth. We try to limit the influence of acquired growth on our results by cleaning the dataset for very large increases in size of more than 1,000 employees over 3 years (20 observations). In a similar vein, a decrease from 1,000 to 0 employees from one year to another is not defined as exit.<sup>14</sup> Moreover, we use legal form as proxy for mode of growth and accordingly test robustness of main results for two types of legal forms: sole proprietorships, which can be considered as independent and therefore growing only organically as well as limited liability and joint stock companies, which are assumed to grow both organically and via acquisition.

Three different types of high-growth firms are used as explanatory variables. The growth indicator for all is the number of employees. Sales and profits cannot be used, because their availability increases with firm size, which would introduce a selection bias when comparing different growth formulas. We use three formulas: first, high growth firm in absolute terms (absolute HGF) includes the 1%<sup>15</sup> of firms with the highest absolute growth over a 3-year period. This corresponds to a minimum growth of 21 employees necessary for being defined as absolute HGF. Second, we follow previous evidence and use log differences. To increase comparability with absolute HGFs, we again choose to use 1% of firms as a cut-off point for being a high growth firm in relative terms (relative HGF). This corresponds to a minimum logarithmic growth rate of 1.94. Third, for a composite growth formula we follow Eurostat-OECD (2007), which is not only used in official firm statistics by Eurostat and OECD, but has recently become popular in academic research as well (Hölzl, 2013; Satterthwaite and Hamilton, 2016). We call the firms selected by this definition OECD HGFs. They are defined as firms that achieve an annualized growth rate of at least 20% during a 3-year period and have a size of at least 10 employees at the beginning of the period. In cumulative terms, this equals minimum growth of 72.8% over 3-years.

As control variables we use firm size indicated by the number of employees. We control for size using dummy variables for ten categories (1-4, 5-9, 10-14, 15-19, 20-24, 25-49, 50-99, 100-249, 250-499 and  $\geq 500$  employees). We choose size categories rather than the absolute number of employees in order to allow for more flexibility in case of potential non-linear relationships with the dependent variable. We moreover control for age. As the date of foundation is not recorded in our dataset, we measure age indirectly. Similar to Kandilov (2009), firms are assigned with an age of 1 in the year when they newly appear in the database.<sup>16</sup> Age accordingly varies for the sample used to estimate growth in  $t+3$  as well as for all exiting firms, but cannot be included as control in regressions for  $t+6$  where the sample is based on firms existing from 2001 until 2010 and all survivors are of identical age (10 years). Additional controls are the industry code at the 2-digit NACE (Rev. 1.1) level comprising 59 different industries. Following Hölzl (2013), we moreover use industry size at the 4-digit level in terms of mean employment for other firms in the same industry as well as industry growth of other firms at the 4-digit level. Both variables should affect the intensity of competitive pressure and therefore firm exit and growth. Industry growth is measured in terms of absolute growth for absolute HGFs and in terms of relative average annualized percentages for relative and OECD HGFs. We also control for the 28 districts a firm can be located in and five different types of legal form (sole proprietorship, limited liability company, joint-stock company, partnership, and other).

The sample used includes in total 369,294 observations over the 3-year periods 2001-2004, 2004-2007, and 2007-2010. The sample for different types of high-growth firms are of comparable magnitude: 3,669 absolute HGFs, 3,665 relative HGFs (each representing 1.0% of firms), and 5,406 OECD HGFs (representing 1.5% of firms).<sup>17</sup>

<sup>14</sup> Re-estimations of results for a sample including firms with growth  $>1,000$  employees over 3-years or  $>1,000$  employees in the year before exit showed that main findings remain unchanged.

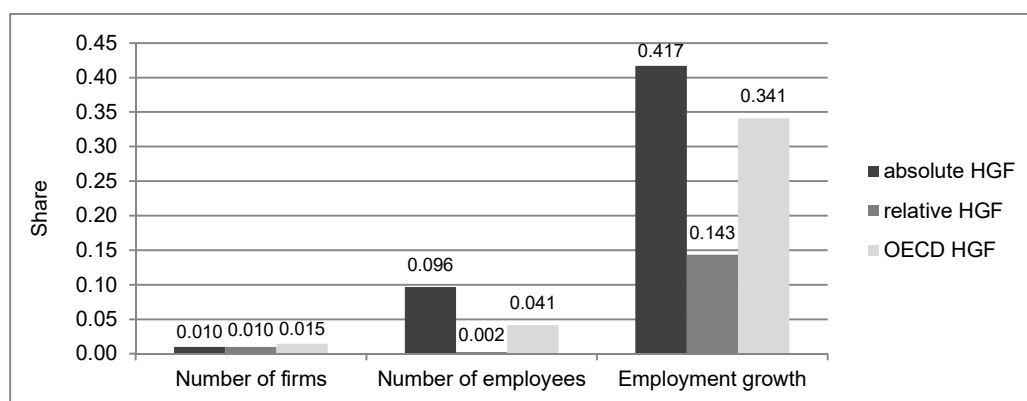
<sup>15</sup> Similar to previous studies (Bjuggren et al., 2013; Daunfeldt and Halvarsson, 2015), the required minimum absolute growth quickly fell off beyond the 1% cut-off point (5 employees for 5%, 2 employees for 10%).

<sup>16</sup> Even though our approach measures age with error, it is considered as advantageous to simply proxying age with size as e.g. in Winker (1999).

<sup>17</sup> 1,770 firms satisfy the definition of both absolute and OECD HGFs, 819 of both absolute and relative HGFs, 163 of both OECD and relative HGFs, and 147 all three definitions of HGFs.

### 3.4 DESCRIPTIVE STATISTICS

We start with descriptively examining the acclaimed contribution of high-growth firms to employment over the high-growth period before turning to descriptive differences in control variables. The idea is that any further evidence on persistent high-growth would be greatly debatable, if this most robust finding for high-growth firms did not hold for our data. Similar to Bravo-Biosca et al. (2016), Figure 3 accordingly reports the share of high-growth firms in the number of firms surviving a 3-year growth period, their share in the number of employees by surviving firms, and their share in gross employment growth. It shows that the contribution by absolute and OECD HGFs in our Bulgarian dataset is in line with what has been found before. Notwithstanding their small number in terms of firms and employees, they contribute disproportionately to employment growth. Absolute HGFs constituting 1.0% of firms and 9.6% of employees are responsible for 41.7% of employment growth. OECD HGFs have a share of 1.5% in firms and 4.1% in employees while contributing to 34.1% of employment growth. Their contribution is larger when compared to a sample of firms with 10+ employees, then amounting to 8.2% in total firms and 55.9% in employment growth. This corresponds to the contribution of OECD HGFs in Bravo-Biosca et al. (2016) for the United Kingdom, Finland, Spain, Italy, the United States or Canada. It also compares very well to the widely-known publication by NESTA (2009) showing that 6% of high-growth firms according to the OECD definition created 54% of new jobs in the United Kingdom. Relative HGFs in contrast have a much lower contribution to employment growth (14.3%). This low share is not country-specific, but related to the chosen 1% cut-off point. Applying a 10% cut-off point instead, results in a contribution to employment growth of 57% for relative HGFs. This relates closer to the share of 75% for the United States in Kirchoff (1994) who uses a similar definition of high-growth, but excludes any acquisitive growth. It is also in line with evidence by Halabisky et al. (2006) for Canada showing that firms growing by more than 50% in employees over 4-years accounted for 56% of employment growth. Given that the 1% definition has been previously used in the literature, the resulting small contribution of relative HGFs to employment shown in Figure 3 is however a finding in its own right. In sum, as was the purpose of this comparison, our sample seems largely representative regarding the employment contribution of high-growth firms.



**Figure 3.** Share of HGFs in number of firms, employees and employment growth.  
*Notes.* Average values for 2001-2004, 2004-2007, and 2007-2010. Number of firms indicates surviving firms from  $t-3$  to  $t$ ; Number of employees indicates employees of surviving firms in  $t-3$ ; Employment growth indicates increase in employees from  $t-3$  to  $t$  by surviving firms with positive growth.

Table 2 presents descriptive differences in control variables between the total sample and the three types of high-growth firms. The variables firm size, industry code and district are presented at a more aggregate level than used for regression analyses for the sake of brevity. The level of aggregation corresponds with robustness checks in section 5.5. As to be expected from the use of different growth formulas, high-growth firms differ considerably in initial size ( $t-3$ ). Firm size in employees amounts to 11.834 employees on average for the total sample. Absolute high-growth firms are large with an average size of 114.839 employees before high-growth. In stark contrast, relative HGFs are very small with 2.711 employees on average. HGFs defined according to OECD are positioned in between these two extremes with 33.496 employees.

Table 2. Summary statistics of control variables

Control variables	Total sample		HGFs absolute		HGFs relative		HGFs OECD	
	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N
Firm size <sup>a</sup>	11.834 (70.177)	369,294	114.839 (237.888)	3,669	2.711 (6.734)	3,655	33.496 (52.912)	5,406
Age	2.488 (1.787)	369,294	3.238 (2.253)	3,669	1.911 (1.497)	3,655	2.813 (1.904)	5,406
Industry size <sup>a</sup>	9.518 (22.485)	369,294	31.620 (59.100)	3,669	15.553 (34.703)	3,655	19.819 (32.390)	5,406
Industry growth (absolute) <sup>a</sup>	-2.366 (7.619)	369,294	-6.716 (20.174)	3,669				
Industry growth (relative) <sup>a</sup>	-0.089 (0.046)	369,294			-0.091 (0.047)	3,655	-0.084 (0.047)	5,406
Industry code	Share		Share		Share		Share	
A-C (Primary)	0.033	369,294	0.038	3,669	0.042	3,655	0.035	5,406
D-F (Secondary)	0.186	369,294	0.417	3,669	0.294	3,655	0.369	5,406
G-K, M-O (Tertiary)	0.781	369,294	0.545	3,669	0.664	3,655	0.596	5,406
District (NUTS 2)								
Northern regions	0.325	369,294	0.273	3,669	0.297	3,655	0.278	5,406
Southern regions	0.675	369,294	0.727	3,669	0.703	3,655	0.722	5,406
Legal form								
Sole proprietorship	0.481	369,294	0.037	3,669	0.120	3,655	0.128	5,406
Limited liability company	0.432	369,294	0.719	3,669	0.773	3,655	0.726	5,406
Joint-stock company	0.037	369,294	0.218	3,669	0.080	3,655	0.112	5,406
Partnership	0.016	369,294	0.007	3,669	0.006	3,655	0.015	5,406
Other <sup>b</sup>	0.035	369,294	0.019	3,669	0.021	3,655	0.019	5,406

Notes. Average values for periods 2001-2004, 2004-2007, and 2007-2010. All values relate to t-3 except industry growth (t)

<sup>a</sup> in number of employees

<sup>b</sup> Includes municipal enterprises, associations and co-operations

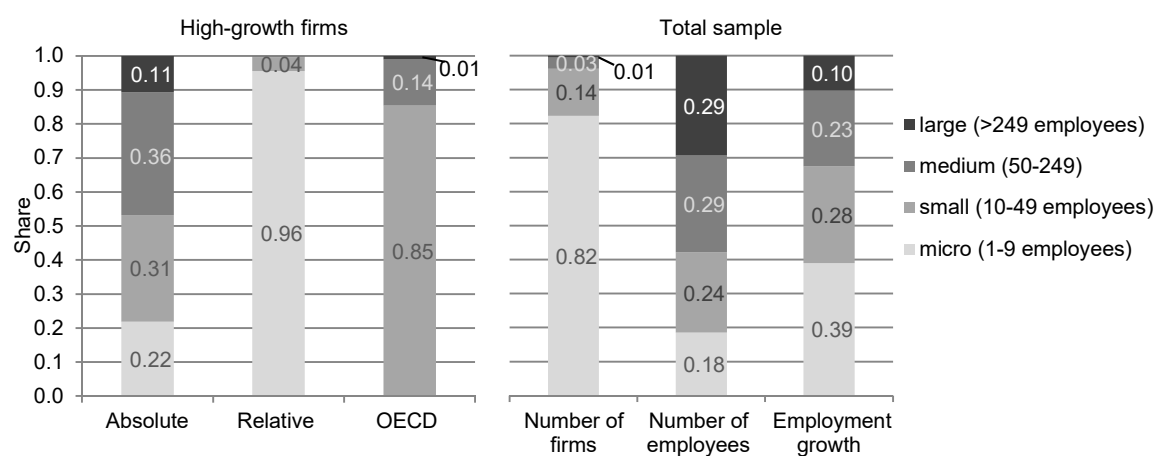


Figure 4. Contribution of firm size classes. See notes in Figure 3.

Figure 4 supplements descriptives on size. The left panel for high-growth firms shows that shares for absolute HGFs are evenly distributed along the four size classes according to Eurostat (micro with less than 10 employees, small with 10-49 employees, medium with 50-249 employees and large with more than 249 employees) including a notable share of 22% of micro-sized firms. Relative HGFs are almost entirely composed of micro-firms and do not include any medium and large firms. In a similar manner, the OECD definition selects smaller firms, but does not contain any micro-firms due to the size threshold of 10+ employees. The right panel of Figure 4 indicates size class shares for the total sample of firms and relates back to Figure 3 before. The largest number of firms is micro-sized with 82%, contributing to 39% of employment growth. Small firms contribute 28% to employment growth, medium-sized firms 23% and large firms 10%. Comparing now the left and right panel in Figure 4 with each other, the size class distribution for absolute HGFs is very similar to that for the total number of employees as well as employment growth. As argued above, absolute HGFs might typically not be

considered as primary target for policy support, because of their large average size and the fact that policy tends to favor support of small firms (sparked by Birch, 1979). Their size class composition however seems to most accurately reflect relevant indicators from a labor market perspective, i. e. the number of employees and employment growth. Relative HGFs only compare best to the total number of firms. The OECD definition of high-growth eventually offsets the emphasis on micro-sized firms inherent to relative growth formulas at the price of ignoring the considerable contribution by micro firms to employment growth.

Further differences in control variables indicated in Table 2 are as follows: Age is positively correlated with size. Absolute and OECD HGFs are older than the total sample firms, relative HGFs are younger. High growth firms are represented in all industries although they occur up to twice as often as average firms in the secondary sector (manufacturing and construction) and are under-represented in the tertiary sector (services). Mean size in employees of other firms in their industry (4-digit level) is considerably higher than for the total sample of firms. Industry growth at the 4-digit level is negative in general and more negative for industries with absolute HGFs. Geographically, HGFs exist in all regions of Bulgaria, but originate slightly more often from the economically more developed Southern region including the capital city. Regarding legal form, our data confirms a positive correlation between liability status and growth detected previously (Almus, 2002; Schreyer, 2000; Storey, 1994). High-growth firms are much more often limited liability or joint stock companies. This lends support to the above described proposition that legal form can be used as proxy for mode of growth, because firms with limited liability grow both organically and via acquisition while sole proprietorships only grow organically. It can be added that limited liability and assumed dependence on other firms could moreover influence the preparedness of owners to take risk and their access to necessary capital for investments into expansion.

## 4 METHOD

Methodologically we combine non-parametric and parametric methods. To provide a first impression of the dynamics of firm growth over time, we report estimated transition probabilities (see Capasso et al., 2013; Daunfeldt and Halvarsson, 2015; Hölzl, 2013). Firms are divided into five growth brackets including one for high-growth. Transition probability matrices then show the estimated probabilities that a firm in a given growth bracket in period  $t$  will be located in that or another growth bracket in the next period  $t+3$  or upper-next period  $t+6$  for each of the three sub-samples of high growth.

We then model future growth of high-growth firms and non-high-growth firms by means of a two part model, which consists of probit regressions for firm survival and exit on the one hand and linear regressions for growth of surviving and exiting firms on the other hand. In a third stage, the resulting conditional means from the two-part model for the two groups of high-growth firms and non-high-growth firms are used for a decomposition of overall growth depending on the sub-sample of HGFs. The choice of a two-part model is motivated by the fact that we want to account for firm exits. One-part models for growth at the firm level pool over exiting and surviving firms and therefore restrict the parameters of explanatory and control variables to have an equal impact on both types of firms. Building on the finding that firm size is negatively related to growth, but positively to survival, this is an important drawback. The two-part model in contrast allows for a decomposition of the specific contributions of firm exit and survival to the persistence of growth depending on the growth formula used.

Our empirical strategy closely follows Huber et al. (2017) and Hölzl (2013). We accordingly start with predicting the conditional probability of firm exit. Formally, the 1<sup>st</sup> part of the two-part model describes the binary response of survival versus exit:

$$y_{i,t+\tau} = \begin{cases} 1 & \text{for } S_{i,t+\tau} \neq 0 \text{ (survival}_{i,t+\tau}) \\ 0 & \text{for } S_{i,t+\tau} = 0 \text{ (exit}_{i,t+\tau}) \end{cases} \quad (4)$$

where the dependent variable  $y_{i,t+\tau}$  denotes the probability to survive at time  $t+\tau$  for a firm  $i$  that has existed throughout the first 3-year period (from  $t-3$  to  $t$ ).  $\tau$  is the time after the first 3-year period with  $\tau$

= (3,6).  $S_{i,t+\tau}$  is firm size in terms of the number of employees, sales or profits at time  $t+\tau$ .  $S_{i,t+\tau}$  equals 1 for firms which survive until the end of the next ( $t+3$ ) or upper-next ( $t+6$ ) period, while it equals zero in case of a firm exit.

The probit model for survival is then given as follows:

$$P(\text{survival}_{i,t+\tau} | HGF_{i,t}, x_{i,t-3}) = \Phi(\beta_0 + \beta_1 HGF_{i,t} + \beta_2 \text{firm\_size}_{i,t-3} + \beta_3 \text{age}_{i,t-3} + \beta_4 \text{industry\_code}_{i,t-3} + \beta_5 \text{industry\_size}_{i,t-3} + \beta_6 \text{industry\_growth}_{i,t} + \beta_7 \text{district}_{i,t-3} + \beta_8 \text{legal}_{i,t-3}) \quad (5a)$$

where P denotes the probability for survival.  $\Phi(\cdot)$  denotes the cumulative distribution function of the standard normal distribution.  $HGF_{i,t}$  is the explanatory variable,  $x_{i,t-3}$  is the set of control variables and  $\beta$  are the parameters estimated by maximum likelihood. The explanatory variable is the indicator  $HGF$  which takes the value 1 if the firm was a high-growth firm (absolute, relative, OECD) at time  $t$  and 0 otherwise. The control variables are as described above. Industry growth is measured as increase from  $t-3$  to  $t$ . All other control variables are measured at  $t-3$ . Controlling for differences in  $t-3$  is motivated by the fact that this study intends to provide guidance on the question if potential high-growth firms are a justifiable target for policy support compared to other firms.

Based on the estimated probability of survival from equation (5a), the probability of exit can simply be derived as the residual

$$P(\text{exit}_{i,t+\tau} | HGF_{i,t}, x_{i,t-3}) = 1 - P(\text{survival}_{i,t+\tau} | HGF_{i,t}, x_{i,t-3}) \quad (5b)$$

In the 2<sup>nd</sup> part of the two-part model, we model future growth rates in coming periods by means of ordinary least squares (OLS) again closely following Huber et al. (2017) and Hölzl (2013).<sup>18</sup> For surviving firms we estimate the following regression:

$$E(g_{i,t+\tau} | HGF_{i,t}, x_{i,t-3}) = \beta_0 + \beta_1 HGF_{i,t} + \beta_2 x_{i,t-3} + \varepsilon_{i,t+\tau} \quad \text{if } \text{survival}_{i,t+\tau} \quad (6a)$$

where the dependent variable  $g_{i,t+\tau}$  denotes growth of firm  $i$  in the number of employees, sales or profits over a 3-year period to  $t+\tau$  with  $\tau = (3,6)$ .  $t+\tau$  therefore indicates the last year of the next or upper-next 3-year period after high-growth.  $HGF_{i,t}$  and  $x_{i,t-3}$  are the same set of explanatory and control variables used in the 1<sup>st</sup> part of the two-part model, whereas the parameters  $\beta$  are now estimated with OLS.  $\varepsilon_{i,t+\tau}$  is the remaining error term.

Equation (6a) is estimated for each type of high-growth firm. The growth formula used for  $g_{i,t+\tau}$  in the case of absolute HGFs is the absolute increase in size, while for relative and OECD HGFs it is the relative annualized percentage change in size over 3-years. In a separate model, we moreover estimate the dependent variable based on different growth formulas than the ones used for the explanatory variable.

In the same way as for surviving firms, we additionally estimate  $g_{i,t+\tau}$  for exiting firms as:

$$E(g_{i,t+\tau} | HGF_{i,t}, x_{i,t-3}) = \beta_0 + \beta_1 HGF_{i,t} + \beta_2 x_{i,t-3} + \varepsilon_{i,t+\tau} \quad \text{if } \text{exit}_{i,t+\tau} \quad (6b)$$

This step is only necessary in the case of absolute growth. For relative growth, when  $E(g_{i,t+\tau} | HGF_{i,t}, x_{i,t-3}) = -1$ , eq. (6b) does not need to be estimated.

Finally, in the third stage of our econometric model, we make use of previous regression results to decompose aggregate growth into different components. We use the conditional mean function to

<sup>18</sup> A standard OLS estimator also seems sufficient for our purposes as we are not trying to distinguish between true and spurious state dependence. If this was attempted, the fact that *firm\_size* includes the lagged dependent variable could indeed lead to inconsistent results (Kaiser and Kongsted, 2008).



calculate predictions (conditional means) from the 1<sup>st</sup> (probit regression) and 2<sup>nd</sup> (linear regression) stage of the two-part model for the three types of high-growth firms on the one hand and non-high-growth firms on the other hand.

Overall growth denoted as  $G_{i,t+\tau}$  is given for high-growth firms by

$$\frac{E(G_{i,t+\tau} | HGF_{i,t} = 1, x_{i,t-3})}{E(g_{i,t+\tau} | exit_{i,t+\tau}, x_{i,t-3})} = \frac{P(survival_{i,t+\tau} | x_{i,t-3}) * E(g_{i,t+\tau} | survival_{i,t+\tau}, x_{i,t-3}) + P(exit_{i,t+\tau} | x_{i,t-3}) * E(g_{i,t+\tau} | exit_{i,t+\tau}, x_{i,t-3})}{E(g_{i,t+\tau} | exit_{i,t+\tau}, x_{i,t-3})} \quad (7a)$$

and for non-high-growth firms by

$$\frac{E(G_{i,t+\tau} | HGF_{i,t} = 0, x_{i,t-3})}{E(g_{i,t+\tau} | exit_{i,t+\tau}, x_{i,t-3})} = \frac{P(survival_{i,t+\tau} | x_{i,t-3}) * E(g_{i,t+\tau} | survival_{i,t+\tau}, x_{i,t-3}) + P(exit_{i,t+\tau} | x_{i,t-3}) * E(g_{i,t+\tau} | exit_{i,t+\tau}, x_{i,t-3})}{E(g_{i,t+\tau} | exit_{i,t+\tau}, x_{i,t-3})} \quad (7b)$$

where for each equation separately we multiply the conditional mean probability of survival as estimated from eq. (5a) with the conditional mean growth of surviving firms in coming period(s) as estimated from eq. (6a) and add to it the product of the conditional mean probability of exit as estimated from eq. (5b) and the conditional mean growth for exits as estimated from eq. (6b).

By taking the differences of HGFs and non-HGFs for each component of eq. (7a) and (7b), that is:

$$E(G_{i,t+\tau} | x_{i,t-3}) = E(G_{i,t+\tau} | HGF_{i,t} = 1, x_{i,t-3}) - E(G_{i,t+\tau} | HGF_{i,t} = 0, x_{i,t-3}) \quad (8)$$

we are eventually able to compare overall future growth of HGFs to non-HGFs.<sup>19</sup> In particular, we can investigate whether future growth differs depending on growth formulas used and how firm exits contribute to potential differences.

## 5 RESULTS

### 5.1 TRANSITION PROBABILITIES

The reported transition probability matrices in Tables 3 a-c provide a first impression of how firms in a given period  $t$  (columns) develop in the next period  $t+3$  (rows) in terms of growth. They moreover allow for testing the suggested implications of different growth formulas, which we developed based on the theoretical model by Jovanovic (1982), i. e. growth negatively depends on size and survival positively depends on size. To this end, firms are divided into five growth brackets: firm exits during a 3-year period are included in the growth bracket  $g_{i,t+\tau}^{(0)}$ , declining firms with negative growth in  $g_{i,t+\tau}^{(1)}$ , stagnating firms with zero growth in  $g_{i,t+\tau}^{(2)}$ , and growing (but not high-growth) firms in  $g_{i,t+\tau}^{(3)}$ . High-growth firms are grouped in bracket  $g_{i,t+\tau}^{(4)}$ . We perform this step for each sub-sample of high-growth firms separately. The set of firms in growth brackets  $g_{i,t+\tau}^{(0)}$  (exiting firms),  $g_{i,t+\tau}^{(1)}$  (firms with negative growth) and  $g_{i,t+\tau}^{(2)}$  (firms with zero growth) is identical irrespective of how high growth is defined. Firms in growth bracket  $g_{i,t+\tau}^{(4)}$  (high-growth firms) obviously differ depending on the sub-sample of high growth firms. Consequently, also firms in growth bracket  $g_{i,t+\tau}^{(3)}$  constituting the residual of firms with positive growth but not high-growth differ slightly across the three sub-samples. The rows in Tables 3 a-c all add up to 100% each. Transition probabilities for  $t+6$  are presented in Tables A2 a-c of the annex and discussed at the end of this sub-section.

The focus is on high-growth firms.<sup>20</sup> We start with their probability to repeat high-growth (cell  $g_{i,t}^{(4)} / g_{i,t+3}^{(4)}$ ). Among absolute HGFs (Table 3a) 28.6% grow highly in two consecutive periods. The probabil-

<sup>19</sup> The chosen approach of using non-HGFs as benchmark is very common in the literature for samples that do not include all firms in an economy (Henrekson and Johansson, 2010, p. 229).

ity for relative HGFs (Table 3b) is with 0.7% as low as for any other firm in our sample, while OECD HGFs (Table 3c) have a probability of 11.5% to repeat high-growth. These probabilities compare closely to previous findings. For a sample of Swedish firms, Daunfeldt et al. (2014) find a probability to repeat high growth in employees of 31.7% for absolute HGFs and 1.5% for relative HGFs. Hölzl (2013) shows for Austria, that 7.6% of OECD HGFs are able to repeat high-growth. As argued above, the repetition of high-growth in subsequent period(s) is not the focus of this study. Nevertheless, we offer the following interpretation: A constant relative growth rate (such as doubling size) requires exponential growth.<sup>21</sup> This makes it is evidently very difficult to uphold relative high growth as time increases. In contrast, absolute growth is of a linear kind (an increase by x employees in each period) and easier to repeat. This could be the reason for the largely differing probabilities between relative and absolute HGFs. As far as OECD HGFs are concerned, in principle similar effects of exponential growth should apply as for relative HGFs. However, the minimum annualized percentage growth for relative HGFs amounts to 61% in our sample, while only 20% is required for OECD HGFs. This can again explain why OECD high-growth is more likely to be repeated. As a result, high attention to growth formulas seems also advisable when assessing the repetition of high-growth. Defining high-growth in terms of log difference in employees, Daunfeldt and Halvarsson (2015) for example arrive at the conclusion that high-growth firms are 'one-hit wonders'. The probabilities to repeat high-growth in our sample for absolute HGFs and to some extent for OECD HGFs suggest a different view.

Table 3a. *Transition probabilities for growth brackets from t to t+3, absolute HGFs*

	$g_{i,t+3}^{(0)}$ exit	$g_{i,t+3}^{(1)}$ negative growth	$g_{i,t+3}^{(2)}$ zero growth	$g_{i,t+3}^{(3)}$ positive growth	$g_{i,t+3}^{(4)}$ absolute HGF	Total
$g_{i,t}^{(1)}$	0.352	0.310	0.129	0.205	0.005	1.000
$g_{i,t}^{(2)}$	0.452	0.086	0.353	0.109	0.001	1.000
$g_{i,t}^{(3)}$	0.209	0.400	0.063	0.313	0.015	1.000
$g_{i,t}^{(4)}$ = absolute HGF	<b>0.068</b>	<b>0.521</b>	<b>0.002</b>	<b>0.124</b>	<b>0.286</b>	1.000

Table 3b. *Transition probabilities for growth brackets from t to t+3, relative HGFs*

	$g_{i,t+3}^{(0)}$ exit	$g_{i,t+3}^{(1)}$ negative growth	$g_{i,t+3}^{(2)}$ zero growth	$g_{i,t+3}^{(3)}$ positive growth	$g_{i,t+3}^{(4)}$ relative HGF	Total
$g_{i,t}^{(1)}$	0.352	0.310	0.129	0.204	0.005	1.000
$g_{i,t}^{(2)}$	0.452	0.086	0.353	0.106	0.004	1.000
$g_{i,t}^{(3)}$	0.203	0.404	0.062	0.323	0.004	1.000
$g_{i,t}^{(4)}$ = relative HGF	<b>0.271</b>	<b>0.376</b>	<b>0.021</b>	<b>0.325</b>	<b>0.007</b>	1.000

Table 3c. *Transition probabilities for growth brackets from t to t+3, OECD HGFs*

	$g_{i,t+3}^{(0)}$ exit	$g_{i,t+3}^{(1)}$ negative growth	$g_{i,t+3}^{(2)}$ zero growth	$g_{i,t+3}^{(3)}$ positive growth	$g_{i,t+3}^{(4)}$ OECD HGF	Total
$g_{i,t}^{(1)}$	0.352	0.310	0.129	0.204	0.006	1.000
$g_{i,t}^{(2)}$	0.452	0.086	0.353	0.108	0.001	1.000
$g_{i,t}^{(3)}$	0.215	0.399	0.063	0.293	0.029	1.000
$g_{i,t}^{(4)}$ = OECD HGF	<b>0.078</b>	<b>0.464</b>	<b>0.018</b>	<b>0.326</b>	<b>0.115</b>	1.000

Notes: Transition probabilities are calculated using frequencies. Growth brackets are defined based on annualized percentage change as follows:  $g_{i,t+\tau}^{(0)} = -1$  (exit),  $-1 < g_{i,t+\tau}^{(1)} < 0$  (negative growth),  $g_{i,t+\tau}^{(2)} = 0$  (zero growth),  $g_{i,t+\tau}^{(3)} > 0$  (positive growth), and  $g_{i,t+\tau}^{(4)} =$  HGF. The definition of growth brackets based on absolute growth or log-differences does not alter results.

Closely related to the implications from linear versus exponential growth, Tables 3 a-c also demonstrate why it is worthwhile not to limit ones research interest to the repetition of high-growth. The high probability of absolute HGFs to repeat high growth (due to linear growth) comes at the cost of a lower probability to exhibit (non-high) positive growth. Adding up probabilities for both growing positively ( $g_{i,t+3}^{(3)}$ ) and growing highly ( $g_{i,t+3}^{(4)}$ ), absolute HGFs (41.0%), relative HGFs (33.2%) and OECD HGFs (44.1%) then have more similar transition probabilities. At the same time, the joint probabilities for

<sup>20</sup> An interesting finding for non-HGFs is that most firms do not grow at all. This is reflected in cells  $g_{i,t}^{(2)}/g_{i,t+3}^{(2)}$  showing that 35.3% of non-HGFs experience no growth for 6 years (t-3 to t+3).

<sup>21</sup> Formally, for a growth rate of 100% the size of a firm at time t would be given by:  $size_t = size_{t=0} * 2^t$

positive and high growth do not confirm our expectations of a negative relationship between size and growth. Smaller relative HGFs do not grow stronger than larger OECD and absolute HGFs. Considering the proposed positive relationship between size and survival however, our expectations are fully supported. As indicated in cell  $g_{i,t}^{(4)} / g_{i,t+3}^{(0)}$ , 6.8% of absolute HGFs, 27.1% of relative HGFs and 7.8% of OECD HGFs exit in the period after high-growth.

Transition probabilities between the state at the end of a period ( $t$ ) and two periods later ( $t+6$ ) presented in Tables A2 a-c have to be interpreted with adequate caution as already pointed out given the recessionary context of the considered growth period 2007-2010. In line with results for  $t+3$ , exit rates are lowest for absolute HGFs (9.8%), highest for relative HGFs (20.2%) and in between for OECD HGFs (12.7%). Absolute HGFs also again exhibit the highest probability to repeat high-growth two periods later (14.2%) compared to 0.8% of relative HGFs and 2.4% of OECD HGFs. Different from  $t+3$ , the negative relationship of size and growth is confirmed for  $t+6$ . Aggregating probabilities for positive and high-growth, absolute HGFs (19.4%) have a lower probability to grow than relative HGFs (23.2%) and OECD HGFs (22.3%). Taken together, the direction of theoretical predictions for size-dependence seem to fully apply as far as survival of high-growth firms is concerned, for subsequent growth it is only confirmed in case of a perspective on  $t+6$ .

## 5.2 RESULTS FOR SURVIVING FIRMS

Before presenting decomposition results, we dedicate this sub-section to surviving firms. Results for probit regressions of survival are presented in Table A3 of the annex (1<sup>st</sup> part of two-part model based on equation 5a) and those for growth of surviving firms (2<sup>nd</sup> part of two-part model based on equation 6a) in Table 4. The focus of this study is on overall growth including exits, because we argue that both the contribution of survivors and exits is relevant for assessing the longer-term effectiveness of high-growth policies. A discussion of results for surviving firms however enables a comparison to previous studies based on relative growth formulas which do not account for exit. It also allows for a discussion of control variables such as size and age in contrast to the decomposition, which is limited to presenting coefficients of explanatory variables.

The dependent variable in Table 4 is future growth in employees ( $g_{i,t+\tau}$ ) of surviving firms. The explanatory variable HGF takes on the value 1 if a firm has been a HGF at time  $t$  and 0 otherwise. The control variables are as described above. We estimate separate specifications of equation (6a) for each type of high-growth firm. The dependent variable for absolute HGFs is measured as absolute increase, while for relative and OECD HGFs it is measured as relative annualized percentage change. Results for growth in  $\tau=3$  are presented in specifications (1-3), those for growth in  $\tau=6$  in specifications (4-6). It shows that being a high-growth firm is significantly associated with future growth in both  $t+3$  and  $t+6$  with  $p < 0.01$  for all three sub-samples. Coefficients' signs however vary depending on the type of high-growth firm and the time-span. Surviving absolute HGFs continue to increase their number of employees by 17.077 in  $t+3$  (specification 1). Relative HGFs decrease in size by -6.9% annually in the three years following high-growth (specification 2). OECD HGFs further increase by 3.9% annually (specification 3). Using the sample of firms which existed in 2001-2004 and survived until 2010 ( $t+6$ ), all three sub-samples of HGFs show negative growth. Absolute HGFs decrease by -52.395 employees (specification 4), relative HGFs by -8.4% annually (specification 5), and OECD HGFs annually by -3.4% (specification 6).

As far as control variables are concerned, the expected size-dependence of growth and survival is well confirmed and supports our choice of a two-part model as empirical strategy. Among the 10 firm size categories used, the one with 25-49 employees is set as reference category. The smaller the initial firm size, all other things equal, the larger the future growth of surviving firms. As shown in Table A3, the probability of survival is positively associated with size. The smaller the initial firm size, the lower the probability to survive. Similar to size, firm age is also negatively associated with growth in  $t+3$ . It is also negatively associated with survival (table A3), which is unexpected, but could be related to our indirect measure of age. Larger industries and higher industry growth are positively associated with

both future growth and survival. Coefficients for most districts and industry codes are also significant and legal forms other than sole proprietorship are positively associated with growth and survival.<sup>22</sup>

Table 4. *Regression results for future growth of surviving firms*

Dependent variable: $g_{i,t+\tau}$ for $survival_{i,t+\tau}$	$\tau=3$			$\tau=6$		
	Absolute HGFs (1)	Relative HGFs (2)	OECD HGFs (3)	Absolute HGFs (4)	Relative HGFs (5)	OECD HGFs (6)
<i>Explanatory variable:</i> HGF	17.077*** (4.624)	-0.069*** (0.010)	0.039*** (0.004)	-52.395*** (8.268)	-0.084*** (0.013)	-0.034*** (0.006)
<i>Control variables</i>						
Firm size dummy (Reference category: 25-49 employees)						
1-4	3.780*** (0.598)	0.106*** (0.003)	0.109*** (0.003)	5.261*** (0.844)	0.078*** (0.006)	0.071*** (0.006)
5-9	3.995*** (0.521)	0.051*** (0.003)	0.054*** (0.003)	4.585*** (0.833)	0.043*** (0.006)	0.038*** (0.006)
10-14	4.101*** (0.467)	0.030*** (0.004)	0.028*** (0.004)	3.791*** (0.824)	0.024*** (0.006)	0.025*** (0.006)
15-19	3.392*** (0.509)	0.022*** (0.004)	0.020*** (0.004)	3.070*** (0.919)	0.008 (0.007)	0.010 (0.007)
20-24	3.087*** (0.576)	0.019*** (0.005)	0.018*** (0.005)	1.747 (1.133)	0.017* (0.009)	0.017** (0.009)
50-99	-6.346*** (1.006)	-0.020*** (0.005)	-0.020*** (0.005)	-6.229*** (1.496)	-0.016** (0.007)	-0.016** (0.007)
100-249	-16.757*** (1.660)	-0.030*** (0.005)	-0.028*** (0.005)	-14.695*** (2.379)	-0.026*** (0.008)	-0.027*** (0.008)
250-499	-58.492*** (5.299)	-0.060*** (0.009)	-0.056*** (0.009)	-47.508*** (7.745)	-0.041*** 0.015	-0.042*** (0.015)
500-1000	-158.630*** (16.392)	-0.050*** (0.012)	-0.045*** (0.011)	-127.839*** (17.243)	-0.032* (0.018)	-0.033* (0.018)
Age	-1.710*** (0.097)	-0.014*** (0.001)	-0.014*** (0.001)	no	no	no
Industry code	yes	yes	yes	yes	yes	yes
Industry size	0.371*** (0.087)	0.000*** (0.000)	0.000*** (0.000)	0.388*** (0.149)	0.000*** (0.000)	0.000*** (0.000)
Industry growth	1.822*** (0.685)	0.427*** (0.017)	0.421*** (0.017)	2.295* (1.289)	0.340*** (0.032)	0.347*** (0.032)
District	yes	yes	yes	yes	yes	yes
Legal	yes	yes	yes	yes	yes	yes
Constant	-1.267 (0.815)	-0.060*** (0.004)	-0.064*** (0.004)	0.930 (3.073)	-0.102*** (0.007)	-0.095*** (0.007)
Observations	95,761	95,761	95,761	28,694	28,694	28,694
R <sup>2</sup>	0.176	0.061	0.061	0.234	0.052	0.051

Dependent variable:  $g_{i,t+\tau} = E_{i,t+\tau} - E_{i,t+\tau-3}$  for absolute HGFs and  $\left(\frac{E_{i,t+\tau}}{E_{i,t-3+\tau}}\right)^{\frac{1}{3}} - 1$  for relative and OECD HGFs.

Note: Robust standard errors in parentheses.

\*\*\*p < 0.01, \*\* p < 0.05, \* p < 0.1

Our interpretation of results for growth of surviving firms in  $t+3$  is as follows. Coefficients for the explanatory variable HGF continue to differ after controlling for initial differences in size, which was assumed to be the main implication from using different growth formulas as far as surviving firms are concerned. Relative HGFs exhibit negative growth, while OECD and absolute HGFs grow positively. Reviewing results by previous studies summarized in Table 1 from the perspective of growth-formulas interestingly reveals a similar pattern: The studies which defined high-growth firms in terms of relative log growth also found that future growth rates are negative (Capasso et al., 2013; Coad, 2007; Coad and Hözl, 2009; Daunfeldt and Halvarsson, 2015). Those which applied a composite formula such as the one by Eurostat-OECD also showed that growth was positive (Acs, 2013; Hözl, 2013; Satterthwaite and Hamilton, 2016). The conflicting findings by previous evidence are therefore put into a very different light. Rather than pointing into different directions, a clear pattern emerges depending on growth formulas used. Our empirical findings add further evidence to that pattern and enlarge it for absolute HGFs. It suggests for surviving firms, that initially larger high-growth firms (absolute and OECD HGFs) continue to grow and smaller high growth firms (relative HGFs) decrease after high-growth – even after controlling for initial differences in size. Disaggregated findings by firm size of

<sup>22</sup> Coefficients for industry code, district and legal are not reported, but can be made available upon request.

Coad (2007) and Coad and Hölzl (2009) support this view and show that smaller high-growth firms are characterized by a negative autocorrelation of growth, while large firms continue to grow. A possible conjecture explaining that pattern would be that firm size is related to further determinants of growth apart from the ones typically controlled for.<sup>23</sup> Parker et al. (2010) for instance demonstrated that effects of past growth on future growth of high-growth firms were not significant, when differences in management strategies were controlled for. The characteristically low values for  $R^2$  statistics of growth rate regressions found in the literature also point to the strong influence of unobservables.

### 5.3 RESULTS INCLUDING EXITING FIRMS

This section tests the proposed main implication from using different growth formulas – how losses in size by firm exits are accounted for. To this end, we present decomposed results from the two-part model. The discussion focuses on overall growth and exits, while results for surviving firms have been dealt with before.

The decomposition in Table 5 shows coefficients of the explanatory variable *HGF* derived from the two-part model. The conditional mean function is used to calculate predictions for  $HGF=1$  (columns 1a-3) and for  $HGF=0$  (columns 4a-6). Differences between coefficients for HGFs and non-HGFs are then presented in columns (7-11). Reported are the conditional probability of survival, the conditional growth for surviving firms, the conditional probability of exit, the conditional growth for exits and overall conditional growth. Table 5 also indicates how columns (3), (6) and (7-11) are calculated based on eq. (8). It should also be noted that coefficients for growth of surviving firms in column (8) correspond with those reported in Table 4 above.

Table 5 confirms the proposition that growth formulas influence how exits contribute to overall growth and that this contribution has large effects for the persistence of high-growth. We first focus on results for differences between HGFs compared to non-HGFs (columns 7-11). For absolute HGFs, the positive contribution to employment in  $t+3$  of surviving firms (17.08 employees as indicated in column 8 of Table 5 or specification 1 in Table 4, respectively) is negative overall when exits are included (-30.73 employees in column 11). In contrast, relative HGFs which exhibit negative growth in  $t+3$  if only surviving firms are considered (-7% annually over 3-years), show small positive overall growth compared to non-HGFs when exits are taken into account (1% annually). The outperformance of non-HGFs by OECD HGFs in the case of survivors (4% annually) becomes even more impressive for overall growth including exits (15% annually). In a similar manner, the recognition of firm exits influences findings for  $t+6$ . Growth of survivors was negative for all three types of HGFs. Absolute HGFs continue to underperform compared to non-HGFs when exits are included (-49.78 employees). Growth rates of relative and OECD HGFs on the other hand are positive compared to non-HGFs when exits are accounted for (annually 15% for relative HGFs and 13% for OECD HGFs).

Investigating exit and growth for HGFs and non-HGFs separately reveals the influence of the two factors proposed in section 2. First, high-growth firms are less likely to exit than non-high-growth firms even when controlling for initial differences (columns 9). Exit rates in  $t+3$  for high-growth firms (column 2a) amount to 23% for absolute HGFs, 26% for relative HGFs and 20% for OECD HGFs, while 32% of non-HGFs exit (column 5a). The difference is even more pronounced for  $t+6$  where the range of exit rates for high-growth firms remains largely unchanged (19-28%), while 42% of non-HGFs exit. Second, the lower rates of exit for absolute HGFs (column 9) are outweighed by absolute losses in employment of exiting absolute HGFs (column 10) resulting in negative overall growth compared to non-HGFs (column 11). The situation is different for relative and OECD HGFs where growth is measured by a relative formula. An exit is always accounted for as a relative decrease in size by -100% no matter how large a firm was at the time of exit. The fact that exiting HGFs are of larger firm size compared to exiting non-HGFs is therefore not affecting overall growth (column 10). Instead, lower average exit rates for HGFs than non-HGFs (column 9) contribute to positive overall growth for HGFs in  $t+3$  and  $t+6$

<sup>23</sup> Possibly, further determinants even affect growth in a different direction than size.

(column 11). In the case of relative HGFs in t+3 and both relative and OECD HGFs in t+6 their lower rate of exit contributes to positive overall growth even though growth for surviving firms was negative.

What do these findings imply? Should high-growth firms be defined according to a relative formula, because relative and OECD HGFs achieve sustainable growth in employment based on Table 5? To test this implication we re-estimate results in t+3 for absolute HGFs (explanatory variable) by measuring overall growth (dependent variable) with a relative formula and vice versa for relative and OECD HGFs (absolute formula for dependent variable). We acknowledge that this is a thought experiment. In practice, there is no reason why future growth should be measured by a different formula than high-growth. According results in Table 6 however demonstrate a very remarkable point: If the dependent variable is measured in relative terms implying that actual size of firm exits is disregarded, absolute HGFs grow overall as well (12% annually in t+3 and 9% annually in t+6 indicated in column 11). On the contrary, if the dependent variable is measured in terms of absolute change, then overall growth by relative HGFs (-0.03 employees in t+3 and -16.14 in t+6) and OECD HGFs (-4.73 employees in t+3 and -15.67 in t+6) is negative. It therefore follows that high growth in employees persists when the size of firm exits is disregarded, while it does not persist when the actual number of job losses is accounted for – irrespective of the type of high-growth firm. Based on our underlying assumption that absolute changes in size including those by exiting firms are an important aspect for policy supporting high-growth, the main conclusion of this study is that high-growth firms decrease in their absolute number of employees after having achieved high-growth. This finding holds for absolute, relative and OECD HGFs. The decisive factor for their negative contribution is the large employment losses by exiting high-growth firms. These losses are only to be accounted for by the choice of an absolute growth formula.

Table 5. Regression results for decomposition of overall future growth in t+3 and t+6

Explanatory variable: HGF	Dependent variable: $g_{i,t+\tau}$	Time	HGFs					Non-HGFs					Differences					Observations	
			Surv rate (1a)	Surv growth (1b)	Exit rate (2a)	Exits growth (2b)	Overall growth (3)	Surv rate (4a)	Surv growth (4b)	Exit rate (5a)	Exits growth (5b)	Overall growth (6)	Surv rate (7)	Surv <sup>a</sup> growth (8)	Exit rate (9)	Exits growth (10)	Overall growth (11)	HGF	Non-HGF
calculated as	Formula																		
Absolute	absolute	$\tau=3$	0.77	14.99	0.23	-192.08	-33.62	0.68	-2.09	0.32	-4.61	-2.89	0.08	17.08	-0.08	-187.47	<b>-30.73</b>	1,390	138,884
Relative	relative	$\tau=3$	0.74	-0.09	0.26	-1	-0.33	0.68	-0.02	0.32	-1	-0.33	0.06	-0.07	-0.06	0	<b>0.01</b>	1,406	138,868
OECD	relative	$\tau=3$	0.80	0.02	0.20	-1	-0.18	0.68	-0.02	0.32	-1	-0.34	0.12	0.04	-0.12	0	<b>0.15</b>	3,727	136,548
Absolute	absolute	$\tau=6$	0.72	-57.53	0.28	-43.53	-53.59	0.58	-5.12	0.42	-1.97	-3.80	0.14	-52.41	-0.14	-41.56	<b>-49.78</b>	500	48,642
Relative	relative	$\tau=6$	0.81	-0.14	0.19	-1	-0.30	0.58	-0.06	0.42	-1	-0.45	0.23	-0.08	-0.23	0	<b>0.15</b>	508	48,634
OECD	relative	$\tau=6$	0.74	-0.09	0.26	-1	-0.33	0.58	-0.06	0.42	-1	-0.45	0.16	-0.03	-0.16	0	<b>0.13</b>	1,583	47,559

Absolute formula =  $S_{i,t+\tau} - S_{i,t+\tau-3}$  and relative formula =  $\left(\frac{S_{i,t+\tau}}{S_{i,t-3+\tau}}\right)^{\frac{1}{3}} - 1$ , where S indicates size measured in number of employees.

Notes: Reported are coefficients for HGF. *Surv rate* reports the conditional probability of survival based on eq. (5a), *Surv growth* the conditional growth for surviving firms based on eq. (6b), *Exit rate* the conditional probability of exit based on eq. (5b), *Exits growth* the conditional growth for exits based on eq. (6b). Overall growth for HGFs is calculated according to eq. (7a) and for non-HGFs according to eq. (7b). Differences in overall growth are based on eq. (8).

All values significant at  $p < 0.01$

<sup>a</sup> as in Table 4

Table 6. Regression results for decomposition of overall future growth in t+3 and t+6, different growth formulas for explanatory and dependent variable

Explanatory variable: HGF	Dependent variable: $g_{i,t+\tau}$	Time	HGFs					Non-HGFs					Differences					Observations	
			Surv rate (1a)	Surv growth (1b)	Exit rate (2a)	Exits growth (2b)	Overall growth (3)	Surv rate (4a)	Surv growth (4b)	Exit rate (5a)	Exits growth (5b)	Overall growth (6)	Surv rate (7)	Surv <sup>a</sup> growth (8)	Exit rate (9)	Exits growth (10)	Overall growth (11)	HGF	Non-HGF
calculated as	Formula																		
Absolute	relative	$\tau=3$	0.77	0.02	0.23	-1	-0.22	0.68	-0.02	0.32	-1	-0.33	0.08	0.04	-0.08	0	<b>0.12</b>	1,390	138,884
Relative	absolute	$\tau=3$	0.74	4.91	0.26	-24.99	-2.88	0.68	-1.93	0.32	-4.83	-2.85	0.06	6.84	-0.06	-20.16	<b>-0.03</b>	1,406	138,868
OECD	absolute	$\tau=3$	0.80	5.14	0.20	-60.20	-7.65	0.68	-2.12	0.32	-4.65	-2.93	0.12	7.26	-0.12	-55.56	<b>-4.73</b>	3,727	136,548
Absolute	relative	$\tau=6$	0.72	-0.11	0.28	-1	-0.36	0.58	-0.06	0.42	-1	-0.45	0.14	-0.06	-0.14	0	<b>0.09</b>	500	48,642
Relative	absolute	$\tau=6$	0.81	-19.85	0.19	-22.21	-20.30	0.58	-5.74	0.42	-1.97	-4.16	0.23	-14.11	-0.23	-20.24	<b>-16.14</b>	508	48,634
OECD	absolute	$\tau=6$	0.74	-21.64	0.26	-13.34	-19.48	0.58	-5.15	0.42	-1.96	-3.81	0.16	-16.49	-0.16	-11.38	<b>-15.67</b>	1,583	47,559

Notes see Table 5. All values significant at  $p < 0.01$

## 5.4 RESULTS FOR FURTHER PERFORMANCE INDICATORS

The analysis in this study so far focused on firm size in terms of employment, which is not necessarily correlated with other size indicators (Daunfeldt et al., 2014; Markman and Gartner, 2002; Shepherd and Wiklund, 2009). Entrepreneurs themselves are presumably more concerned with financial performance than growth in employees. It could consequently be the case that high-growth firms further expand in terms of other size indicators, even though they are not able to sustain growth in employees. It is the purpose of this sub-section to test for that possibility.

Our dataset contains information on the two additional performance indicators net revenue from sales and net profit after taxes. Compared to the number of employees, information on sales and profits is available to a very limited extent on average (14%). This share is larger for high-growth firms. Out of those high-growth firms used for our regressions in  $t+3$ , data on sales and profits is available for 46% of absolute HGFs, for 24% of relative and for 37% of OECD HGFs. The different shares reflect the fact that the availability of information on financials in our database increases with firm size as smaller firms are not obliged to file annual accounts.

Based on insights above, the dependent variable is measured by an absolute formula to account for exits and results are limited to  $t+3$ . As presented in Table 7, coefficients for each type of high-growth firm are significant at  $p < 0.1$ . Rates of survival are generally higher than those reported in Tables 5 and 6 due to the fact that firms with available information on sales and profits tend to be larger. Growth in sales for surviving non-HGFs is positive compared to negative growth in employees for the total sample of surviving non-HGFs, which seems also related to sample-selection of larger firms. Notwithstanding these differences, Table 7 very much confirms our previous findings for overall growth of high-growth firms compared to non-high-growth firms (column 11). We can therefore conclude that overall growth is not only negative in terms of employees, but also in terms of sales and profits when losses by exiting firms are accounted for.

Results for profits moreover allow testing the discussed Penrose-effect. It predicts that high-growth firms experience a decline in profitability compared to slower-growing firms, because managers focusing on expansion divert their attention from operating efficiency. This effect is confirmed for relative HGFs, where surviving firms are found to have negative profits compared to positive profits for surviving non-HGFs. Absolute and OECD HGFs on the hand have higher profits than slower-growing non-HGFs. Penrose (1959) does not explicitly refer to possible firm exits in her model. If the Penrose-effect is however understood as comprising the contribution by both survivors and exits, then our results for absolute overall growth largely support a decline in profitability after high-growth.

## 5.5 ROBUSTNESS CHECKS

We add two types of robustness checks for our findings. First, we examine whether main results for absolute overall growth in Tables 5 and 6 are robust across different industries, districts and legal forms. Results are reported in Table 8. As for descriptive statistics, industries are grouped into primary and secondary sector on the one hand and tertiary sector on the other hand. For each industry group separately (column 2 for primary and secondary sectors, column 3 for tertiary sector), we then estimate overall growth in  $t+3$ , which is close to results for our total sample (column 1). The difference in overall growth between absolute HGFs and non-HGFs for example amounts to -33.86 employees in the case of primary and secondary sector. For firms in the service sector the difference is -29.52 employees. The differences between sectors for growth of relative and OECD HGFs are small as well. Results are also similar, when firms are grouped from a geographical point of view into the economically less developed northern regions (column 4) and more developed southern regions (column 5). Additionally, we assess overall growth for different legal forms to proxy modes of growth as described above. Results in columns 6 and 7 accordingly show that sole proprietorships (proxying organic growth) among absolute HGFs decline more than limited liability or joint stock companies (proxying both organic and acquisitive growth). Although less pronounced, the latter ones however have negative growth as well. The same holds for relative and OECD HGFs.



Second, we re-estimate the decomposition of main results in  $t+3$  from Tables 5 and 6 for a sample including firms that newly appear in the dataset throughout the growth period used for defining high-growth firms (2001-2004 and 2004-2007, respectively). The included firms are not necessarily only genuine new entrants, because as noted before the coverage of firms in the database increases over time and we do not dispose of information on the year of foundation. Since relative growth cannot be calculated for a base year with size=0, firms newly appearing in the last year of each period are moreover not included. In accordance with relative growth, these firms are neither used for absolute growth, although the calculation of an absolute increase from size=0 would of course be possible. Results are presented in Table 9. It shows that the sample including entrants is more than twice as large as the one used for our main analysis. Entry rates reported by Eurostat<sup>24</sup> for Bulgaria amount to 11-15% annually from 2001-2007. Given that the sample in Table 9 increases over 3-years by more than 100%, this points to an important share of entrants due to increased coverage in the dataset. At the same time, exit rates are 6-7 percentage points lower for HGFs and 8 percentage points lower for non-HGFs. Losses in size by exits are generally lower as well. This in turn could be related to effects from genuine new entrants exhibiting a lower probability to exit immediately after entry and not having grown as large in case of exit. Overall, main results for absolute growth from tables 5 and 6 again remain largely unchanged. High-growth firms decline in the subsequent period when size of exits is taken into account.

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<sup>24</sup> <http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>

Table 7. Regression results for decomposition of absolute overall future growth in t+3, additional performance indicators

Explanatory variable: HGF	Dependent variable: $g_{i,t+3}$		HGFs					Non-HGFs					Differences					Observations	
	Formula	Indicator	Surv rate (1a)	Surv growth (1b)	Exit rate (2a)	Exits growth (2b)	Overall growth (3)	Surv rate (4a)	Surv growth (4b)	Exit rate (5a)	Exits growth (5b)	Overall growth (6)	Surv rate (7)	Surv growth (8)	Exit rate (9)	Exits growth (10)	Overall growth (11)	HGFs	Non-HGFs
Absolute	absolute	sales	0.88	3,279	0.12	-54,084	-3,627	0.86	361	0.14	-640	216	0.02	2,918	-0.02	-53,443	<b>-3,844</b>	639	19,662
Absolute	absolute	profits	0.88	134	0.12	-3,827	-332	0.86	5	0.14	-65	-5	0.03	129	-0.03	-3,762	<b>-327</b>	656	19,033
Relative	absolute	sales	0.89	1,046	0.11	-6,524	226	0.86	553	0.14	-1,172	218	0.04	493	-0.04	-5,352	<b>-77</b>	331	19,970
Relative	absolute	profits	0.89	-76	0.11	-605	-134	0.86	12	0.14	-102	-5	0.03	-88	-0.03	-502	<b>-130</b>	339	19,350
OECD	absolute	sales	0.89	1,794	0.11	-25,862	-1,116	0.85	352	0.15	-685	200	0.04	1,442	-0.04	-25,177	<b>-1,315</b>	1,398	18,903
OECD	absolute	profits	0.90	47	0.10	-1,901	-152	0.85	7	0.15	-68	-4	0.04	40	-0.04	-1,832	<b>-148</b>	1,394	18,295

Absolute formula =  $S_{i,t+3} - S_{i,t}$  where S indicates size measured as net revenue from sales or net profit after taxes. Sales and profits indicated in thousand EUR based on IMF exchange rates.

Notes see Table 5. All values significant at  $p < 0.1$

Table 8. Robustness check: Absolute overall future growth in t+3, disaggregated by industries, regions and legal forms

Explanatory variable: HGF	Total sample (Table 5 and 6) (1)	Primary and secondary industries (2)	Tertiary industries (3)	Northern regions (5)	Southern regions (4)	Sole proprietorships (6)	LLC, JSC (7)
Absolute	-30.73	-33.86	-29.52	-35.58	-26.89	-44.54	-16.00
Relative	-0.03	0.00	-0.05	-0.07	-0.01	-0.80	-0.01
OECD	-4.73	-5.46	-3.94	-8.84	-2.62	-13.97	-0.72
Observations	140,274	37,923	102,351	44,491	95,783	60,562	69,246

$G_{i,t+\tau} = E_{i,t+\tau} - E_{i,t+\tau-3}$  for absolute HGFs and  $\left(\frac{E_{i,t+\tau}}{E_{i,t+\tau-3}}\right)^{\frac{1}{3}} - 1$  for relative and OECD HGFs.

Note: Reported is difference between HGFs and non-HGFs in overall growth as defined in equation (8). Primary and secondary industries include firms in section A-F according to the NACE Rev. 1.1 classification system. Tertiary industries include firms in section G-O according to NACE Rev. 1.1. Statistical regions (NUTS Level 2) as defined by NSI Bulgaria. Additional legal forms not included.

All values significant at  $p < 0.01$

Table 9. Robustness check: Regression results for decomposition of absolute overall future growth in t+3, sample including entrants

Explanatory variable: HGF	HGFs					Non-HGFs					Differences					Observations	
	Surv rate (1a)	Surv growth (1b)	Exit rate (2a)	Exits growth (2b)	Overall growth (3)	Surv rate (4a)	Surv growth (4b)	Exit rate (5a)	Exits growth (5b)	Overall growth (6)	Surv rate (7)	Surv growth (8)	Exit rate (9)	Exits growth (10)	Overall growth (11)	HGF	Non-HGF
Absolute	0.86	4.21	0.14	-134.27	-15.40	0.76	-0.64	0.24	-3.41	-1.30	0.10	4.85	-0.10	-130.85	-14.09	2,972	295,830
Relative	0.81	2.7	0.19	-25.12	-2.60	0.76	-0.62	0.24	-3.57	-1.33	0.05	3.38	-0.05	-21.54	-1.27	2,983	295,819
OECD	0.86	3.05	0.14	-56.86	-5.31	0.76	-0.67	0.24	-3.46	-1.34	0.10	3.72	-0.10	-53.40	-3.97	7,042	291,760

For notes see Table 5. All values significant at  $p < 0.01$

## 6 CONCLUSION

In this study we investigated if sustainable high-growth depends on the choice of the formula used for measuring growth. We argued that the use of different growth formulas is not a mere academic matter of definitions, but has far-reaching practical implications: First, different growth formulas select high-growth firms of different firm size and are therefore important for anything related to size such as survival and growth. Second, growth formulas account differently for subsequent firm exits. While losses by exiting high-growth firms are fully taken into account by an absolute formula, actual size of exits is disregarded when a relative formula is used. The second implication is particularly relevant in the context of persistent high-growth where exiting firms have grown to considerable size over the high-growth period.

To our knowledge, this study is the first to provide empirical evidence for measuring persistent high-growth by an absolute formula. It is also the first systematic comparison of different growth formulas in this context – absolute, relative and composite. The main indicator for growth used in our analysis is the number of employees, but additional evidence is provided for growth in sales and profits.

Based on the underlying assumption that absolute changes in size are of high relevance, our findings offer an answer to the debate if high-growth is sustainable over time. High-growth did not persist – neither in the number of employees, nor sales or profits – when size of firm exits was taken into account. Subsequent losses by exiting high-growth firms outweighed further gains in size by survivors. Most notably, this finding did not only hold for the 1% fastest growers in absolute terms, but was also confirmed for the 1% fastest growers in terms of relative log growth as well as for high-growth firms defined according to Eurostat-OECD. Our results were moreover robust across different industries, regions, modes of growth and when entrants during each growth period were included.

Viewed through the lens of growth formulas, we moreover detected a clear pattern of previous findings on persistent high-growth, which had seemed to be inconclusive so far: If growth is measured as relative log differences, surviving firms decrease in size after the high-growth event. If it is measured according to Eurostat-OECD or other composite formulas similar to the one suggested by Birch, surviving high-growth firms continue to grow. Further support to that pattern was added by empirical evidence from this study.

This study additionally contributed to the external validity of previous findings in a different economic setting. While the existing evidence had exclusively drawn upon datasets from high-income countries, this study was based on firms from Bulgaria, a middle-income transition country in Eastern Europe. We proposed reasons why findings might differ related to changes in the firm environment introduced by the transition process. With respect to high-growth, similarities however seemed to prevail and findings throughout this study closely compared to high-income contexts.

Our results relate to theories on firm growth in the following way: The predicted positive relationship of size and rate of survival in the model by Jovanovic (1982) is largely confirmed by our findings. The negative association of size and growth is partially supported. Coefficients for size in growth regressions are as predicted. Unconditional transition probabilities for t+6 further confirm that initially smaller relative HGFs grow stronger than larger OECD and absolute HGFs. Transition probabilities for growth in t+3 are however very similar for all three types of high-growth firms. The Penrose-effect (Penrose (1959), which suggests that high-growth firms experience lower levels of profitability than non-high growth firms, is supported by our results for overall growth including exits as well as by findings for surviving relative HGFs. Absolute and OECD HGFs however have higher profits following high-growth than slower-growing firms. Theories predicting random (Gibrat, 1931) or positive autocorrelation of growth (Barney, 1991; Peteraf, 1993; Greiner, 1972) would be rejected on the basis of our results.

While we believe our study and its empirical results provide important insights into the question of persistent high-growth, our findings are subject to a number of limitations, which in turn open avenues for further research. A first set of limitations concerns the control variables available in our dataset and

their explanatory power for the identified pattern that relative high-growth firms decline after high-growth whereas absolute and OECD high growth firms continue to grow. We conjectured that additional unobserved variables affect growth which are related to size, but not captured by size and other controls used in this study. One such variable might be firm age, which could only be indirectly measured. Since all of the previous studies examining persistent high-growth in terms of relative log growth did not control for actual age either, this opens an important area for future research. Using a dataset with detailed information on firm age including a representative coverage of young firms could not only add to empirical evidence, but possibly also contribute to theory development for high-growth firms similar to what Coad et al. (2018) recently provided for growth in general. Another promising area for further investigation in this vein could be controlling for characteristics which are more directly derived from the management literature such as firm strategies (for a similar suggestion see Bianchini et al., 2017; Moschella et al., 2018). A first important contribution to this field has been made by Parker et al. (2010) showing how particular strategies (e. g. not issuing shares to employees) positively affect growth of previous high-growth firms. Senderovitz et al. (2016) moreover examined how niche versus broad market strategies moderate future profitability of high-growth firms. Additional research in this area could study further strategies related to corporate finance or investigate entrepreneurial motivations of high-growth firms' owners and managers.

A second set of limitations concerns our methodological choices for measuring growth. We examined three different growth formulas, used employees, sales and profits as indicators of growth, measured growth over 3-year periods and mainly focused on total growth. A number of further analyses could be envisaged to test our findings for alternative choices. Building on first evidence by Daunfeldt et al. (2014) and Du and Temouri (2015), investigating growth in productivity seems particularly relevant, since it ultimately determines economic growth and hence prosperity of a country. An analysis of future productivity would moreover allow for further testing the Penrose-effect supported by our findings for overall growth in profitability.

Third, we had to remain mute regarding any spillover effects by high-growth firms. Even though high-growth has been shown not to persist, high-growth firms might still positively contribute to an economy beyond their direct impact. They might for example act as role models for other potential entrepreneurs and therefore positively affect regional employment growth of all firms in the long run (Van Praag and Versloot, 2007). They possibly also induce aggregate productivity growth and innovation (Colombelli et al., 2013). Such beneficial effects might be reflected in survival rates and growth of non-high-growth firms in our analysis, but cannot be singled out. A quantification of potential spillover effects could therefore to some extent alleviate our finding that high-growth does not persist.

We conclude with policy implications of our findings. They are evident and have gravity. High-growth policy initiatives are typically motivated by the contribution of high-growth firms to employment. This contribution is negative after high-growth regarding what is of arguably large relevance to policymakers - absolute changes in headcount. It is also negative with respect to absolute changes in sales and profits which should be additional important aspects of high growth from a fiscal policy perspective. This implication gains further strength, because we found negative absolute future performance irrespective of how high-growth firms were defined. One could argue that a definition of high-growth firms according to an absolute formula might typically not be favored, because policy tends to focus on support of small firms. The measure by Eurostat-OECD has therefore been widely used in the policy context. However, both high-growth firms in absolute terms as well as those according to Eurostat-OECD (or log differences) decline when size of subsequent exits is taken into account. The long-run effectiveness of high-growth policies in general is therefore largely put at question by our results. At the same time, we want to add that our focus was on the full set of high-growth firms. Initiatives able to specifically target the sub-set of high-growth firms which does manage to further grow are of course exempt from our pessimistic view. Evidence for Finland has shown that such initiatives indeed exist (Autio and Rannikko, 2016). Further policy evaluations along with a better understanding of relevant firm characteristics that lead to persistent high-growth are expected to provide more guidance on how to pick winners.

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## APPENDIX

**Table A1** Comparison of firms reported in Amadeus and NSI (National Statistical Institute), start and end year of growth periods

	2001		2004		2007		2010	
	NSI <sup>a</sup>	Amadeus <sup>b</sup>	NSI	Amadeus	NSI <sup>a</sup>	Amadeus	NSI	Amadeus
Number of firms	230,959	71,764	240,408	113,251	257,987	256,870	366,929	362,075
Firm size class								
Micro (1-9 employees)	91.8	75.8	90.2	81.1	89.0	88.9	91.9	91.1
Small (10-49 employees)	6.5	18.4	8.0	15.1	8.9	9.0	6.6	7.1
Medium (50-249 employees)	1.4	4.8	1.5	3.2	1.8	1.8	1.3	1.6
Large (>249 employees)	0.3	0.9	0.3	0.6	0.3	0.3	0.2	0.2

<sup>a</sup> Data for NSI corresponds to year 2002. Additional industries reported since 2008 leading to increased number of firms.

<sup>b</sup> Number of firms and firm size classes corresponds with industries reported by NSI

**Table A2a** Transition probabilities for growth brackets from t to t+6, absolute HGFs

	$g_{i,t+3}^{(0)}$ exit	$g_{i,t+3}^{(1)}$ negative growth	$g_{i,t+3}^{(2)}$ zero growth	$g_{i,t+3}^{(3)}$ positive growth	$g_{i,t+3}^{(4)}$ HGF (absolute)
$g_{i,t}^{(1)}$	0.438	0.298	0.115	0.141	0.008
$g_{i,t}^{(2)}$	0.627	0.116	0.169	0.087	0.002
$g_{i,t}^{(3)}$	0.315	0.396	0.083	0.189	0.018
$g_{i,t}^{(4)}$ = HGF (absolute)	<b>0.098</b>	<b>0.697</b>	<b>0.010</b>	<b>0.052</b>	<b>0.142</b>

**Table A2b** Transition probabilities for growth brackets from t to t+6, relative HGFs

	$g_{i,t+3}^{(0)}$ exit	$g_{i,t+3}^{(1)}$ negative growth	$g_{i,t+3}^{(2)}$ zero growth	$g_{i,t+3}^{(3)}$ positive growth	$g_{i,t+3}^{(4)}$ HGF (relative)
$g_{i,t}^{(1)}$	0.438	0.298	0.115	0.147	0.003
$g_{i,t}^{(2)}$	0.627	0.116	0.169	0.087	0.002
$g_{i,t}^{(3)}$	0.312	0.400	0.082	0.204	0.002
$g_{i,t}^{(4)}$ = HGF (relative)	<b>0.202</b>	<b>0.540</b>	<b>0.026</b>	<b>0.224</b>	<b>0.008</b>

**Table A2c** Transition probabilities for growth brackets from t to t+6, OECD HGFs

	$g_{i,t+3}^{(0)}$ exit	$g_{i,t+3}^{(1)}$ negative growth	$g_{i,t+3}^{(2)}$ zero growth	$g_{i,t+3}^{(3)}$ positive growth	$g_{i,t+3}^{(4)}$ HGF (OECD)
$g_{i,t}^{(1)}$	0.438	0.298	0.115	0.143	0.006
$g_{i,t}^{(2)}$	0.627	0.116	0.169	0.086	0.003
$g_{i,t}^{(3)}$	0.324	0.386	0.082	0.192	0.014
$g_{i,t}^{(4)}$ = HGF (OECD)	<b>0.127</b>	<b>0.622</b>	<b>0.028</b>	<b>0.199</b>	<b>0.024</b>

**Notes:** Transition probabilities are calculated using frequencies. Growth brackets are defined based on annualized percentage change as follows:  $g_{i,t+\tau}^{(0)} = -1$  (exit),  $-1 < g_{i,t+\tau}^{(1)} < 0$  (negative growth),  $g_{i,t+\tau}^{(2)} = 0$  (zero growth),  $g_{i,t+\tau}^{(3)} > 0$  (positive growth), and  $g_{i,t+\tau}^{(4)} = \text{HGF}$ . The definition of growth brackets based on absolute growth or log-differences does not alter results.



**Table A3** Regression results for probability of survival

<i>Explanatory variable</i>	T=3			T=6		
	Absolute HGFs (1)	Relative HGFs (2)	OECD HGFs (3)	Absolute HGFs (7)	Relative HGFs (8)	OECD HGFs (9)
HGF	0.084*** (0.016)	0.058*** (0.011)	0.125*** (0.004)	0.136*** (0.026)	0.230*** (0.016)	0.160*** (0.013)
<i>Control variables</i>						
Firm size dummy (Reference category: 25-49 employees)						
1-4	-0.243*** (0.005)	-0.248*** (0.005)	-0.238*** (0.005)	-0.294*** (0.009)	-0.306*** (0.008)	-0.287*** (0.009)
5-9	-0.108*** (0.005)	-0.112*** (0.005)	-0.104*** (0.005)	-0.147*** (0.009)	-0.155*** (0.009)	-0.144*** (0.009)
10-14	-0.063*** (0.006)	-0.066*** (0.006)	-0.070*** (0.006)	-0.100*** (0.011)	-0.104*** (0.010)	-0.111*** (0.011)
15-19	-0.029*** (0.007)	-0.030*** (0.007)	-0.032*** (0.007)	-0.049*** (0.012)	-0.051*** (0.012)	-0.056*** (0.012)
20-24	-0.015* (0.008)	-0.016** (0.008)	-0.017** (0.008)	-0.034** (0.014)	-0.038*** (0.014)	-0.040*** (0.014)
50-99	0.025*** (0.007)	0.026*** (0.007)	0.027*** (0.007)	0.020 (0.012)	0.021* (0.012)	0.023** (0.013)
100-249	0.045*** (0.008)	0.048*** (0.007)	0.051*** (0.008)	0.078*** (0.012)	0.080*** (0.012)	0.085*** (0.012)
250-499	0.055*** (0.013)	0.061*** (0.012)	0.064*** (0.013)	0.071*** (0.023)	0.078*** 0.022	0.084*** (0.022)
500-1000	0.083*** (0.015)	0.084*** (0.014)	0.088*** (0.014)	0.095*** (0.029)	0.101*** (0.026)	0.107*** (0.027)
Age	-0.063*** (0.001)	-0.063*** 0.001	-0.063*** (0.001)	no	no	no
Industry code	yes	yes	yes	yes	yes	yes
Industry size	0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.001)	0.002*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Industry growth	0.003*** (0.001)	0.716*** (0.026)	0.709*** (0.026)	0.004*** (0.001)	0.954*** (0.044)	0.938*** (0.044)
District	yes	yes	yes	yes	yes	yes
Legal	yes	yes	yes	yes	yes	yes
Constant	0.682*** (0.001)	0.682*** (0.001)	0.682*** (0.001)	0.583*** (0.002)	0.583*** (0.002)	0.583*** (0.002)
Observations	140,274	140,274	140,274	49,134	49,134	49,134
Pseudo R <sup>2</sup>	0.114	0.118	0.119	0.134	0.146	0.146

Dependent variable: Conditional probability of survival based on eq. (5a). It equals 1 for firms which survive until  $t+r$ , and zero in case of firm exit.

*Note:* Average marginal effects presented. HGF and industry growth measured from  $t-3$  to  $t$ , all other variables measured at  $t-3$ . Robust standard errors in parentheses. For growth in  $t+6$ , the indirect measure of age cannot be included as control, because surviving firms are of identical age.

\*\*\* $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$