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High-growth, innovative enterprises in Europe

Counting them across countries and sectors

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Abstract

High-growth, innovative enterprises are a key source of business dynamics, but little is known about their actual share in the enterprise population. This is due to an inherent uncertainty in how to define the threshold that distinguishes high-growth firms from non-high-growth firms – illustrated by the lack of agreement between the definitions applied by Eurostat and the OECD. This explorative study aims to help measure the share of high-growth, innovative enterprises in the European enterprise population, test how the choice of definition affects their share. We introduce a methodology to address the uncertainty in the definition, and compute national and sectoral average scores for high-growth and innovation in order to assess their distribution across countries and sectors of economic activity. We test the impact of a number of alternative definitions on a pooled sample of 92,960 European firms observed by the 2012 wave of the Community Innovation Survey (CIS). Our finding suggests that the share of high-growth, innovative enterprises in Europe may range between 0.1 to 10%, depending on the definitions, and the outcomes are most sensitive to the growth measure (employment- or turnover-based) and threshold (absolute or relative), as well as the degree of novelty expected of the innovations introduced by firms. With the help of aggregate measures, we observe a trade-off between high-growth and innovation performance at the country-level, which disappears at the overall European sectoral level. This observation highlights the importance of structural differences across EU Member States in terms of firms' innovation profile, size and associated high-growth performance.

Keywords: high-growth, innovative enterprises, indicators, uncertainty, innovation, business dynamics, entrepreneurship, firm growth

1 Introduction

High-growth, innovative enterprises are seen as particularly important elements of the business economy, which account for a disproportionate share in new job creation. While an increasing number of studies are analysing high-growth, innovative enterprises (HGIEs), very little is known about their share in the European firm population.[1] This is not surprising, because it is very difficult to measure what is difficult to define, and there is a lack of convergence to a clear definition that distinguishes high growth from low growth, innovative firms. The use of different definitions of growth limits the generalizability of findings on high-growth (see Daunfeldt et al., 2014; Hölzl and Janger, 2014). Despite the fact that most studies on the topic acknowledge definitions as a source of sensitivity, there is little empirical evidence on what proportion of firms is affected by changing certain thresholds of growth or innovativeness.

A main issue to address is the uncertainty in the application of thresholds. For a firm to qualify as a high-growth one, should it double its size, or perform at least 10 or 20% growth over a given period? For how long should a firm demonstrate strong growth to be considered as high growth? What makes a firm innovative? Can a firm that introduced a product it had not produced or sold before be considered as innovative, or is it a necessary condition for innovativeness that this product is new to the market? We argue that answers to these questions are far from obvious, and need to be carefully addressed especially when HGIEs are policy targets. Obviously, a higher growth threshold flags a significantly smaller set of companies as HGIEs, but it is unclear what the actual difference is.

While there is no single, official definition of "high-growth, innovative firms", the scale of their presence is considered to be an important measure of business dynamics in a country. The 2016 editions of the European Innovation Scoreboard (EIS) and the Innovation Output Indicator (IOI) of the European Commission both have benchmarked countries in terms of "employment dynamism of high-growth enterprises in innovative sectors". The main consideration for such an indicator is that high-growth firms generate a disproportionate amount of new jobs as well as other measures of economic growth (see i.e. Schreyer, 2000; Daunfeldt et al, 2014), and their concentration in the most innovative sectors drives structural change and fosters competitiveness. The indicators used in the EIS and IOI are derived from sectoral-level calculations. However, in order to measure business dynamics associated with HGIEs in a more precise way, one would ideally need to measure both growth as well as innovation for the same firm. The availability of such firm-level micro data for multiple countries would significantly improve our understanding of the HGIEs and support policy making.

The main purpose of this explorative study is to help better measure the share of high-growth, innovative enterprises in the European enterprise population, test how the choice of definition affect their share. Following a review of relevant literature on the definition and measurement of high-growth and innovation, we introduce a methodology to assess the scale of their co-occurrence across countries and sectors of economic activity. We test the impact of a number of alternative definitions on a sample of 92,960 firms observed by the 2012 wave of the Community Innovation Survey (CIS).

The novelty of this study is three-fold. First, it estimates the share of HGIEs in Europe for the first time using firm-level data from 20 European countries. Second, that rather than providing a single estimate, the study introduces a high-growth and innovation matrix, which addresses the uncertainties in the definition of HGIEs and offers a direct comparison of alternative definitions. Third, the study provides evidence on negative correlation between high-growth and innovation performance of firms observed at the country-level, which is not found at the sectoral level for the pooled European sample.

[1] In this study, we use the term firm and enterprise interchangeably.

2 Theoretical considerations

Employment creation and the induction of structural change are among the top key priorities of EU policy makers in the aftermath of the global financial crisis in de facto stagnating advanced economies. In this context, HGIEs play a central role, and especially a small group of them is able to generate a large share of new employment as well as positive externalities through demand and demonstration effects. At a time when Europe's knowledge- and technology-intensity gap vis-à-vis countries such as the US or South Korea widens, high-growth innovative firms have a central role to play to ensure productivity growth and sustained competitiveness through structural change towards a more knowledge-intensive European economy.

It is therefore not surprising that high-growth, innovative firms have captured a synchronized interest at the policy and academic levels (Audretsch, 2012; Capasso et al., 2015; Coad et al., 2014b; European Commission, 2015, 2013; Henrekson and Johansson, 2010a; OECD, 2012). Nevertheless, empirical evidence on the nature and drivers of high growth innovative firms is quite scanty, and often focus on single countries or certain sectors of the economy. Given the data demand, only a few of such studies can take a more in-depth view on the innovation process. There are a few single-country studies investigating the barriers to innovation and growth, and only very few of them offer cross-country comparisons (Hessels and Parker, 2013; Hölzl and Janger, 2013). Thus, evidence on innovative high growth at a multi-country, multi-sector scale is certainly needed for a better understanding of the phenomena and to support policy making in Europe.

There is controversial evidence showing that small firms generate more jobs than large ones in US (Birch, 1979; Birch and Medoff, 1994); that there is no association between firm size and job creation (Davis et al., 1996); especially when controlling for age (Haltiwanger et al., 2013). Nevertheless, several scholars find that most small firms have a low or zero growth rate and that a few high-growth firms are key for increasing jobs (Acs et al., 2008; Acs and Mueller, 2008; Birch and Medoff, 1994; Brüderl and Preisendörfer, 2000; Davidsson and Henrekson, 2000; Fredrick Delmar et al., 2003; Halabisky et al., 2006; Littunen and Tohmo, 2003).

A synthesis of the most recent literature points to a list of seven stylized facts to consider when studying high-growth firms (Coad et al., 2014b; Moreno and Coad, 2015):

1. Growth rates distributions are heavy-tailed
2. Small number of high-growth firms create a large share of new jobs
3. High-growth firms tend to be young but are not necessarily small
4. High-growth firms are not more common in high-tech industries
5. High growth is not to be persistent over time
6. Difficult to predict which firms are going to grow
7. The use of different growth indicators selects a different set of firms.

This report focuses on the 7th stylized fact listed above.

2.1 Defining and measuring high-growth

The term "high-growth enterprise" is used in official statistics, but a lack of global agreement on their definition is a potential source of confusion. Eurostat defines high-growth enterprises as those with at least 10 employees in the beginning of their growth and having average annualised growth in number of employees greater than 10% per annum, over a three-year period.[2] The OECD applies a stricter definition with a 20% threshold (and considers enterprises with the average annualised growth mentioned above between 10 and 20% as medium growth), but measures growth both by the

[2] Commission implementing regulation (EU) No 439/2014 [http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:JOL_2014_128_R_0013&from=EN]

number of employees as well as by turnover.[3] The purpose of the size threshold of 10 employees is to reduce statistical noise (i.e., to avoid classifying a small enterprise growing from 1 to 2 employees over three years). Official statistics are produced accordingly at the level of sectors or the business economy. This leads to three main issues. Firstly, the use of two rather different definitions limits international comparability, i.e. the performance of the US with that of the EU. Second, as a result of the absolute growth thresholds, the three-year observation window and the publication of aggregate statistics, a changing pool of firms are captured in each year's statistics, making inter-temporal comparisons difficult to interpret. For instance, a company that achieved a 40% growth rate in the first year, but 0% in three subsequent years qualifies as a high-growth enterprise according to the Eurostat definition over the 3 years, but would not qualify if the observation period starts in the 2nd and ends at the 4th year. Hence, it is part of the pool of firms for which aggregate sectoral or country-wide data is produced in the third year, but is outside the pool of firms in the same sector or country in the fourth year. Third, aggregate figures in business demography statistics may be useful to characterize sectors or entire economies on the occurrence of high-growth firms. However, aggregate figures offer limited information on high-growth *and innovative* firms, since innovation cannot be measured at the level of firms for the same firms. In sum, these limitations of official statistics imply that exploring the occurrence and characteristics of high-growth, innovative firms requires other, firm-level data sources.

In the burgeoning literature on HGIEs, there is a lack of convergence to a single definition of what distinguishes high growth from low growth, innovative from non-innovative firms. It is therefore not surprising that a common conclusion of the various studies is that definition matters for the outcomes of interest. While it would be tempting to select, based on the above conclusions, a definition for HGIEs that best fits the model and gives the most intuitive results, the policy relevance of any such study would be severely limited or outright biased, as models would be run on a qualitatively different set of firms depending on the identification method (Daunfeldt et al., 2014).

As economic outcomes are highly sensitive to the definition of firm growth (Coad et al., 2014a), it is important to address the issue of defining firm growth, and identifying high-growth firms. Following the four points proposed by Delmar (1997) and Delmar *et al* (2003) as well as Coad et al (2014a), we can conclude that there is need for methodological prudence when it comes to measuring firm growth the following parameters of any potential definition:

1. the indicator of growth;
2. the calculation of the growth measure;
3. the period analysed;
4. the process of growth
5. the selection of the growth threshold

Regarding the *indicator* of growth, sales (or turnover) and number of employees are the most commonly used in the literature. Authors have measured firm growth using multiple indicators, indicators on performance or market shares (in some cases, even subjective, perception-based measures), or assets. Different indicators may be more pertinent to capture different phases in the development of a firm – and also, different dynamics. For instance, sales growth typically precedes employment growth in a firm, but not necessarily. In fact, the dynamic sequence has been shown to be the reverse in certain cases where a firm decided to outsource certain activities (Delmar, 2006).

Second, the choice of using an absolute or relative *measure of growth* produces significant differences, especially when considering the firm size. Smaller firms are more easily appearing as HGEs if growth is defined using a relative rate rather than an absolute measure. Hybrid growth indicators make use of both absolute and relative

[3] See the Eurostat – OECD Manual on Business Demography Statistics, 2007.

employment growth, such as the Birch index (defined as $(E_t - E_{t-k})*E_t/E_{t-k}$, where E_t notes employment at time t) that is less biased towards small firms and lowers the impact of firm size on the growth indicator (Hölzl, 2009; Schreyer, 2000).

Third, the length of the *period* for which the growth measure is computed is intrinsically linked to the research problem addressed. While the choice of a longer period flattens the statistical noise (Henrekson and Johansson, 2010b), it may hide high growth spurts experienced over a shorter period (Daunfeldt et al., 2014; Hölzl, 2014). At the same time, the selection of the observation period is also conditioned by the availability of time-series data.

Fourth, there is a variation in the *processes* by which firm growth occurs. Typically, acquired (or external) growth – growth resulting from acquisitions or mergers – is distinguished from organic (or internal) growth. McKelvie and Wiklund (2010) argue that one should also take into consideration that over time, a firm may choose between the two processes of growth resulting in hybrid modes.

A final issue is the identification of a *growth threshold*, which aims at distinguishing high-growth and non-high-growth firms (including the rest of the population, or only those growing). Coad et al (2014a) distinguish two methods to identify HGEs. First, identify HGEs as the share of firms in a population that see the highest growth during a particular period (the top N % of the distribution – for instance, the 1% or 5% of firms with the highest growth rate). The other method is to define HGEs as firms growing at or above a particular pace or threshold. The advantage of the former method is that it is non-parametric, based on an observed distribution, however, the disadvantage is the lack of comparability across time or across countries. Furthermore, it is very likely that smaller firms will be overrepresented among the share of firms with the highest growth performance. This could be overcome by grouping the firms into size classes before selecting the top N% from each class. A certain degree of arbitrariness nevertheless remains regarding the cut-off threshold (i.e. what justifies the selection of the top 1, 5, 10 or 20% of firms?), which is why it is important to have more empirical findings available across time, countries and sectors. As for the second method – define HGEs as those with a growth rate above a fixed absolute threshold – is that while the growth distribution of firms may change across time and space, a fixed threshold offers clearer comparisons. However, this is its major shortcoming (alongside the arbitrariness of establishing thresholds on the continuous scale of growth): restrictively defined thresholds may select very few observations in certain cases, which may reduce the reliability of obtained statistics.

2.2 Defining and measuring innovativeness at the firm level

Defining what makes firms innovative is no less challenging than defining what makes them high-growth. We address the main consideration in this sub-section with an interest in finding an inclusive definition of innovation for high-growth firms. In this study, we are less interested in why firms innovate, rather, how they do it and how to measure it.

Innovation covers a wide set of activities that involve bringing new ideas to the market, and may refer to products, processes or other activities firms perform. Based on the work of Schumpeter, the 3rd edition of the OECD-Eurostat Oslo Manual (2005) proposes the following four types of innovation:

1. *Product innovation:* A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics;

2. *Process innovation:* A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software;
3. *Marketing innovation:* A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing;
4. *Organisational innovation:* A new organisational method in business practices, workplace organisation or external relations.

Following the Oslo Manual, the minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new or significantly improved to the firm. This includes products, processes and methods that firms are the first to develop and also those that have been adopted from other firms or organisations. OECD and Eurostat distinguish "innovation active" from "non-innovative" enterprises. An enterprise, in this definition is innovation active if it successfully introduced any kind of innovation in the past three years, or have ongoing or abandoned activities.[4]

Scholars intending to measure innovation usually rely on hard data (such as research and development (R&D) spending; R&D intensity; patents; product announcements, etc.), or survey data. Both types involve a set of limitations: R&D is a measure of input, but not output, though R&D intensity (R&D expenditure/ sales) is a combined input and output index; patents measure inventions and thus may be seen as both, input and output according to how they feed into the innovation process; they are not necessarily comparable to measure the inventiveness in all the industries, such as in the services sectors, or for small firms. Survey data, such as CIS may present limitations, nevertheless it allows comparisons across industries and countries (Coad and Rao, 2008; Gault, 2013).

The scope of possible definitions is closely linked to the nature of data. Innovation surveys, particularly the CIS, combine quantitative and qualitative data on firms' innovation activities including the types of innovation (e.g. product, process, marketing, organization innovation, etc.), their degree of novelty, as well as the importance of new of significantly improved products to a firm's turnover (Cucculelli and Ermini, 2012; Mairesse and Mohnen, 2010). CIS survey results have triggered a rich economic literature over the past two decades. The many papers that used CIS data have opted for a variety of ways to define innovative firms. Pellegrino and Savona (2013) considered firms to be 'innovative' if they have introduced or developed a new product or process or had been in the process of doing so during the surveyed period'. Others built composite innovation indicators from quantitative and/or qualitative data in the CIS in order to measure the innovation intensity (Coad and Rao, 2008; Mohnen and Dagenais, 2000) or to distinguish R&D innovators from non-R&D innovators (Hervas-Oliver et al., 2008; Hölzl and Janger, 2013).

[4] See i.e. Eurostat Reference metadata to the Results of the community innovation survey 2012 (CIS2012) (inn_cis8) [http://ec.europa.eu/eurostat/cache/metadata/en/inn_cis8_esms.htm]

3 Methodology: the growth and innovation matrix

Rather than making any *a priori* selection of a HGIE definition, in our study we aim to be as open and comprehensive as possible by developing a methodology accommodating multiple definitions for high-growth as well as innovativeness. This follows from the conclusion that the definition of firm growth has a significant impact on outcomes (Coad et al, 2014).

The uncertainty in establishing growth thresholds is highly visible in the parallel system of definitions used by Eurostat and the OECD. The OECD-Eurostat Entrepreneurship Indicators Programme (EIP) definition uses the 20% definitions both in terms of sales and employment, while Eurostat elsewhere uses a 10% employment growth threshold (both consider annual average growth over a 3-year time frame, for firms above 10 employees). In the context of innovativeness, as seem above, there is at least in the academic literature uncertainty as to what constitutes innovativeness. Neglecting the existence of valid arguments in support of a broad range of alternative classification (or, in other words, the "fuzzines" of definitions) would easily lead to mismeasurement of the scale of HGIEs. *The HGIE matrix we propose acknowledges the viability of different definitions of both 'high-growth' (applying different thresholds) and degrees of innovativeness (applying different definitions of innovation) and considers all of these simultaneously.*

Based on the literature and information available in the CIS 2012 dataset, we propose a set of alternative (potentially overlapping, not mutually exclusive) definitions for high-growth (hg_1 to hg_I) and for innovativeness (inn_1 to inn_J). If we consider all of these definitions valid, their combination will be valid as well. The combination of the HG and Inn definition results in a HGI definition matrix.

Figure 1 The high-growth and innovation (HGI) definition matrix

$$\begin{array}{c} \\ hg_1 \\ \dots \\ hg_I \end{array} \begin{array}{c} \begin{array}{ccc} inn_1 & \dots & inn_J \end{array} \\ \begin{bmatrix} HGI_{1,1} & \cdots & HGI_{1,J} \\ \vdots & \ddots & \vdots \\ HGI_{I,1} & \cdots & HGI_{I,J} \end{bmatrix} \end{array}$$

For each firm in the CIS dataset (k=1 to K), we assess whether it meets or not the different high-growth and innovation criterion, and attribute a score of 1 if so, and 0 otherwise. We test 30 definitions of high-growth (I=30) and 50 definitions for innovation (J=50) which will be further elaborated in sections 3.2 and 3.3 respectively.[5] By summing these values for each firm (that is, the number of times it meets the combined high-growth and innovative criteria), we obtain a $HGI_k(i,j)$ score for the k-th firm. This score can range from 0 to IxJ. Firms with a score of 0 – we expect that this will characterize the majority of firms – fail to meet any of the combined high-growth and innovative criterion. A score equal to IxJ means that a firm meets all potential high-growth criteria and can be safely assumed to be a high-growth, innovative firm. The higher the value the more frequently the enterprise is labelled as high-growth and innovative, implying that more robust conclusions can be drawn in subsequent firm-level studies on the various factors behind HGI. Firms with low scores are particularly sensitive to the HGI definition.

Summing up the $HGI_{i,j}$ scores (i.e., for the entire economy or for a given sector) shows the total number of firms that meet a given definition combination. This allows to compare how restrictive or broad various definition combinations are, and understand the impact of changing certain thresholds.

[5] For instance - anticipating the specific definitions introduced later in this report –, the Eurostat 10% employment growth definition combined with the introduction of any type of innovation refers to cell (i, j)=(3, 6).

The main advantages of this approach are its ability to accommodate the overlapping definitions of high-growth and innovativeness, in a non-arbitrary way, as well as its relatively low computation demands. Furthermore, although one could say that a few combinations of high-growth & innovativeness may be more frequently used in the literature than others, our method considers each combination of equal importance.[6] While the scores may be influenced by the set of high-growth and innovation definitions used, the methodology is sufficiently flexible to accommodate any newly proposed definitions.

3.1 Preparing the dataset

We decided to use the firm level microdata from the most recent, 2012 wave of the CIS for our analysis for two main reasons. First, because it contains information on growth (employment and turnover growth) and innovation performance (innovation types introduced, novelty of innovations, etc.) of manufacturing and service sector firms. Although only accessible at the Eurostat Safe Centre in Luxembourg, the harmonized dataset offers a cross-European comparison. The main shortcoming of this CIS data is that the observation of firm growth is limited to a 2-year window, thus it is not possible to analyse longer growth trajectories.

The CIS 2012 data used for the high-growth, innovativeness matrix was prepared according to the following steps. First, firms with missing employment or turnover data for any of the two years were removed in order to be able to measure growth. As a result, 4,722 firms, including all Finnish firms (for which no values were reported for the variables of 2010) were excluded from the initial sample of 148,153. In a second step, we removed firms undergoing non-organic growth (mergers or acquisitions), affecting a further 8,468 companies. We next removed micro firms (applying an upper threshold of 10 employees and 1 million Euros turnover in any of the two years observed), in order to avoid observing high growth fluctuation due to the very small scale. This step affected 41,149 firms.[7] In a final step, we trimmed what we considered outlier growth performance in terms of employment as well turnover change, that is, the top 0.5 percentile.[8] We considered it necessary to purge spurious variation in the growth variables of interest. This affected a further 854 firms. After the cleaning process, our final sample consisted of 92,960 observations from 19 EU Member States as well as Norway. These represent about 450,000 European firms, when applying the sampling and – where available – the non-response weights, see Table 1. About half of the observations are from Spain, France and Italy (see unweighted sample, left side of Table 1); while about 47% of sampled companies are located from Italy and Germany, and a further 32% in Spain and France (see weighted sample, right side of Table 1).

About 50% (or 76%) of the firms are small firms, 33% (or 20%) medium-sized, and 13% (4%) large (applying weighted measure).[9]

[6] A future extension could also attribute weights to the various proposed options.
[7] We noted that in case we used a more restrictive 2 million euro turnover threshold, our sample would have been reduced by an additional 21,030 firms.
[8] The thresholds applied were 1.8 and 3.33 for the employment and turnover change ratios, respectively. This is in accordance with the literature to ensure that clerical or measurement errors do not influence results. Since the study focuses on the top of the distribution, we implement a cautious approach and only trip the top 0.5 percentile.
[9] We defined size classes by employment levels reported for 2010 – 10-50 employees: small, 50-250: medium, and above 250: large.

Table 1 Number of firms in the unweighted and weighted sample by size class

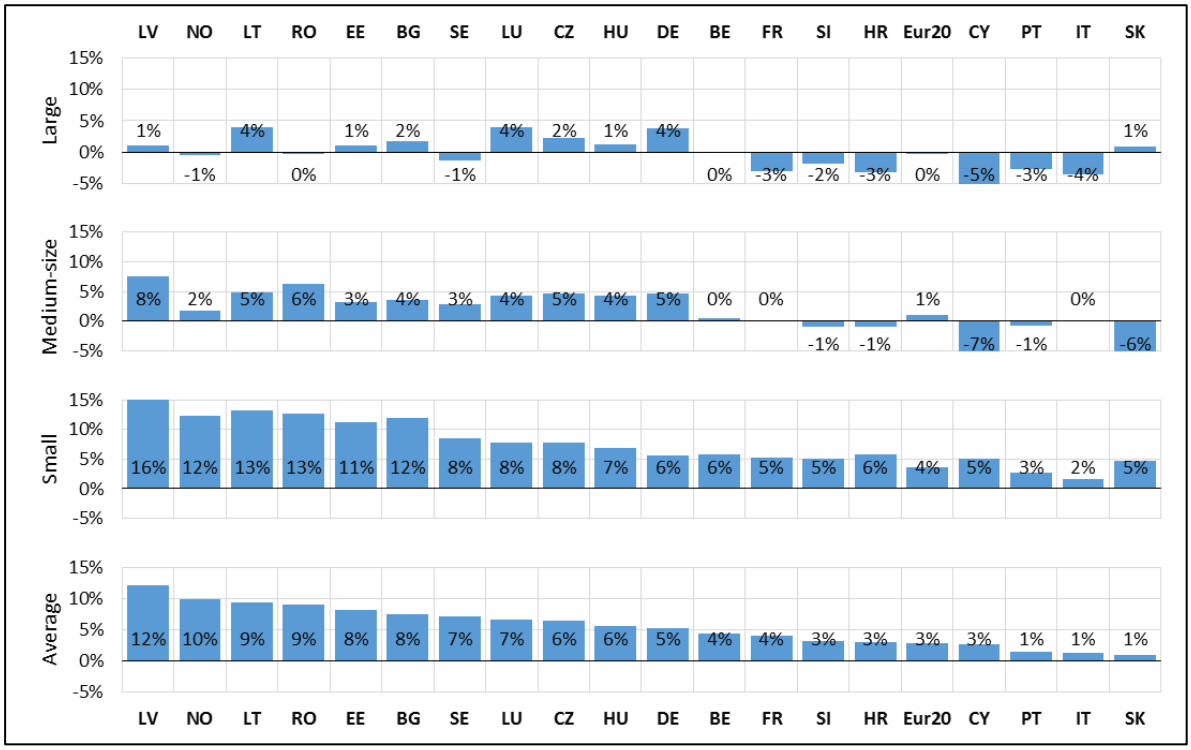
Country	Unweighted sample					Weighted sample				
	Small	Medium	Large	Total		Small	Medium	Large	Total	
				N	%				N	%
BE	2,361	1,071	260	3,692	*4%*	8,642	2,391	434	11,467	*3%*
BG	2,096	1,664	460	4,220	*5%*	2,096	1,664	460	4,220	*1%*
CY	603	168	31	802	*1%*	761	168	31	960	*0%*
CZ	1,252	1,288	764	3,304	*4%*	7,207	3,620	879	11,706	*3%*
DE	1,753	1,332	1,222	4,307	*5%*	70,648	25,050	5,297	100,995	*22%*
EE	444	439	56	939	*1%*	1,062	543	64	1,669	*0%*
ES	11,289	7,871	2,923	22,083	*24%*	66,588	16,164	3,153	85,904	*19%*
FR	9,659	2,649	1,797	14,105	*15%*	44,124	9,978	2,316	56,417	*13%*
HR	558	905	242	1,705	*2%*	2,318	1,191	266	3,775	*1%*
HU	1,140	1,513	494	3,147	*3%*	4,144	2,205	505	6,854	*2%*
IT	8,919	2,945	1,299	13,163	*14%*	96,381	13,411	1,975	111,766	*25%*
LT	288	603	169	1,060	*1%*	1,577	1,188	176	2,941	*1%*
LU	300	292	75	667	*1%*	845	341	81	1,267	*0%*
LV	317	344	108	769	*1%*	941	597	106	1,645	*0%*
NO	2,116	1,105	218	3,439	*4%*	5,864	1,374	220	7,457	*2%*
PT	1,914	1,623	425	3,962	*4%*	5,366	2,537	457	8,360	*2%*
RO	987	2,411	961	4,359	*5%*	5,356	3,658	1,047	10,061	*2%*
SE	2,188	1,251	457	3,896	*4%*	11,291	2,374	518	14,183	*3%*
SI	658	535	134	1,327	*1%*	1,752	692	142	2,587	*1%*
SK	833	848	333	2,014	*2%*	3,245	1,784	373	5,402	*1%*
Total	49,675	30,857	12,428	92,960	*100%*	340,206	90,931	18,499	449,636	*100%*
%	*53%*	*33%*	*13%*	*100%*		*76%*	*20%*	*4%*	*100%*	

Source: authors' calculations using CIS2012 microdata

3.1.1 Employment growth

Figure 2 shows the employment growth broken down by size classes, and the left part of **Table 2** shows how country growth rates correlate across different size classes. Unsurprisingly, due to the high share of small firms (with 10-50 employees) in the sample, the overall average rates correlates very strongly with the growth rate observed for small firms (correlation r = 0.96), in other words, in countries where the average growth is low (i.e. Italy or Portugal), we also find low growth among small firms. Average employment growth over the 2-year period from 2010 to 2012, ranges among small firms from 16% in Latvia through 13% in Lithuania and Romania to 2% in Italy. Medium-sized firms grow slower than small ones in all countries, and faster than large ones in all but two countries. The two exceptions are Slovakian and Cypriot large firms that outperform medium-sized ones, with positive growth in the case of Slovakia and more modest decline in the case of Cyprus. The percentage point differences in growth rates between small and medium-sized companies vary largely between countries, from 1 percentage point observed in the case of German firms and 12 percentage points observed in the case of Cypriot firms. Large firms, unsurprisingly, show the weakest relative growth performance, with no growth on average for the 20 country weighted average (Eur20). As we go up in size classes, we observe a particularly strong drop in the rate of growth in the case of Latvian (15-percentage point drop) as well as Norwegian and Romanian firms (13-percentage point drop). At the other extreme, German large firms grow by only 2 percentage points slower than small firms, Slovakian and Luxembourgish large firms grow by 4 percentage points slower than small ones. There are still considerable differences across countries, with the strongest performance among Lithuanian, Luxembourgish and German large firms (4% growth) and strongest decline among Cypriot (-5%), Italian (-4%), French, Croatian and Portuguese large firms (-3%). We note that firms show at least a 3% growth (at or above the cross-European average) in all three size classes in three countries: Lithuania, Luxembourg and Germany.

Figure 2 Average employment growth in the weighted sample by country & size class, 2012/2010



Source: authors' calculations using CIS2012 microdata

Table 2 Correlation of country growth rates in the weighted sample across indicators & size classes

Indicator		Employment growth, 2012/2010				Turnover growth, 2012/2010			
	Size class	Small	Medium	Large	Average	Small	Medium	Large	Average
Employment growth, 2012/2010	**Small**	1							
	Medium	0.727	1						
	Large	0.557	0.671	1					
	Average	0.968	0.789	0.531	1				
Turnover growth, 2012/2010	**Small**	0.824	0.420	0.429	0.792	1			
	Medium	0.920	0.764	0.620	0.949	0.851	1		
	Large	0.775	0.633	0.714	0.782	0.811	0.906	1	
	Average	0.862	0.501	0.469	0.850	0.989	0.910	0.850	1

Notes: Pearson correlation coefficients; N=21

Looking at growth distribution in greater details, we observe for the weighted European sample of 20 countries a 0% median growth. However, there is a considerable variation across countries. As shown in panel *a)* of **Figure 3**, the median growth is higher for Latvian (7.4%), Norwegian (6.2%), Estonian (4%), Lithuanian and Luxembourgish (3.7%), Bulgarian (3.4%) and German (3.2%) firms. Spanish firms in our weighted sample are different from those in other countries, due to the negative median growth (2.4% decline). Countries show an even higher variation when it comes to relative top performance, if measured as the top 10% of the distribution (the black dots in panel *a)* of **Figure 3** showing the 90th percentile, also the ordering principle of countries in the chart). The top 10% fastest growing firms of Germany achieved at least 20% growth, hardly outperformed by firms from other larger EU Member States such as Spain, France, or Italy. They fall below the 25% growth observed for the 20-country sample, which is driven mostly by the strong performance of Romania (50%), Latvia (47%), Norway (46%), Bulgaria and Lithuania (42%) and Sweden (36%). There is also a high variation across countries in terms of the growth observed for the top 5% of firms, which is notably higher than the variation in the decline of the bottom 5%. Such figures, however,

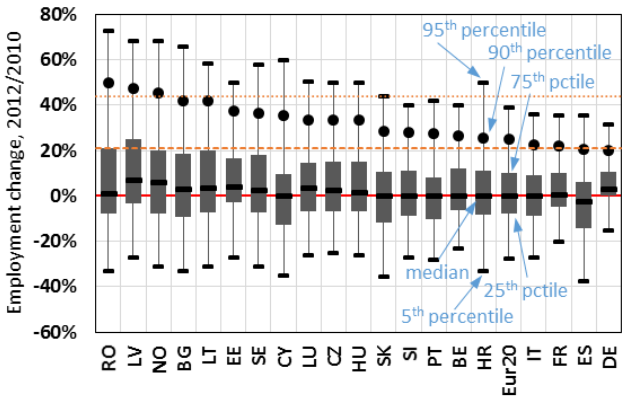
call for caution, given the low number of observations behind the respective values particularly in the case of the Baltic States or Cyprus. Interestingly, the variation in terms of firm growth is the lowest in Germany among the countries observed, so a relatively modest high-growth performance is coupled with a strong overall performance – about 75% of all German firms in our weighted sample show positive growth.

It is also remarkable that the absolute threshold used by Eurostat, the 10% annual average growth average growth – which translates to a 21% growth for the two-year period 2010 to 2012 we were forced to consider given the CIS data constraints (dashed orange line in panel *a)* of **Figure 3**) –, distinguishes a very different share of companies across countries. While it captures the top 10% of the Spanish firms, it selects somewhat less in the case of German firms, but as much as a quarter or more of Latvian, Romanian, Norwegian or Lithuanian firms. The high-growth threshold of 20% annual average growth applied by the OECD EIP translates to 44% overall growth in our case (dotted orange line in panel *a)* of **Figure 3**). This threshold proves to be very restrictive, as it captures less than 5% of the companies in the case of the largest EU Member States in the sample – Germany, Spain, France and Italy –, as well as Belgium, Portugal and Slovenia.

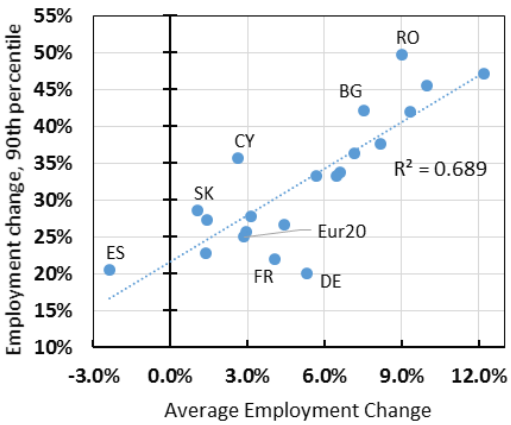
We also investigated how good a "predictor" of high-growth performance can be the more easily accessible average growth performance by country. As shown in panel b) of **Figure 3**, there is a strong positive association between employment change at the 90th percentile and average employment change (r^2=0.69). However, we note that in our case, Romania, Bulgaria, Cyprus, Slovakia and Spain exceed the expected rank in terms of high-growth, while Germany and France perform weaker than expected.

Figure 3 The distribution of employment change by country and a comparison of high-growth (90th percentile) with average growth in the weighted sample (2012/2010)

a) Distribution of employment change by country



b) High- vs. Average employment growth



Source: authors' calculations using CIS2012 microdata. *Notes for panel a):* Shaded area of box plots capture 50% of the growth distribution, while 90% is captured within the whiskers. Black dot shows the 90th percentile, which is the ordering principle for countries in the chart. Dashed orange line shows the 10% annual average growth threshold (21% overall); the orange dotted line shows the 20% (44% overall) growth threshold. Eur20 refers to the overall distribution for the 20 countries in the sample.

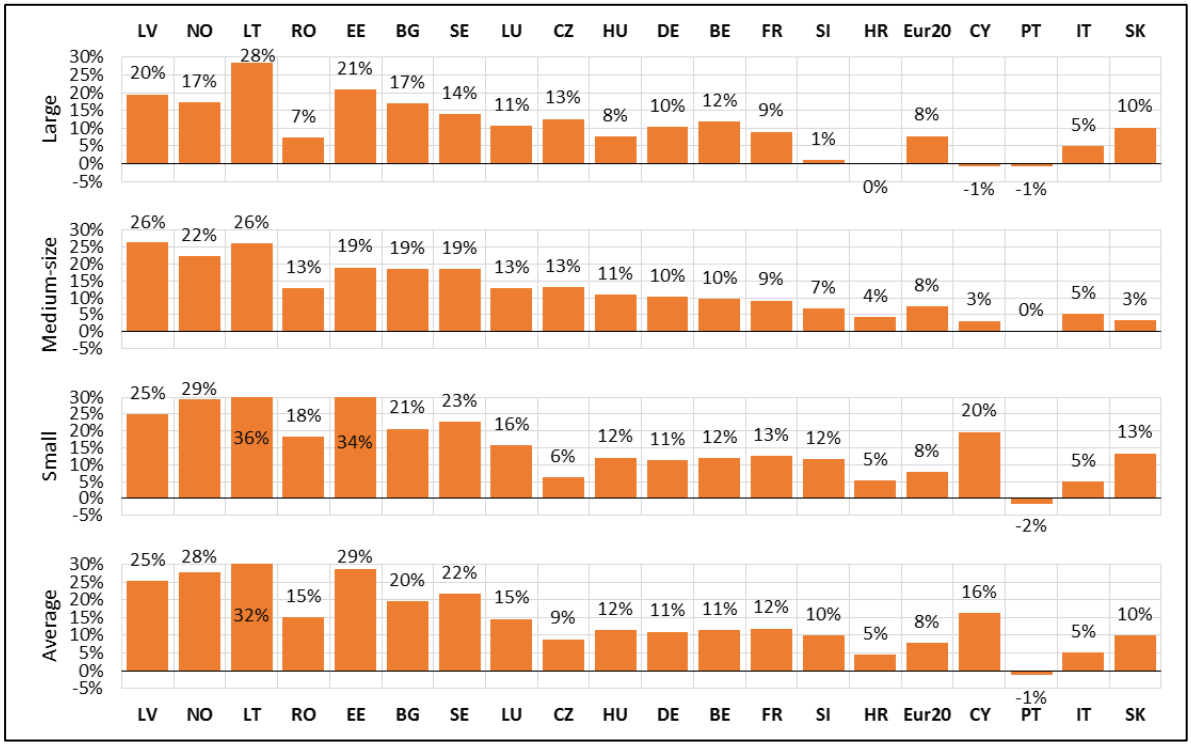
3.1.2 Turnover change

The average turnover (or sales) growth of companies exceeds their employment growth in all countries and all size classes with the exception of Portuguese small firms (and the overall average), as shown in **Figure 4**. In contrast with employment change, average

turnover change is nearly always positive, with the exception of Portuguese and large Cypriot firms. Average turnover growth is about 2.7 times higher than average employment growth, for the overall sample, and exceeds 20% for the 2 years between 2010 and 2012 in six countries, including Lithuania (32%), Estonia (29%), Norway (28%) as well as Latvia, Sweden and Bulgaria.

As in the case of employment change, due to their prevalence, small firms are the main drivers of our observed overall average turnover change, although there is a significantly higher correlation across the various size classes in the case of turnover change (right part of **Table 2**). Small firms in seven out of the twenty countries show a growth performance of at least 20%, and in a further eight countries above 10%. Medium-sized firms show a rather strong performance, with three countries out of the twenty exceeding 20% growth in the class (Latvia, Lithuania, Norway) and a further 10 countries exceeding 10% growth. Large companies in all the three Baltic states grow faster than 20%, and in a further 8 countries faster than 8%. Across all size classes, we observe the weakest performance in Portugal, Italy and Croatia.

Figure 4 Turnover change (orange) and employment change (blue) in the weighted sample by country and size classes (2012/2010)



Source: authors' calculations using CIS2012 microdata

Company performance in terms of turnover change shows an even more skewed distribution compared to what we observed above for employment change (**Figure 5**). The median turnover growth is 4% for the entire weighted sample, which varies by country ranging from a 5% (Spain and Portugal) to 3% (Cyprus) decline to growth up to 23% and 22% (for Estonia and Lithuania, respectively). This has a number of implications on the relative and absolute thresholds distinguishing performance groups of firms. The absolute thresholds of 10% and 20% annual average growth (21% and 44% overall, see dashed and dotted orange lines respectively in panel *a)* of **Figure 5**) captures a significantly larger share of firms than in the case of employment growth. The 10% annual average growth threshold used by Eurostat captures as much as about half of the Estonian, Lithuanian and Norwegian firms. The 20% annual average growth threshold used by the OECD EIP in the case of turnover captures at least 5% of the firms in all countries, and, apart from Spain, Portugal, Belgium, Germany, Italy and Croatia,

capture the top 10% of firms. Notably, the top 10% of firms in 11 of the countries in our sample grew faster than 50% over the two-year period.

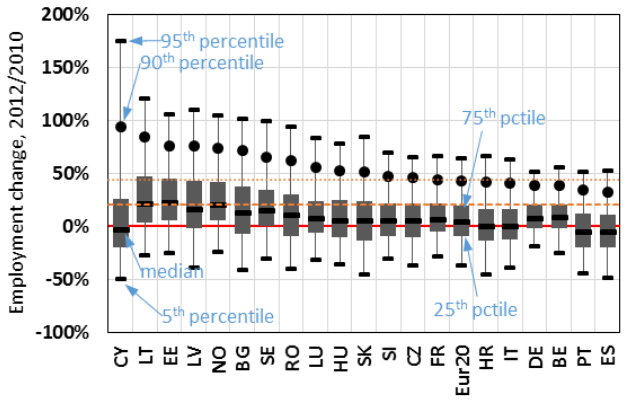
In the case of turnover change, average growth is a better predictor of high growth if high-growth is measured in terms of minimum growth of the top 10% of firms (panel *b)* of **Figure 5**)). Notable outliers are Cyprus that exceeds, as well as Belgium, Germany and France that fall behind expected high-growth performance.

While the growth rates obtained for each country are different when measured in terms of employment or turnover, we observe a strong, positive correlation at the country level between the median, 90th and even the 95th percentiles (r=0.79, 0.80 and 0.71, respectively). This calls for caution when setting the same absolute growth thresholds for employment as well as turnover.

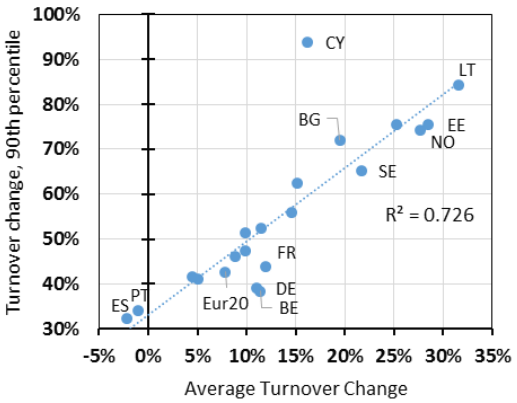
The observed difference between firms' growth performance in terms of turnover and employment change is in line with past literature and highlights the need to dedicate special attention to the two measures separately.

Figure 5 The distribution of turnover change by country and a comparison of high-growth (90th percentile) with average growth in the weighted sample

a) Distribution of turnover change by country



b) High- vs. Average turnover growth



Source: authors' calculations using CIS2012 microdata. *Notes for panel a):* Shaded area of box plots capture 50% of the growth distribution, while 90% is captured within the whiskers. Black dot shows the 90th percentile, which is the ordering principle for countries in the chart. Dashed orange line shows the 10% annual average growth threshold (21% overall); the orange dotted line shows the 20% (44% overall) growth threshold. Eur20 refers to the overall distribution for the 20 countries in the sample.

3.1.3 The growth of innovators and non-innovators

The CIS2012 dataset makes it possible to study growth and innovation at the same time, in a cross-sectional view. **Table 3** presents country average growth rates measured by employment and turnover for the two main types of innovators (product and process), and highlights the difference between the average growth observed for innovators and non-innovators. For the 20 country weighted sample, we find that innovators grow faster than non-innovators. The difference is about 3.1 percentage points in the case of both product and process innovators when growth is measured in terms of employment; and 5.7 and 5.4 percentage points for product and process innovators respectively, when growth is measured in terms of turnover.

There are a few apparent peculiarities at the level of countries in **Table 3**. First, that in many countries, process innovators appear to grow on average faster in terms of employment than product innovators (including Member States such as Germany or Sweden). Such comparisons can be misleading because there is a considerable overlap

between product and process innovators (i.e., process innovators are often also product innovators).[10] Second, while on average innovators grow faster than non-innovators, a few countries show a reverse picture. Notable examples in both measures of change are Lithuanian and Norwegian firms with no product innovation, or Latvian firms with no process innovations, or, in terms of turnover change, Luxembourgish firms with no process innovation. While it is difficult to explain this trend, it is important to highlight that in all these cases, the average growth performance of the innovator firms was at or above the overall European sample average.

Table 3 Average employment and turnover change 2012/2010 by country and product- and process innovators (percent; weighted sample)

Country	Average Employment Change (%)							Average Turnover Change (%)						
	All firms	Product Innovators			Process Innovators			All firms	Product Innovators			Process Innovators		
		Yes	No	Diff.	Yes	No	Diff.		Yes	No	Diff.	Yes	No	Diff.
BE	4.4	4.9	4.2	0.7	6.1	3.7	2.4	11.4	13.0	10.7	2.3	13.5	10.5	2.9
BG	7.5	9.4	7.2	2.2	8.1	7.4	0.7	19.5	25.9	18.4	7.5	24.3	18.6	5.7
CY	2.6	4.2	2.2	2.0	4.0	2.0	2.0	16.2	10.0	18.0	-8.0	19.5	14.7	4.9
CZ	6.5	8.1	5.8	2.3	9.9	5.1	4.8	8.9	12.9	7.2	5.7	14.3	6.7	7.6
DE	5.3	6.4	4.7	1.7	7.2	4.7	2.5	11.0	13.5	9.6	3.9	14.4	9.7	4.7
EE	8.2	10.7	7.5	3.2	11.6	6.7	4.9	28.5	27.9	28.7	-0.7	28.3	28.6	-0.3
ES	-2.4	0.3	-2.6	2.9	0.1	-2.8	2.9	-2.2	3.0	-2.6	5.6	2.9	-2.9	5.8
FR	4.0	5.0	3.7	1.2	5.0	3.7	1.3	11.9	15.1	10.9	4.2	15.7	10.8	4.9
HR	3.0	4.6	2.6	2.0	5.7	2.2	3.5	4.5	8.4	3.7	4.7	11.4	2.7	8.8
HU	5.7	8.1	5.3	2.8	8.9	5.2	3.6	11.5	11.6	11.4	0.1	15.1	11.0	4.1
IT	1.4	3.8	0.5	3.3	4.2	0.3	3.9	5.0	9.4	3.4	6.0	9.4	3.4	6.0
LT	9.3	5.2	10.1	-4.9	10.3	9.1	1.2	31.6	24.2	33.0	-8.8	33.6	31.2	2.4
LU	6.6	12.6	4.0	8.5	8.8	5.5	3.3	14.6	15.7	14.2	1.5	9.9	17.0	-7.1
LV	12.2	13.4	11.9	1.5	5.4	13.6	-8.1	25.2	23.5	25.5	-2.0	22.6	25.7	-3.1
NO	10.0	7.5	10.4	-3.0	10.4	9.9	0.5	27.7	25.4	28.2	-2.7	23.5	28.2	-4.7
PT	1.4	3.5	0.4	3.1	3.9	-0.3	4.1	-1.0	1.6	-2.3	3.9	3.4	-4.1	7.4
RO	9.0	10.8	8.9	1.9	9.2	9.0	0.2	15.1	22.1	14.7	7.3	23.0	14.5	8.4
SE	7.2	9.6	6.2	3.4	11.9	5.9	5.9	21.7	22.5	21.3	1.2	25.3	20.7	4.6
SI	3.1	3.3	3.1	0.2	3.0	3.2	-0.1	9.9	11.1	9.4	1.7	10.4	9.7	0.8
SK	1.0	4.2	0.5	3.7	2.5	0.8	1.7	9.8	14.7	9.0	5.7	15.7	8.9	6.8
Eur20	2.9	5.2	2.1	3.1	5.3	2.2	3.1	7.8	12.2	6.5	5.7	12.0	6.6	5.4

Source: authors' calculations using CIS2012 microdata.

[10] Process innovation is, in general, understood as having a labor-saving effect, since often a key reason for companies to implement process innovation is to reduce costs by i.e. automation. At the same time, product innovations have the tendency to create new business opportunities or opens new markets, resulting in a positive employment effect (see i.e. Pianta and Vivarelli, 2003). These firm-level effects, however, may be mitigated at the country level if new products cannibalize old ones, or the effect may occur with a certain lag.

3.2 Variables defining high-growth firms for the matrix

With the aim to be comprehensive, we constructed 30 measures to identify high-growth firms taking into account, and further broadening the scope of previous empirical work and the considerations suggested by Delmar (1997) and Delmar et al (2003) and Daunfeldt et al (2014). As summarized in **Table 4**, we consider both the number of employees and turnover as indicators of growth, relative growth as well as a measure of growth less biased by size (the Birch index). Given the constraints of our dataset, we focus on growth over the period 2010 to 2012. This is restrictive in two aspects. First, accelerated growth may be sporadic events in the evolution of a firm, so in effect we can only focus on growth spurts that may be exceptions. Second, we are forced to depart from the 3-year observation window used in the Eurostat and OECD definitions and consider only a 2-year period.[11] We exclude mergers and acquisitions and study organic growth only, to avoid spurious values. We further consider, for the identification of high-growth firms, both absolute (following the philosophy of the Eurostat and OECD approaches, but introducing a broader set of alternatives), and relative thresholds (a more data-driven method) and consider potential growth differences across industries and size classes (considering the findings of Coad et al., 2014a). Admittedly, many of our definitions may be overlapping, may be too restrictive or too broad. Considering such a large set of alternative definitions is in line with the explorative nature of our study, and our primary aim is to be able to draw more nuanced conclusions that may be informative for future studies of high-growth firms.

Table 4 Alternatives considered for the definition of high-growth firms

Element of definition	Alternatives considered
Indicator of growth	number of employees; value of turnover
Measure of growth	Relative; Birch index
Growth period	2010-2012
Growth process	Organic only (excl. mergers and acquisitions)
Identification	Distribution-based: top P%, where $P \in (1, 5, 10, 15)$; as well as absolute threshold-based: growth ≥ N% $N \in (10, 15, 21, 44, 100)$
Additional qualification	all firms vs. growing firms (<=0 growth excluded), by size class; by industry

The 30 definitions we tested are presented in the Variable and Description columns of **Table 5**. Ten of these definitions (hg1-hg10) are based on relative sales and employment growth applying a fixed threshold (i.e., 10-100% growth). Another four definitions (hg11-hg14) are based on the Birch index, which aims to be less biased towards small firms (see discussion in section 2.1). We defined the Birch index both in terms of employment and sales (although many use it only in employment context, see i.e. Hölzl, 2009). A further sixteen definitions (hg15-hg30) are based on taking the top *N*% of the distribution of firms by 3 size classes, in terms of employment and sales growth as well as the Birch Index. We compute the various measures as follows:

- total employment growth is computed using the formula: $EMPL_{2012}/EMPL_{2010}-1$;
- sales growth is computed as $TURN_{2012}/TURN_{2010}-1$;
- the Birch index (defined in terms of employment as well as sales) is computed as: $(EMPL_{2012}-EMPL_{2010})*EMPL_{2012}/EMPL_{2010}$ or $(TURN_{2012}-TURN_{2010})*TURN_{2012}/TURN_{2010}$ respectively.
- When we consider the top *N%* of the distribution, we control for firm size, where we distinguish small, medium and large firms using 50 and 250 employees as thresholds.

[11] Accordingly, we re-compute relevant growth rates in the following way: annual average growth of 10% refers to 21%, 20% refers to 44% growth over the 2-year period.

Using a similar methodology as described in the preceding section, alongside scores for the HGI matrix, we also compute a high-growth vector. For each firm, we compute a total high-growth score [hgtot], which is a sum of the various hg_i scores (in effect, equal to the number of times the firm meets the given criteria).

Table 5 Descriptive statistics of the variables defining high-growth firms in the weighted sample

Variable	Description	Min	Max	unweighted sample					weighted sample				
				N	mean	sd	skew.	kurt.	N	mean	sd	skew.	kurt.
Relative sales and employment growth, fixed thresholds													
hg1	total employment growth > 10%	0	1	92,960	0.27	0.44	1.0	2.1	92,926	0.26	0.44	1.1	2.2
hg2	total employment growth > 15%	0	1	92,960	0.20	0.40	1.5	3.2	92,926	0.19	0.39	1.6	3.6
hg3	total employment growth > 21%	0	1	92,960	0.14	0.35	2.1	5.2	92,926	0.12	0.33	2.3	6.4
hg4	total employment growth > 44%	0	1	92,960	0.05	0.22	4.1	17.5	92,926	0.04	0.20	4.7	23.0
hg5	total employment growth > 100%	0	1	92,960	0.01	0.10	10.1	102.6	92,926	0.01	0.08	12.4	154.5
hg6	sales growth >= 10%	0	1	92,960	0.41	0.49	0.4	1.1	92,926	0.39	0.49	0.5	1.2
hg7	sales growth >= 15%	0	1	92,960	0.33	0.47	0.7	1.5	92,926	0.31	0.46	0.8	1.7
hg8	sales growth >= 21%	0	1	92,960	0.26	0.44	1.1	2.2	92,926	0.23	0.42	1.3	2.6
hg9	sales growth >= 44%	0	1	92,960	0.11	0.32	2.4	6.9	92,926	0.10	0.29	2.7	8.6
hg10	sales growth >= 100%	0	1	92,960	0.03	0.16	5.9	35.3	92,926	0.02	0.14	6.9	48.7
Using the Birch Index (absolute x relative growth)													
hg11	Birch Index (empl) > 10%	0	1	92,960	0.46	0.50	0.1	1.0	92,926	0.46	0.50	0.2	1.0
hg12	Birch Index (empl) > 100%	0	1	92,960	0.45	0.50	0.2	1.0	92,926	0.45	0.50	0.2	1.0
hg13	Birch Index (sales) > 10%	0	1	92,960	0.59	0.49	-0.3	1.1	92,926	0.58	0.49	-0.3	1.1
hg14	Birch Index (sales) > 100%	0	1	92,960	0.59	0.49	-0.3	1.1	92,926	0.58	0.49	-0.3	1.1
Top of the distribution (Top N% in terms of employment and sales growth and Birch Index; by size class)													
hg15	Among top 5% relative empl. growth (by size class, growing firms)	0	1	92,960	0.02	0.15	6.3	41.0	92,926	0.01	0.12	8.0	65.3
hg16	Among top 10% relative empl. growth (by size class, growing firms)	0	1	92,960	0.05	0.21	4.3	19.6	92,926	0.03	0.17	5.4	30.1
hg17	Among top 15% relative empl. growth (by size class, growing firms)	0	1	92,960	0.07	0.25	3.4	12.4	92,926	0.05	0.22	4.1	17.8
hg18	Among top 25% relative empl. growth (by size class, growing firms)	0	1	92,960	0.12	0.32	2.4	6.7	92,926	0.09	0.29	2.9	9.3
hg19	Among top 5% relative sales growth (by size class, growing firms)	0	1	92,960	0.03	0.17	5.6	32.2	92,926	0.02	0.14	6.8	47.8
hg20	Among top 10% relative sales growth (by size class, growing firms)	0	1	92,960	0.06	0.23	3.8	15.1	92,926	0.04	0.20	4.5	21.4
hg21	Among top 15% relative sales growth (by size class, growing firms)	0	1	92,960	0.09	0.28	2.9	9.5	92,926	0.07	0.25	3.5	13.3
hg22	Among top 25% relative sales growth (by size class, growing firms)	0	1	92,960	0.15	0.35	2.0	5.0	92,926	0.12	0.33	2.3	6.5
hg23	Among top 5% in terms of Birch Index (empl), by size class, growing firms)	0	1	92,960	0.02	0.15	6.3	41.0	92,926	0.01	0.11	8.8	78.4
hg24	Among top 10% in terms of Birch Index (empl), by size class, growing firms)	0	1	92,960	0.05	0.21	4.3	19.6	92,926	0.03	0.16	5.8	34.1
hg25	Among top 15% in terms of Birch Index (empl), by size class, growing firms)	0	1	92,960	0.07	0.25	3.4	12.4	92,926	0.04	0.21	4.4	20.6
hg26	Among top 25% in terms of Birch Index (empl), by size class, growing firms)	0	1	92,960	0.12	0.32	2.4	6.7	92,926	0.08	0.27	3.0	10.3
hg27	Among top 5% in terms of Birch Index (sales), by size class, growing firms)	0	1	92,960	0.03	0.17	5.6	32.2	92,926	0.02	0.14	6.8	47.6
hg28	Among top 10% in terms of Birch Index (sales), by size class, growing firms)	0	1	92,960	0.06	0.23	3.8	15.1	92,926	0.04	0.20	4.5	21.6
hg29	Among top 15% in terms of Birch Index (sales), by size class, growing firms)	0	1	92,960	0.09	0.28	2.9	9.5	92,926	0.07	0.25	3.4	12.7
hg30	Among top 25% in terms of Birch Index (sales), by size class, growing firms)	0	1	92,960	0.15	0.35	2.0	5.0	92,926	0.12	0.32	2.3	6.5
hgtot	Total HG scores by firm	0	30	92,960	5.06				92,926	4.57			

Source: authors' calculations using CIS2012 microdata.

3.3 Variables defining innovation for the matrix

The matrix captures various types of innovation and their degree of novelty (i.e., whether it is new to the firm, market or to the world). Furthermore, it offers "hard data" on what firms spend on innovation – alongside R&D, firms also report other innovation expenditure. This is particularly important for the service sector, as R&D expenditure is typically concentrated to manufacturing industries.

In the same vein as in the case of our variables defining growth thresholds, our various measures of innovativeness considers multiple innovation profiles for firms. Our key consideration for defining variables were to start with a broad definition which flags a firm innovative if it introduced any kind of technological (product or process) or non-technological (organizational or marketing) innovation, which is considered new to the firm. These can be further restricted by selecting innovators by:

- type of innovations – successful implementation of product, process or a combination of the four types;
- degree of novelty – to take into account whether a new technological innovation (for which data exists) is new to the firm, to the market, or to the world. We further test how the information provided on the share of sales associated with certain degrees of novelty further sharpens the definition. In sum, we propose a set of indicators ranging from diffusion of innovation to radical innovations.
- the innovation process (whether the firm performed in-house R&D, and if so, whether it is among the top R&D spenders in certain aspects (controlling for differences across industries);

The 50 indicators described in **Table 6** take the value of 1 for each firm which meets the given criteria. For the expenditure variables, we apply both absolute thresholds (i.e., R&D intensity at least 10%) as well as relative ones (i.e., within the top *n* % in terms of R&D expenditure or overall innovation expenditure). We also make use of information on how important innovative products are in the total sales of a given company.

As we use the CIS data, we cannot include other often used output measures, such as those relating to intellectual property (i.e. patents).

We include among the variables of innovation also variables based on R&D or innovation expenditure, or other measures such as knowledge-intensity. While we do not consider this as a "core" measure of innovativeness, the main purpose is to offer a contextual understanding of innovative performance. The CIS data is rather exceptional in providing information about innovation outcomes, R&D spending is more widely available from firm-level financial data.

Table 6 Descriptive statistics of variables defining innovativeness of firms in the weighted sample

Var.	Description	Min	Max	unweighted sample					weighted sample				
				N	mean	sd	skew.	kurt.	N	mean	sd	skew.	kurt.
By main types													
inn1	product innovation (good or service)	0	1	92,917	0.27	0.44	1.1	2.1	92,917	0.24	0.43	1.2	2.5
inn2	process innovation (any)	0	1	92,896	0.27	0.44	1.0	2.1	92,896	0.23	0.42	1.3	2.7
inn3	product or process innovation (any)	0	1	92,924	0.37	0.48	0.5	1.3	92,924	0.33	0.47	0.7	1.5
inn4	organizational or marketing innovation (any)	0	1	91,879	0.41	0.49	0.4	1.1	91,879	0.39	0.49	0.4	1.2
inn5	organizational or marketing innovation only (not prod/proc)	0	1	92,644	0.15	0.36	2.0	4.9	92,644	0.16	0.37	1.8	4.4
inn6	any kind of inn. (prod/proc/organizational or marketing)	0	1	92,643	0.52	0.50	-0.1	1.0	92,643	0.49	0.50	0.0	1.0
By novelty													
inn7	product or process innovation is new to the market	0	1	92,960	0.18	0.38	1.7	3.9	92,926	0.14	0.35	2.1	5.3
inn8	Prod. Inn. is new to the market and first in the country	0	1	92,960	0.09	0.28	2.9	9.5	92,926	0.07	0.26	3.3	11.7
inn9	Radical: New to market prod/proc. Inn is a World or Eur. 1st	0	1	92,960	0.05	0.22	4.0	16.8	92,926	0.05	0.22	4.1	18.0
inn10	=inn9, and the company is an exporter	0	1	92,960	0.05	0.22	4.2	18.6	92,926	0.05	0.21	4.4	20.2
inn11	New to firm product or process innovation	0	1	92,960	0.19	0.39	1.6	3.5	92,926	0.17	0.38	1.7	3.9
inn12	Innovation new to firm/market represent at least 90% of sales	0	1	92,960	0.02	0.15	6.2	39.2	92,926	0.01	0.11	8.5	73.5
inn13	Innovation new to firm/market represent at least 75% of sales	0	1	92,960	0.03	0.18	5.2	27.6	92,926	0.02	0.15	6.5	42.7
inn14	Innovation new to firm/market represent at least 50% of sales	0	1	92,960	0.05	0.23	3.9	16.5	92,926	0.04	0.20	4.5	21.5
inn15	Innovation new to firm/market represent at least 25% of sales	0	1	92,960	0.09	0.29	2.8	8.6	92,926	0.08	0.27	3.0	10.3
inn16	New to market Innovation represent at least 75% of sales	0	1	92,960	0.01	0.10	9.4	88.7	92,926	0.01	0.08	12.9	166.7
inn17	New to market Innovation represent at least 50% of sales	0	1	92,960	0.02	0.14	6.6	44.9	92,926	0.01	0.12	8.3	70.5
inn18	New to market Innovation represent at least 25% of sales	0	1	92,960	0.04	0.20	4.6	22.3	92,926	0.03	0.17	5.5	31.1
inn19	At least 5% of turnover from world-first product innovations	0	1	92,960	0.01	0.09	10.8	118.4	92,926	0.01	0.12	8.4	72.0
inn20	At least 10% of turnover from world-first product innovations	0	1	92,960	0.01	0.07	13.7	188.1	92,926	0.01	0.09	11.0	121.9
inn21	At least 25% of turnover from world-first product innovations	0	1	92,960	0.00	0.05	21.9	479.7	92,926	0.00	0.06	18.0	326.4
By the innovation process: R&D performance, innovation expenditures													
inn22	Perform in-house R&D	0	1	92,781	0.23	0.42	1.3	2.6	92,781	0.17	0.38	1.8	4.1
inn23	Perform in-house R&D & product or process innovator	0	1	92,799	0.21	0.40	1.5	3.1	92,799	0.15	0.36	1.9	4.7
inn24	Continuously in-house R&D performer with perm. R&D staff	0	1	83,302	0.15	0.35	2.0	5.0	83,302	0.07	0.26	3.3	11.7
inn25	Among top 10% absolute R&D spender (all firms, 0's incl.)	0	1	90,611	0.10	0.30	2.7	8.1	90,611	0.05	0.22	4.1	17.6
inn26	Among top 10% absolute R&D spender (all firms, 0's excl.)	0	1	90,611	0.02	0.15	6.6	43.9	90,611	0.01	0.09	11.4	130.0
inn27	Among top 10% absolute R&D spender (by nace, 0's incl.)	0	1	90,611	0.41	0.49	0.4	1.1	90,611	0.45	0.50	0.2	1.0
inn28	Among top 10% absolute R&D spender (by nace, excl. 0's)	0	1	90,611	0.02	0.16	6.1	38.1	90,611	0.01	0.10	9.4	89.8
inn29	Among top 10% absolute R&D spender (by country, 0's incl.)	0	1	90,611	0.22	0.41	1.4	2.9	90,611	0.10	0.30	2.7	8.4
inn30	Among top 10% absolute R&D spender (by country, excl. 0's)	0	1	90,611	0.02	0.15	6.5	43.7	90,611	0.01	0.08	12.8	165.4
inn31	Among top 10% in terms of R&D intensity (all firms, 0's incl.)	0	1	90,611	0.10	0.30	2.7	8.1	90,611	0.07	0.25	3.5	13.4
inn32	Among top 10% in terms of R&D intensity (all firms, 0's excl.)	0	1	90,611	0.02	0.15	6.6	43.9	90,611	0.01	0.11	8.6	75.0
inn33	Among top 10% in terms of R&D intensity (by nace, 0's incl.)	0	1	90,611	0.41	0.49	0.4	1.1	90,611	0.46	0.50	0.2	1.0
inn34	Among top 10% in terms of R&D intensity (by nace, excl. 0's)	0	1	90,611	0.03	0.16	6.1	37.7	90,611	0.02	0.13	7.6	59.5
inn35	Among top 10% in terms of R&D int. (by country, 0's incl.)	0	1	90,611	0.22	0.41	1.4	2.9	90,611	0.11	0.32	2.4	6.9
inn36	Among top 10% in terms of R&D int. (by country, excl. 0's)	0	1	90,611	0.02	0.15	6.5	43.7	90,611	0.02	0.12	7.9	62.8
inn37	Among top 10% overall inn spending int. (all firms, 0's incl.)	0	1	91,790	0.10	0.30	2.7	8.1	91,790	0.08	0.28	3.0	10.0
inn38	Among top 10% overall inn spending int. (all firms, 0's excl.)	0	1	91,790	0.03	0.18	5.1	26.7	91,790	0.03	0.16	5.8	35.1
inn39	Among top 10% overall inn spending int. (by nace 2-d, 0's incl)	0	1	91,790	0.12	0.33	2.3	6.3	91,790	0.13	0.34	2.2	5.7
inn40	Among top 10% overall inn spending int. (by nace 2-d, 0's excl)	0	1	91,790	0.04	0.19	4.8	24.1	91,790	0.03	0.18	5.2	28.0
inn41	Among top 10% overall inn. spending int. (by country, 0's incl)	0	1	91,790	0.10	0.30	2.7	8.1	91,790	0.08	0.27	3.1	10.8
inn42	Among top 10% overall inn. spending int. (by country, 0's excl)	0	1	91,790	0.03	0.18	5.1	26.6	91,790	0.03	0.17	5.4	30.4
inn43	R&D intensity (RD/turnover) is 15% or more (YIC definition)	0	1	92,960	0.02	0.13	7.3	54.5	92,926	0.01	0.10	9.6	94.1
inn44	R&D or machinery purchaser, without in-house R&D	0	1	92,605	0.11	0.32	2.4	7.0	92,605	0.13	0.33	2.2	6.0
inn45	R&D or machinery purchaser, not performer, prod/proc inn'r	0	1	92,669	0.10	0.31	2.6	7.7	92,669	0.11	0.32	2.4	6.9
inn46	Non-R&D innovator	0	1	92,798	0.16	0.37	1.8	4.4	92,798	0.18	0.38	1.7	3.9
By knowledge-intensity													
inn47	Knowledge-intensive product or process innovator	0	1	92,960	0.10	0.29	2.7	8.5	92,926	0.06	0.25	3.5	13.6
inn48	Knowledge-intensive any kind of innovator	0	1	92,960	0.13	0.34	2.2	5.9	92,926	0.09	0.29	2.8	8.9
inn49	=inn48, with new to market/firm innovation >= 75% of sales	0	1	92,960	0.01	0.10	9.7	94.3	92,926	0.01	0.07	13.5	182.0
inn50	=inn48, with new to market innovation >= 75% of sales	0	1	92,960	0.00	0.06	16.4	270.6	92,926	0.00	0.04	24.0	578.5
Inntot	Total inn scores by firm	0	43	92,960	6.00	6.35	1.5	5.2	92,926	5.18	5.64	1.6	6.1

Source: authors' calculations using CIS2012 microdata.

4 Results

This section presents results on firms within the population of 92,960 CIS microdata firms (representing almost 450,000 firms) that meet the high-growth and innovative criteria as an outcome of the HGI Matrix. We noticed that about 40% of firms in the pooled CIS 2012 sample do not meet any of the 30 definitions of high-growth, and slightly less than 50% of the firms do not meet any of the 50 definitions for different degrees of innovativeness. From the patterns shown by the rest of companies that may be considered either as high-growth, or innovative, we can draw a number of conclusions on how firms perform in terms of the various measures of high-growth and innovation making use of the descriptive statistics on the individual indicators presented in **Table 5** and **Table 6**. We next analyse the European share of companies identified as *high-growth and innovative* using the definition combinations reported in a matrix format in **Figure** Error! No text of specified style in document.. As the many dimensions make it difficult to interpret the results for policy purposes, in a subsequent step, we study the association between the variables with the aim to reduce dimensionality by eventually aggregating a selected set of variables. Using these measures, we focus our analysis on the performance of countries as well as 1- and 2-digit NACE sectors in terms of high-growth and innovativeness.

4.1 High-growth firms and innovative firms

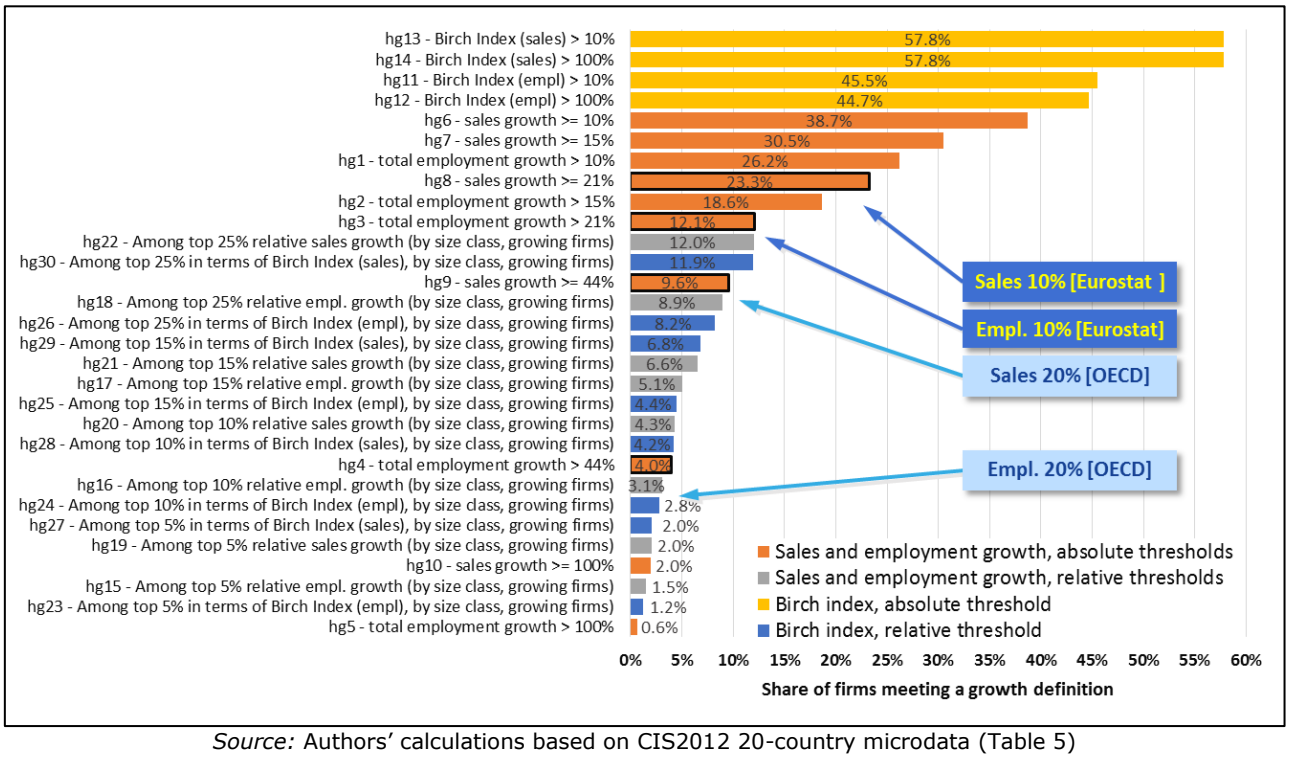
From among the 30 potential variables we tested for identifying **high growth**, we see a large variance in terms of the number of firms that meet a certain definition. As shown by the mean scores reported in **Table 5** – and in a graphical way, in **Figure 6** – these can range from 0.6% (in the case of *hg5*) to 57.8% (*hg13* or *hg14*).

The color-coding in **Figure 6** help identify patterns in the various set of high-growth definitions. The Birch indices applying fixed thresholds of 10-100% growth (yellow bars, variables *hg11-13*) flags about half of the firms (44.7-57.8%) as "high-growth", which proves to be an excessively broad definition. There remains to be a considerable variation among the share of high-growth firms selected by the other three types of definitions, mostly due to those applying the absolute threshold (orange bars). While these definitions encompass the Eurostat and OECD definitions that range from 4% to 23.3% of firms, if the threshold for employment growth over the 2 years is set at 100% (*hg5*), only 0.6% of firms can be considered as high-growth ones, whereas a sales growth threshold of 10% (*hg6*) of the 2 years flags 38.7% of firms as high-growth.

The relative definitions (top *N%* of the distribution, gray bars) were selected by restricting the measure to growing firms only, but take the top of the distribution by size class, resulting in a share ranking between 1.5% (*hg15*) and 12% (*hg22*). This range would double if all, not only the growing firms were included in the definitions.

The set of definitions shows that there are considerable differences between turnover and employment-based definitions in the share of firms flagged as high-growth ones, but more overlap between the definitions applying an absolute fixed growth threshold and those applying a relative one. The association between the various definitions will be further discussed in section 4.3.1.

Figure 6 The share of European companies in the weighted sample meeting a certain high-growth definition

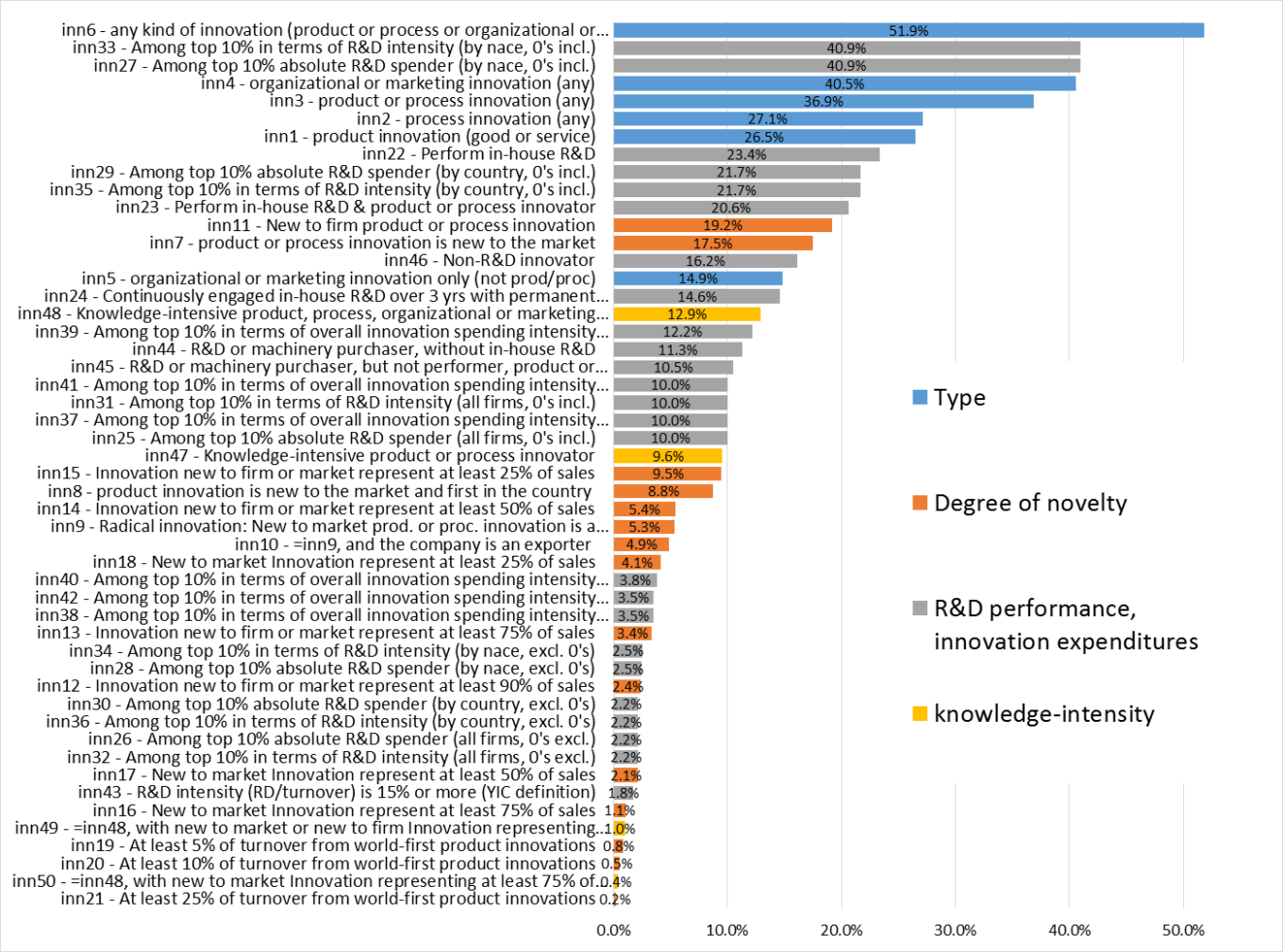


Source: Authors' calculations based on CIS2012 20-country microdata (Table 5)

Figure 7 offers a graphic overview of the average firm performance in the 50 innovation variables presented in **Table 6**. The color coding distinguishes the main set of variables which distinguish innovation by type, degree of novelty, top R&D performance and innovation expenditure, as well as knowledge-intensity. In a rather clear pattern, the variables capturing the main types of innovation (product, process, organizational or marketing – blue bars) select the largest share of firms in the weighted sample of 20 European countries. In fact, 51.9% of the sample firms qualify as innovative if the criterion is having successfully introduced any type of innovation (*inn6*).[12] This baseline definition, unsurprisingly, lies at the upper extreme of the distribution, all other definitions used selected a significantly smaller share of firms. Technological product or process innovators (*inn3*) represent only 36.9% of firms in the sample. Adding as a further qualification the novelty requirement that technological innovations should be new at least to the firm (*inn11*) nearly halves the set of flagged innovators to 19.2%. This is not much different from the share of firms with new-to-market product or process innovation (*inn7*), 17.5%. The orange bars in **Figure 7** show that by adjusting the expected degree of novelty for an innovation, such as a requirement that at least 5% of a firm's turnover should come from technological innovations that are new to the world (*inn19*), the share of – admittedly, highly – innovative firms drops below 1% of the sample.

[12] This definition is somewhat more restrictive compared to the Eurostat definition of "innovative enterprises", which also considers firms with ongoing or abandoned innovative activities.

Figure 7 The share of European companies in the weighted sample meeting an innovativeness definition



Source: authors' calculation based on CIS2012 microdata (Table 6).

Innovation is usually associated with R&D activities, but there is a considerable share of non-R&D innovators: 16.2% of sample firms introduced an innovation but did not perform in-house R&D (*inn46*). 23.4% of sample firms performed in-house R&D (regardless of successful innovation outcomes; *inn22*). As the gray bars of **Figure 7** show, we find rather different performances in terms of R&D expenditure and intensity. As R&D tends to concentrate to high-tech, manufacturing industries, it is not surprising that when we select the top 10% R&D spenders by industry (*inn33*), about 41% of firms are selected, rather than the 10%, as expected if we select all firms (*inn31*). While R&D spending characterizes manufacturing industries, a high share of tertiary graduates ("knowledge intensity") characterizes service sectors. Nevertheless, we find a more restricted set of firms that qualify as knowledge-intensive innovators (of any type): only about 12.9% (*inn48*). An even smaller, 9.6% are knowledge-intensive technological innovators.

As highlighted earlier, the point of including among the variables R&D or innovation expenditure, or other measures such as knowledge-intensity, was to offer a more contextual understanding of innovative performance. The share reported above suggest that these variables show little similarities with the "core" variables based on innovation type – but we report more details on associations between the variables in section 4.3 below.

4.2 High-growth and innovative firms

In this step, we analyse the differences in the share of firms that meet the various combinations of the high-growth and innovation definitions discussed above separately. In other words, if we found

that 51.9% of firms are innovative if the definition allows any type of innovation, how does this share drop if we select only the high growth firms? As described in section 3 above, since there is uncertainty with regards to the definition of both dimensions, we are confronted with a matrix where each cell represents a different combination of high-growth and innovativeness.

The resulting matrix with the share of enterprises in the 20-country European CIS2012 dataset that may, in a certain aspect, be flagged as high-growth *and* innovative, are shown in **Figure 4**. As the range of the definitions considered for the two dimensions offered a rather broad variance, it is of little surprise that the share of HGIEs range from 0.1 to 31% of sample firms. The matrix serves as a reference for understanding the differences in scale across the various definitions. We limit our discussion to a few selected definitions.

For instance, we notice that about 22% of European firms grow at least at 10% (5% annual average) in terms of turnover and have introduced a technological or non-technological innovation (*hg6 & inn6*). This share falls to 16% in the case of technological product or process innovators (*hg6 & inn3*), and further to 12% if only product innovators are considered to be "innovative" (*hg6 & inn1*). Moving vertically, rather than horizontally in the matrix and fixing the innovation variable shows that increasing the annual turnover growth threshold to 21% (10% annual) reduces the share of HGIEs to 14% (*hg8 & inn6*), and further increasing the sales growth threshold to 100% reduces HGIEs to 1% (*hg10 & inn6*).

About 7% of European firms are HGIEs following the definition in accordance with the Eurostat definition of high-growth and any type of innovation for innovativeness (*hg3 & inn6*). The HGIE share can double to 14% in case a lower growth threshold is applied (10% for the 2 years, 5% annual average; *hg1 & inn6*). The share can drop from 7 to 3% in case the OECD EIP's 20% (44% over the two years) employment threshold is applied (*hg4 & inn6*), and further to less than 0.5% if a 100% threshold is applied for employment growth over the 2 years (*hg5 & inn6*). Applying, in contrast, the OECD EIP's threshold using turnover change as the growth measurement and keeping the introduction of any type innovations as a condition for innovativeness results in flagging 6% of firms as HGIEs (*hg9 & inn6*). Recalling that the difference between *hg3* and *hg9* in terms of the firms covered is about 2.5%, the observed 1% difference between the *hg3&inn6* and *hg9&inn6* suggests that there are more innovative firms among the high-growth firms selected by the OECD EIP's 20% turnover-based *hg9* definition.

Restricting innovativeness by the degree of novelty, in general, reduces the share of HGIEs to about two-thirds if we consider product or process innovator firms (irrespective of the growth definition) that report that their innovation is new to the firm. Only about 22% of the product and process innovators report that this innovation is new to the world.

HGIEs appear to have a portfolio of, rather than one single, innovative products. We find that less than 0.5% of firms in the sample report that at least 25% of their sales originates from new to the market innovations, and less than 0.5% of firms in the sample report that such a product represents 5% of turnover.

In terms of R&D activity, we find that HGIEs perform above average in R&D spending. Nearly half of high-growth firms with any kind of innovation perform in-house R&D (*inn22*); about a quarter of the rest purchase R&D from outside the firm. At the same time, non-R&D innovators (*inn46*) represent about 0.1 to 10% of high-growth firms, depending on the high-growth definition. Introducing R&D intensity thresholds, such as a minimum of 15% related to turnover[13] (*inn43*) proves to be rather strict: we notice that at most 1% of the companies are flagged as HGIEs, depending on the high-growth definition – for instance, the Eurostat and OECD high-growth thresholds (applying any growth measure) renders less than 0.5% of the companies HGIEs.

It is fair to conclude that the share of HGIEs in Europe are highly sensitive to the definitions applied. Much of the observed sensitivity is due to the uncertainty in the growth threshold used for the absolute measures, rather than for the relative (top of growth distribution) measures. As shown by **Table 7**, the differences between the turnover and employment-based measures tends to be significantly higher for the absolute measures than for the relative ones (5.2 vs. 1.1% for the set

[13] This is one of the elements of the "young, innovative company (YIC)" definition applied in various funding instruments across Europe.

selected measures, or 1.4% in the case of the Birch indices), and the difference only decreases if we apply a high growth threshold (100%).

Uncertainty in the measurement of innovation is a further source of sensitivity. The main selection criteria are the inclusion of certain types of innovation (such as technological or non-technological), or the implementation of a degree of novelty threshold reduces the share of HGIEs regardless of the high-growth measurement.

Table 7 Difference in the share of firms identified as HGIEs due to employment- vs. turnover-based measures of high-growth if any type of innovation is considered

Absolute	**Growth threshold** (relevant variables)	**10%** (hg1, hg6)	**15%** (hg2, hg7)	**21%** (hg3, hg8)	**44%** (hg4, hg9)	**100%** (hg5, hg10)	**Average**
	Employment	14.3%	10.6%	7.4%	2.6%	0.5%	7.1%
	Turnover	21.8%	17.7%	14.0%	6.1%	1.4%	12.2%
	Difference	*7.5%*	*7.2%*	*6.6%*	*3.5%*	*1.0%*	*5.2%*
Relative	**Top … % of growth distribution** (relevant variables)	**5%** (hg15, hg19)	**10%** (hg16, hg20)	**15%** (hg17, hg21)	**25%** (hg18, hg22)		**Average**
	Employment	1.2%	2.3%	3.6%	6.2%		3.3%
	Turnover	1.6%	3.2%	4.8%	8.0%		4.4%
	Difference	*0.4%*	*0.8%*	*1.2%*	*1.8%*		*1.1%*
	Top … % of growth distribution (relevant variables)	**5%** (hg23, hg27)	**10%** (hg24, hg28)	**15%** (hg25, hg29)	**25%** (hg26, hg30)		**Average**
	Birch index (employment)	1.2%	2.5%	3.8%	6.3%		3.4%
	Birch index (turnover)	1.8%	3.5%	5.3%	8.7%		4.8%
	Difference	*0.6%*	*1.1%*	*1.5%*	*2.4%*		*1.4%*

Note: the shares were obtained using any type of innovation (*inn6*) in combination with the high-growth measures reported in the table.

Figure Error! No text of specified style in document. Heat-map of the share of high-growth and innovative enterprises in Europe

HGiINNj		inn1	inn2	inn3	inn4	inn5	inn6	inn7	inn8	inn9	inn10	inn11	inn12	inn13	inn14	inn15	inn16	inn17	inn18	inn19	inn20	inn21	inn22	inn23	inn24	inn25	inn26	inn27	inn28	inn29	inn30	inn31	inn32	inn33	inn34	inn35	inn36	inn37	inn38	inn39	inn40	inn41	inn42	inn43	inn44	inn45	inn46	inn47	inn48	inn49	inn50
		Prod.	Proc.	Pd/Pc	Org/Mkt		Any	new2mk	cntry1st	world1st		new2frm	new2frm/mkt % sales				New2mkt % sales			New to world %...			in-house R&D...			Top R&D spenders...						Top R&D intensity...						Top overall inn spending intensity						RDi15%+	No inRD		NonR&D	Knowledge		Intensive...	
hg1	EMPL	7%	8%	10%	11%	4%	14%	5%	3%	2%	2%	5%	1%	1%	2%	3%	0%	1%	1%	0%	0%	0%	7%	6%	4%	3%	1%	10%	1%	7%	1%	3%	1%	11%	1%	7%	1%	3%	1%	4%	1%	3%	1%	1%	3%	3%	4%	3%	4%	0%	0%
hg2	EMPL	5%	6%	7%	8%	3%	11%	4%	2%	1%	1%	4%	1%	1%	1%	2%	0%	1%	1%	0%	0%	0%	5%	4%	3%	2%	0%	8%	0%	5%	0%	2%	1%	8%	1%	6%	1%	2%	1%	3%	1%	2%	1%	1%	2%	2%	3%	2%	3%	0%	0%
hg3	EMPL	4%	4%	5%	6%	2%	7%	3%	1%	1%	1%	3%	0%	1%	1%	2%	0%	0%	1%	0%	0%	0%	3%	3%	2%	1%	0%	5%	0%	4%	0%	2%	0%	6%	0%	4%	0%	2%	1%	2%	1%	2%	1%	0%	2%	2%	2%	2%	2%	0%	0%
hg4	EMPL	1%	1%	2%	2%	1%	3%	1%	0%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%	1%	1%	0%	0%	2%	0%	2%	0%	1%	0%	2%	0%	2%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg5	EMPL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	c.	c.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	c.
hg6	SALES	12%	12%	16%	17%	6%	22%	8%	4%	3%	2%	8%	1%	1%	3%	5%	1%	1%	2%	0%	0%	0%	11%	9%	6%	5%	1%	15%	1%	10%	1%	4%	1%	15%	1%	10%	1%	5%	2%	5%	2%	5%	2%	1%	5%	5%	7%	4%	5%	0%	0%
hg7	SALES	9%	10%	13%	14%	5%	18%	6%	3%	2%	2%	7%	1%	1%	2%	4%	0%	1%	2%	0%	0%	0%	9%	8%	5%	4%	1%	12%	1%	8%	1%	4%	1%	12%	1%	8%	1%	4%	1%	4%	1%	4%	1%	1%	4%	4%	5%	3%	5%	0%	0%
hg8	SALES	7%	8%	10%	11%	4%	14%	5%	3%	2%	2%	5%	1%	1%	2%	3%	0%	1%	1%	0%	0%	0%	7%	6%	4%	3%	1%	9%	1%	7%	1%	3%	1%	9%	1%	7%	1%	3%	1%	3%	1%	3%	1%	1%	3%	3%	4%	3%	4%	0%	0%
hg9	SALES	3%	3%	4%	5%	2%	6%	2%	1%	1%	1%	2%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	3%	2%	2%	1%	0%	4%	0%	3%	0%	1%	0%	4%	0%	3%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	2%	1%	2%	0%	0%
hg10	SALES	1%	1%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hg11	Birch Empl.	13%	14%	18%	20%	7%	25%	9%	5%	3%	3%	10%	1%	2%	3%	5%	1%	1%	2%	0%	0%	0%	12%	11%	7%	5%	1%	18%	1%	11%	1%	5%	1%	18%	1%	11%	1%	5%	2%	6%	2%	5%	2%	1%	6%	5%	8%	5%	7%	1%	0%
hg12	Birch Empl.	13%	13%	18%	19%	7%	25%	9%	5%	3%	3%	9%	1%	2%	3%	5%	1%	1%	2%	0%	0%	0%	12%	11%	6%	5%	1%	18%	1%	11%	1%	5%	1%	17%	1%	11%	1%	5%	2%	6%	2%	5%	2%	1%	6%	5%	8%	5%	7%	1%	0%
hg13	Birch Sales	17%	17%	23%	24%	9%	31%	11%	6%	4%	3%	12%	1%	2%	3%	6%	1%	1%	3%	1%	0%	0%	15%	13%	8%	6%	1%	22%	2%	13%	1%	6%	1%	22%	1%	13%	1%	6%	2%	7%	2%	6%	2%	1%	7%	7%	10%	6%	8%	1%	0%
hg14	Birch Sales	17%	17%	23%	24%	9%	31%	11%	6%	4%	3%	12%	1%	2%	3%	6%	1%	1%	3%	1%	0%	0%	15%	13%	8%	6%	1%	22%	2%	13%	1%	6%	1%	22%	1%	13%	1%	6%	2%	7%	2%	6%	2%	1%	7%	7%	10%	6%	8%	1%	0%
hg15	Top Empl	1%	1%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	c.	0%	0%	0%	0%	0%	1%	0%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hg16	Top Empl	1%	1%	2%	2%	1%	2%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	0%	0%	2%	0%	2%	0%	0%	0%	2%	0%	2%	0%	0%	0%	1%	0%	1%	0%	0%	1%	1%	1%	0%	1%	0%	0%
hg17	Top Empl	2%	2%	2%	3%	1%	4%	1%	1%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	2%	1%	1%	1%	0%	3%	0%	2%	0%	1%	0%	3%	0%	2%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg18	Top Empl	3%	3%	4%	5%	2%	6%	2%	1%	1%	1%	2%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	3%	2%	2%	1%	0%	5%	0%	3%	0%	1%	0%	5%	0%	4%	0%	1%	1%	2%	1%	1%	1%	0%	1%	1%	2%	1%	2%	0%	0%
hg19	Top Sales	1%	1%	1%	1%	0%	2%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hg20	Top Sales	2%	2%	2%	3%	1%	3%	1%	1%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	0%	2%	0%	2%	0%	1%	0%	2%	0%	2%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg21	Top Sales	3%	3%	3%	4%	1%	5%	2%	1%	1%	1%	2%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	2%	2%	1%	1%	0%	3%	0%	3%	0%	1%	0%	3%	0%	3%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg22	Top Sales	4%	4%	6%	6%	2%	8%	3%	2%	1%	1%	3%	0%	1%	1%	2%	0%	0%	1%	0%	0%	0%	4%	3%	2%	2%	0%	5%	0%	4%	0%	2%	0%	5%	0%	4%	0%	2%	1%	2%	1%	2%	1%	0%	2%	2%	2%	2%	2%	0%	0%
hg23	Top Birch Er	1%	1%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hg24	Top Birch Er	1%	1%	2%	2%	1%	2%	1%	0%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	0%	2%	0%	2%	0%	1%	0%	2%	0%	2%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg25	Top Birch Er	2%	2%	3%	3%	1%	4%	1%	1%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	2%	2%	1%	1%	0%	3%	0%	2%	0%	1%	0%	3%	0%	2%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg26	Top Birch Er	3%	3%	5%	5%	2%	6%	2%	1%	1%	1%	2%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	3%	3%	2%	1%	0%	5%	0%	4%	0%	1%	0%	5%	0%	4%	0%	1%	1%	2%	1%	1%	1%	0%	1%	1%	2%	1%	2%	0%	0%
hg27	Top Birch Sales	1%	1%	1%	1%	0%	2%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	1%	0%	1%	0%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
hg28	Top Birch Sales	2%	2%	3%	3%	1%	4%	1%	1%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	2%	2%	1%	1%	0%	3%	0%	2%	0%	1%	0%	3%	0%	2%	0%	1%	0%	1%	0%	0%	0%	0%	1%	1%	1%	1%	1%	0%	0%
hg29	Top Birch Sales	3%	3%	4%	4%	1%	5%	2%	1%	1%	1%	2%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	3%	2%	1%	2%	1%	4%	1%	2%	0%	1%	0%	3%	0%	2%	0%	1%	0%	1%	0%	1%	0%	0%	1%	1%	1%	1%	2%	0%	0%
hg30	Top Birch Sales	5%	5%	7%	7%	2%	9%	3%	2%	1%	1%	3%	0%	1%	1%	2%	0%	0%	1%	0%	0%	0%	5%	4%	2%	2%	1%	6%	1%	4%	1%	2%	0%	5%	0%	3%	0%	1%	0%	2%	1%	1%	0%	0%	2%	2%	2%	2%	2%	0%	0%

Source: authors' calculations based on CIS2012 microdata; N=92,926. The graph presents the share of HGIEs according to the different definition combinations described above in the weighted, pooled European data.

4.3 High-growth and innovative performance of countries and sectors

While the 30 and 50 alternative definitions for high-growth and innovative enterprises was useful to better understand differences in magnitude across the various definitions, the excessive complexity is less helpful when the aim is comparing the high-growth, innovative performance of countries and sectors. Many of the definitions are potentially overlapping. For these reasons, we explore ways of reducing the dimensions. Our aim is to propose one or a few aggregate measures for high-growth and innovativeness at the company level. In order to do so, we first assess the association pattern of the various hg_i and inn_j measures, before discussing the key issues and results of a proposed method of aggregation.

4.3.1 Association between high-growth and innovation variables

To simplify the discussion of our findings, we consider as our baseline the "Eurostat definition"-based measure – average 10% annualized employment growth (21% over the 2-year period), *hg3*. This indicator is positively associated with the other 29 measures (see **Table A1** in the Appendix)[14]. It is associated relatively more strongly with the set of definitions using an employment-based indicator of growth – those that apply both the fixed (*hg1-hg5*) and the relative thresholds (*hg15-18*), as well as those defined according to the top of the distribution following the employment-based Birch index measure (*hg23-26*). It is worth highlighting the two strongest observed association in order to see what other relative and absolute measures are statistically the closest to the "Eurostat definition". The set of firms in our sample selected by the 10% annualized average employment growth definition (*hg3*) shows the greatest similarity to a relative definition that selects firms among the top 25% in terms of employment growth (*hg18*). The *hg3* definition is also highly similar in statistical terms to *hg1* and *hg2*, definitions that apply – the more restrictive – absolute thresholds of 10% and 15% employment growth, respectively, over the two-year period.

The "Eurostat" definition and the "employment-based OECD EIP" definitions (*hg3* and *hg4*) are associated positively, but moderately, as expected from the fact that the two definitions capture 12% and 4% of the sample firms, respectively. The two variables are associated in a different way to the top-of-distribution-based set of variables defined in terms of employment (*hg15-hg18*). We notice that in general, the OECD EIP definition is in general more strongly associated with all the top-of-distribution-based definitions, and particularly strongly with those applying the 10 and 15% growth threshold (*hg16* and *hg17*).

The statistical similarity between employment-based and turnover-based measures of growth are relatively lower – as indicated by the degrees of association between the above-discussed *hg3* and absolute and relative turnover-based variables (i.e., *hg6-hg10; hg19-hg22*). Relatively the strongest association is observed between *hg3* and the variable using the same 10% annualized absolute growth threshold *hg8* as well as the *hg22*, capturing the top 25% of the turnover distribution.

The turnover-based definitions in a sense mirror those of the employment, given the relatively stronger "inter-group" association between the variables applying an absolute threshold *hg6-hg9* (*hg10*, with the most restrictive 100% growth limit is stands out in a similar way as *hg5* does from among the employment-based measures).

We defined Birch indices in two ways, based on absolute thresholds and relative (top N%) thresholds. We observe that for the absolute thresholds that there is virtually no difference between the 10% and 100% thresholds in the case of both the employment-

[14] In our tests we computed Pearson correlation coefficients. Obtained coefficients should be interpreted with caution in the case of binary variables, so we refrain from reporting scores, but focus on the magnitude and signs, which may be considered useful given the similarity with results obtained using i.e. Pearson's 'Phi coefficient'.

(*hg11-hg12*) and turnover-based (*hg13-hg14*) measures of Birch index. At the same time, the two sets of measures show a rather low association.

We also defined Birch indices in the relative way, based on top N% of the distribution – both using employment and turnover as measures of growth. These two sets of Birch indices – based on employment (*hg23-hg26*) and turnover change (*hg27-hg30*) – show little or no association with one another. Within-group association is relatively high in both cases. The main difference between the top N% employment change-based and turnover change-based sets of variables is the strength to which the two variables are associated with the absolute and relative set of measures of growth using simply employment or turnover change, not the Birch index. While the employment-change-based, relative (top N%) definitions of the Birch index is overall strongly associated with the absolute and (*hg23-hg26* vs *hg1-hg3*) relative measures of employment (*hg23-hg26* vs *hg15-hg18*), the turnover-based Birch index that applies the relative threshold (*hg27-hg30*) shows rather low association with the two sets of sales-based variables (*hg6-hg10* and *hg19-hg22*). A notable exception is *hg30*, which applies the least restrictive top 25% of Birch index growth distribution, which shows relatively higher degree of association with the rest of the sales variables.

These observations on the association pattern leads us to affirm that the **key sources of differences between the high-growth variables** are whether defined based on employment or turnover change, and the cut-off threshold applied. While we see also differences between the absolute and relative measures, these, however, have a lesser impact and a disproportionate one in the case of employment and turnover-based definitions. For instance, in the case of the employment-based definition applying an absolute threshold, a general pattern shows a break between the 21% and 44% growth rate over the two years, while in case of sales, the main difference, in general, is due to moving from 44% to 100% absolute threshold. This difference is not observable in such a marked way in the case of the relative measures.

Among the **innovation variables**, our two baseline measures are product innovators (*inn1*) and innovators of any type (*inn6*). Product innovators are positively associated with process innovators (*inn2*), but not as strongly as product innovators with firms that introduced any technological (product or process) innovation (*inn3*) or new-to-firm product or process innovations (*inn11*). Product innovators are also positively associated with firms performing in-house R&D (whether or not continuously employing R&D staff) (*inn22-24*). At the same time, the product innovation variable shows little association with the non-R&D innovators variable (*inn46*).

Firms with any type of innovation are most strongly associated with organizational or marketing innovators (*inn4*), followed by product or process innovators (*inn3*).

We notice that process innovator firms (*inn2*) show a moderate, positive association with non-R&D innovators (*inn46*), and positive association with any type of innovators (*inn6*). Organizational or marketing innovators stand somewhat apart from the rest of the innovation types (with the exception, by definition, of 'any type' of innovators).

The basic definitions of innovation types (*inn1-inn6*) show little or no association with the set of variables based on top 10% R&D and innovative spending (*inn25-inn42*). Within this group, product innovators tend to be relatively more associated with top 10% R&D spenders across all firms (*inn1-inn25*), but the association decreases for process innovators and organizational or marketing innovators, and decreases even more when top 10% R&D spenders are selected within industrial sectors or countries (*inn27* and *inn33*). Apart from these latter two variables, the third variable that is persistently negatively or not associated with the rest of the variables is the one measuring firms that introduced a non-technological innovation, but did not introduce a technological innovation (*inn5*).

Most of the variable groups that by construction show little difference are closely associated, for instance, the group of variables by novelty (*inn7-inn10* in which *inn9* and *inn10* are essentially identical, whereas *inn11*, defining the least radically new innovation definition stands apart); the group of variables with new-to-market share of sales (*inn12-inn15*) or variables by overall innovation spending intensity (*inn37-inn42*).

In sum, the two main source of differences across the innovation variables is the inclusion or not of organizational or marketing innovation, and the introduction of a novelty threshold. We also included among the innovativeness variables other measures of innovation input, such as R&D expenditure, intensity or innovation spending intensity, as well as knowledge intensity (a high share of tertiary graduates among employees). We notice that these contextual variables show little overlap with the main set of definitions, in other words, select a different population of firms in comparison to the main types of innovators.

4.3.2 Towards aggregate scores of high-growth and innovation

While in a the cases reported above, some variables of high-growth and innovation overlap, but a larger set of them do not, implying that unless we retain multiple dimensions, much of the information contained in the individual variables are lost. This presents us with a choice whether to retain all the information contained in the variables or select only the most relevant ones. We recall that we introduced many of the alternative definitions for high-growth and innovation with the explicit purpose to increase the variance in the set of alternatives for analytical purposes, but the set of variables discussed above may not be equally relevant for policy purposes. Therefore, in this exercise, we chose to propose a concept-driven selection of one or two statistically robust dimensions, in line with our goal of offering sectoral and country-level average performance in the two measures derived from firm-based performance.

We also tested, but abandoned two alternative ways of aggregating variables of high-growth and innovation. The first approach aimed to make use of all variables, assigning firms a score of 1 if it performs above the median in the various measures. The main problem with such an approach was the fact that the median value was 0 for 28 of the 30 high-growth variables and 49 of the 50 innovation variables. Consequently, this method would essentially measure the number of times a firm meets the 28 or 49 criteria, which would be biased by the double counting of strongly associated variables. A second alternative was to follow a principal component analysis (PCA) based approach to identify multiple dimensions for both high-growth and innovation. The main limitation of this approach was the difficulty to find a conceptual (and intuitive) foundation for the 7 and 13 latent dimensions identified.[15]

For selecting the set of relevant variables of **high growth**, our baseline measures were the two variables following the "Eurostat definition" (*hg3*) as well as the OECD EIP's employment-based definitions (*hg4*). Using the observed association and statistical support by PCA, we noted that five variables based on the absolute threshold in terms of employment growth (*hg1, hg2, hg3, hg4*) as well as in terms of the Birch index (growth >=10%) (*hg11*) were associated with a single latent dimension. This dimension, which explained 65.9% of variance in the firm-level data, can be interpreted as "**high employment growth measured applying absolute thresholds**". We henceforth refer to this index as the "absolute" high-growth pillar 1, or HG-P1.

Our strategy was to next identify a statistically coherent pillar which essentially identifies high-growth using relative, rather than absolute thresholds. Among these variables, we found that relative measures of employment growth in the top 25% of the employment

[15] We also note the limitations of PCA in case of a high number of dimensions of binary data, however, alternative methods such as polychoric PCA require excessive computation on the number of observations which would have required longer time at the Eurostat Safe Centre.

growth (*hg15-18*) and top 5% of sales (*hg19*) growth distribution, or the top 5, 15, and 25% of growth distribution measured in terms of the (employment-based) Birch index (*hg23, hg25, hg26*) are strongly associated with a single latent dimension. We interpret this dimension (which explains about 63.7% of variance in the data) as a "**relative measure of high growth**". We henceforth refer to this index as the "relative" high-growth pillar HG-P2.

Using the 'any type of innovation' (*inn6*) as the baseline, we also computed an aggregate index for innovativeness. The purpose of an aggregate index is to be broader than one single measure, as we acknowledge the inherent uncertainty in the measurement of innovativeness.

Making use of the association patterns discussed above and aiming to ensure a statistically coherent index, we selected an aggregate that capture innovators with successful product (*inn1*), process (*inn2*), any of these two (*inn3*), or any type (including organizational and marketing) (*inn6*) of innovations. In additions, we further added two variables quantifying the degree of novelty of technological innovations, those that are new to the world (*inn9*) or new to the firm (*inn11*). These six variables were all associated with a single latent dimension, capturing 61.4% of variance in the data. We refer to this index as the "**successful innovators**" pillar (INN-P1). We chose not to aggregate further measures of innovation as these already captured all main types of innovation, as well as variables referring to degrees of novelty of innovations, and we considered many of the additional measures related to R&D and knowledge-intensity as contextual ones that do not refer to successful innovation outcomes.

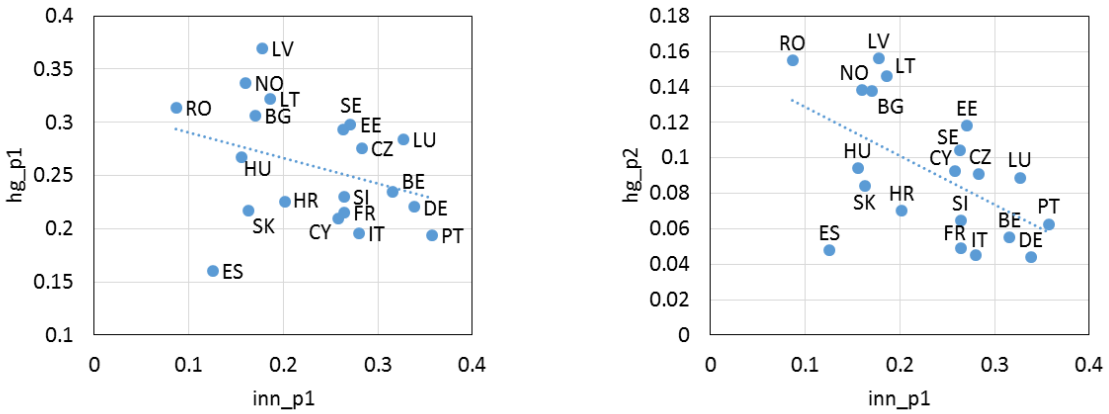
For each of the three pillars, we computed aggregate pillar index scores at the firm level by taking the averages of the relevant component variables. We subsequently aggregated the pillar scores by country as well as 1- and 2-digit NACE sectors.

4.3.3 Cross-country and cross-sectoral evidence

We first assessed how countries performed in terms of high-growth and innovativeness by aggregating relevant firm-level scores by country. The obtained scores plotted in **Figure 8** show that both the absolute and relative high-growth pillars (HG-P1 and HG-P2) are anti-correlated with the successful innovators pillar (INN-P1) at the country level (see also left part of **Table 8**). The reason why Spain noticeably stands apart from the rest of the countries is that we used data for many of the non-core innovation activities, typically service sectors that are not available for other countries. The negative correlation between HG-P2 (relative) and INN-P1 are significant at 5% level, while the correlation between HG-P1 and INN-P1 are not significant. However, should we choose to exclude Spain, the negative correlation between HG-P1 and INN-P1 increases in strength (-0.54, at 5% significance level) as does the correlation between HG-P2 and INN-P1 (-0.71, at 1% sign.). The negative correlation is also consistently observed within the three size classes, and is the strongest among large firms.

What we see is that countries with firms that are strongest in introducing successful innovation are relatively weaker in terms high-growth (a prime example are Germany, France and Italy), and vice versa, the less innovative firms grow fast in countries of Eastern Europe and the Baltics, such as Romania, Bulgaria, Latvia and Lithuania, and also in Norway. The two high-growth pillars HG-P1 and HG-P2 are strongly correlated (r=0.9), hardly distinguishing, at this level, country performance.

Figure 8 High-growth vs innovation performance of sample firms at country level



Source: authors' calculations based on CIS2012 microdata**;** [weighted sample; country average of scores in N=92,926]

Table 8 Correlation between the high-growth and innovation aggregate indices at the country and sectoral (NACE 1- and 2-digit) level

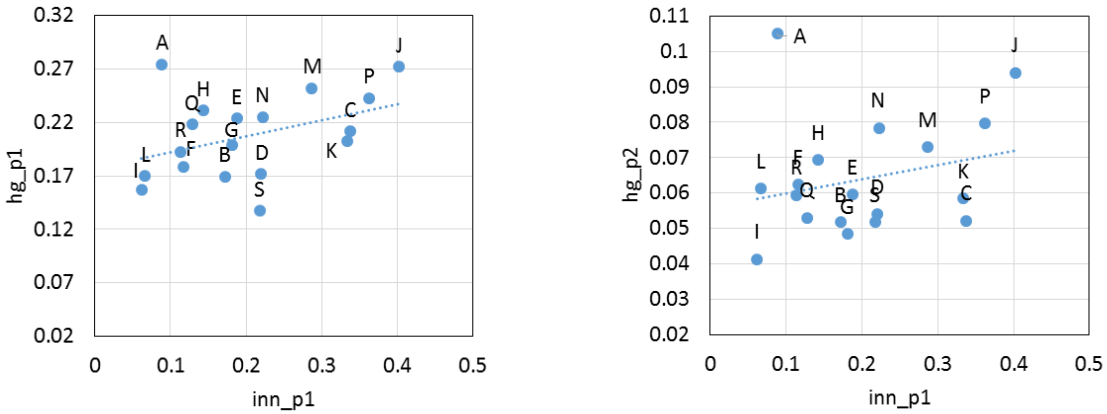
	Country-level			NACE 1-digit			NACE 2-digit		
	inn_p1	**hg_p1**	**hg_p2**	**inn_p1**	**hg_p1**	**hg_p2**	**inn_p1**	**hg_p1**	**hg_p2**
inn_p1	1			1			1		
hg_p1	-0.329	1		0.406 *	1		0.183	1	
hg_p2	-0.553 **	0.904 ***	1	0.257	0.819 ***	1	-0.012	0.774 ***	1

Source: authors' calculations based on CIS2012 microdata; N countries = 20; N sectors (1-digit) = 18; N sectors (2-digit) = 83. Stars indicate significance at 1, 5 and 10%.

The negative correlation between high-growth and innovation scores observed at the country reverses as soon as we look at the indices in a **large industrial cross-section** (NACE 1-digit level, pooled European data – see middle part of **Table 8**). The change in the correlation pattern suggests that country performance in the two dimensions is largely influenced by countries' sectoral specialization. Unfortunately, disaggregating the obtained index scores to a fine-grained sectoral level by each country is not possible due to confidentiality considerations.

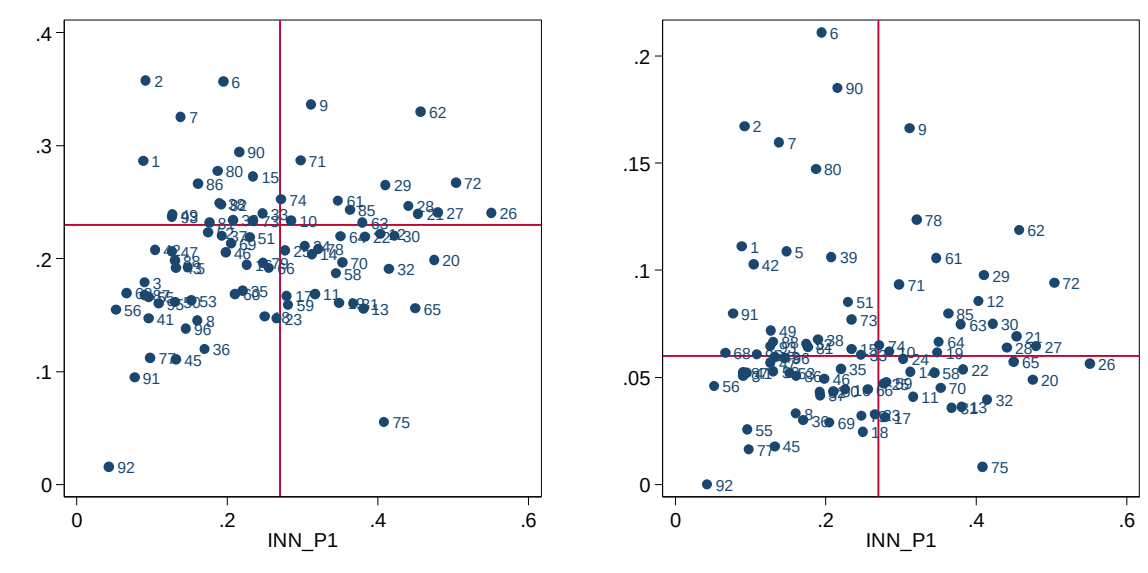
Figure 9 reveals that service sectors typically associated with the "knowledge economy" (J - Information and communication; M – Professional, scientific and technical activities; and P – Education) are also strong performers in terms of high growth. Accommodation and food service activities (I) turn out to be neither innovative, nor fast-growing sectors. We register a relatively lower high-growth performance for the rather innovative financial (K) and manufacturing (C) industries, but a strong growth performance for the Agricultural, forestry and fishing sector (A), which is weak in terms of innovative performance. In fact, agriculture is an outlier sector outside the core innovation activities, thus countries provide data on a voluntary basis, which is why it is less representative. Removing sector A from the sample renders all correlations positive and significant at the 2% level.

Figure 9 High-growth vs innovation performance of sample firms by large sectors (NACE 1-digit)



Source: authors' calculations based on CIS2012 microdata

Figure 10 High-growth vs innovation performance of sample firms by sectors (NACE 2-digit)



Source: authors' calculations based on CIS2012 microdata. *Note*: red lines indicate average performance by dimension.

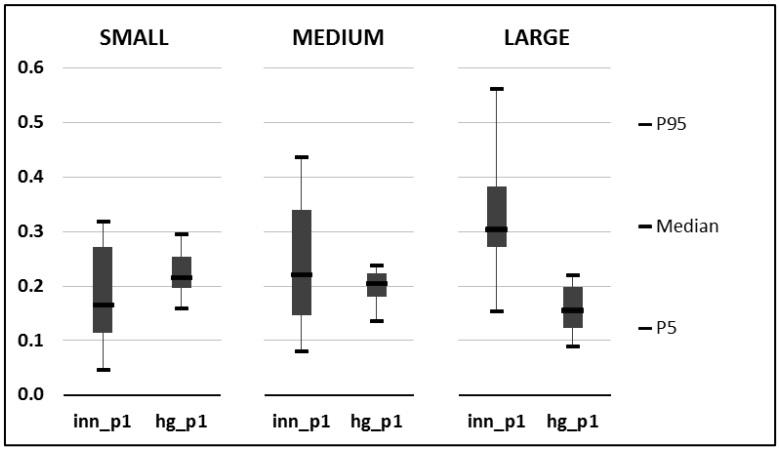
Curiously, at a more fine-grained sectoral level, the positive association between high-growth and innovation disappears (NACE 2-digit level, pooled European data – see right part of **Table 8**). While part of this is due to the within-sectoral heterogeneity of firm performance in the three observed dimensions, the scatterplots in **Figure 10** also reveal that a few subsectors of agriculture and mining, as well as outliers in the service sector, such as M75 (veterinary activities) add noise to the data. In fact, excluding these sectors results in a clearly positive correlation between HG_P1 and the Innovation pillar. However, still no association is found between the "relative measure of high growth" HG_P2 and innovation pillar. In comparison with the country-level or large sectoral level, the two high-growth pillars HG_P1 and HG_P2 show somewhat different performance of 2-digit sectors.

The sectors found to be both high-growth (in both measures) and innovative, according to **Figure 10**, are rather intuitive, as they include a set of knowledge-intensive manufacturing (including computer, electronics and optical parts – 26; electrical

equipment – 27; machinery and equipment – 28; motor vehicles – 29; and pharmaceuticals - 21) and service activities (such as scientific R&D – 72; computer programming – 62; or Telecommunications – 61). At the same time, many firms also seem to have found considerable growth opportunities in many less-innovative sectors. These are rather diverse, encompassing natural resource-based industries (oil and gas extraction – 6; or mining of metal ores – 7), as well as waste collection, treatment, etc. – 38 or manufacture of leather – 15. Sectors in the lower right corner of the two graphs are more innovative than the average, but underperform in terms of the average share of high growth firms. This either refers to situations where technological opportunities and market opportunities are not aligned, or where innovation is needed for business to survive, rather than to grow. A good example for this situation is the chemical industry (20), which is characterized by large, innovative, but slow-growing firms.

Industry scores can be further broken down by size class. As shown by **Figure 11**, innovation performance (INN_P1) tends to increase by firm size. This is exactly the oppose trend observed for the (absolute) high-growth performance (HG_P1), which tends to decrease by size class. This is an important observation which reveals at least part of the complexity of the relationship between high-growth and innovation. It also suggests that firms of different size are likely to face different obstacles and opportunities to innovation or the likelihood to achieve high growth, which warrants more in-depth studies as well as carefully targeted policy measures.

Figure 11 Distribution of sectoral (NACE 1-digit) HG_P1 and INN_P1 indices by size class



Source: authors' calculations based on CIS2012 microdata. *Note:* Shaded area of box plots capture 50% of the index scores' distribution across NACE 1-digit sectors, 90% of distribution ranges within whiskers.

5 Conclusions

In this study, we attempted, for the first time, to measure the share of high-growth, innovative firms in Europe, by recognizing the uncertainty in the definition as to the delineation of high growth performance (as well as innovation performance). We proposed a method to identify the differences across multitude of potentially viable methods making use of the growth-innovation matrix.

Disregarding the uncertainty in the definition, and using Eurostat's high-growth definition and the broadest understanding of innovation (the successful introduction of any kind of innovations), we may conclude that 7% of European companies are HGIEs. However, we found that, as expected, the definitions significantly influence the share of firms flagged as HGIEs. The observed share of HGIEs in the pooled European data from the CIS2012 ranged between 0.1 and 31%, and between 0.1 and 10% in case of 90% of the proposed definition combinations. While our results confirm the sensitivity of outcomes to the choice of the growth indicator and measure (Delmar and Davidsson, 1998), we also add two qualifications. First, we extended the sensitivity to the definition of innovativeness, and second, we highlighted the key sources of sensitivity. Recognizing the difference in the outcomes whether high-growth is measured in terms of employment or turnover growth, we found that the choice of absolute versus relative thresholds mattered even more. As for defining innovation, the key choices were found to be whether to include non-technological (organizational or marketing) innovation alongside the variables of technological innovation, and whether to impose a degree of novelty (or radicalness) threshold. Policy targeting high-growth, innovative firms need to exercise particular attention to these uncertainties in order to better address the intended target population of firms.

Using aggregate indices of high-growth (based on the absolute employment growth thresholds and a broader, relative threshold) and innovation, we found evidence of negative correlation between high-growth and innovation at the country level, which disappeared at a pooled, European sectoral level. This calls for further investigation to go beyond the observation of such associations, and understand the driving forces. One of the potential sources is the firm size structure in countries and sectors. We notice that high-growth firms are overrepresented among small firms, while innovative firms are overrepresented among large firms. In order to support economy-wide employment growth, inter-sectoral as well as inter-firm linkages – through which companies of different size can benefit from innovation as well as growth opportunities – need to be carefully studied. There is also need for a better understanding of the different kinds of barriers firms of different size face with regards to innovation and growth. It is also important to understand how successful firms managed to achieve high growth, what strategies did they follow and what obstacles did they face, i.e. in terms of availability of finance or regulatory conditions.

In light of the observed negative correlation at the country level, it is also important to recognize that in many cases, policy may be chasing two targets that are unachievable at the same time. A potential source of trade-off between high-growth and innovativeness, especially in countries of Eastern Europe, is the need to upgrade the technological capabilities of often large firms. A primary tool for this is diffusion of innovations across countries and across sectors, rather than the introduction of world-first novelties.

Many of the limitations of our study were linked to the properties of the data we chose to analyse. Measuring the share of high-growth, innovative enterprises requires firm-level data on both growth performance as well as innovation, ideally for a representative sample of the European economy. Business registers are useful sources for measuring growth, but offer little if any information on innovation performance. CIS data offers sophisticated information on innovation and some information on firm performance, but – at least if the aim is to offer results at the European level – offers no information on whether the growth of a firm is persistent over time, and includes only limited financial

data. Introducing linkages across survey waves or with other firm surveys would therefore be highly welcome for enriching the analysis. Similarly, if microdata were available for research use for countries currently not covered in this analysis would offer a more complete picture of European HGIEs beyond the 20 countries we could cover. Our analysis was carried out on the CIS2012. The findings may be to a certain extent overshadowed by the slow recovery from the financial crisis of 2007/08. It may be therefore informative to repeat the analysis in the future on other CIS waves, not only for a test of robustness, but also to be able to use the obtained country- or sectoral performance scores as indicators plotting the trends in business dynamics.

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List of abbreviations and definitions

CIS	Community Innovation Survey
EIP	Entrepreneurship Indicators Programme
EIS	European Innovation Scoreboard
EU	European Union
HGIE	High-growth, innovative enterprises
IOI	Innovation Output Indicator
NACE	Statistical Classification of Economic Activities in the European Community (nomenclature statistique des activités économiques dans la Communauté européenne)
OECD	Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
R&D	Research and development

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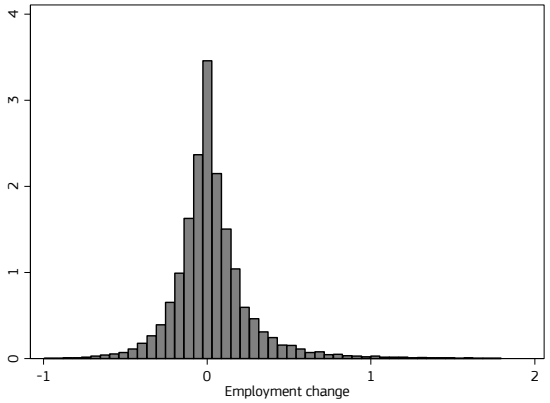
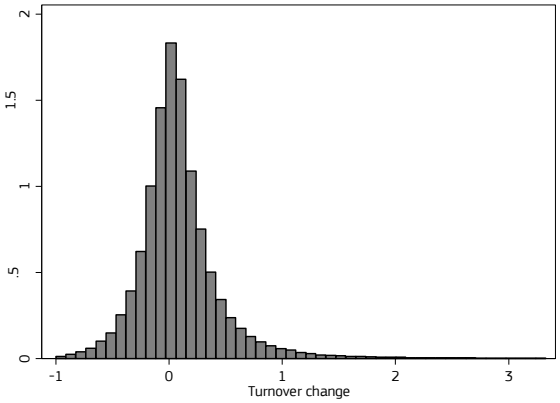
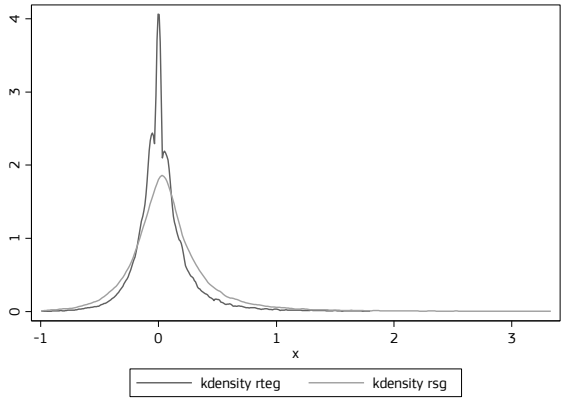
Figure A1 Distribution of growth across firms in the overall sample and kernel density plot





Kernel density plots of the employment change ['rteg'] and turnover change ['rsg'] variables



Source: authors' calculations based on CIS2012 microdata

Table A1 Firm-level correlation among the variables defining high-growth (hg1-hg30)

		EMPL					SALES					Birch Empl.		Birch Sales		Top Empl				Top Sales				Top Birch Empl.				Top Birch Sales			
		hg1	**hg2**	**hg3**	**hg4**	**hg5**	**hg6**	**hg7**	**hg8**	**hg9**	**hg10**	**hg11**	**hg12**	**hg13**	**hg14**	**hg15**	**hg16**	**hg17**	**hg18**	**hg19**	**hg20**	**hg21**	**hg22**	**hg23**	**hg24**	**hg25**	**hg26**	**hg27**	**hg28**	**hg29**	**hg30**
hg1	EMPL	1																													
hg2	EMPL	0.823	1																												
hg3	EMPL	0.666	0.809	1																											
hg4	EMPL	0.383	0.465	0.575	1																										
hg5	EMPL	0.161	0.196	0.242	0.422	1																									
hg6	SALES	0.332	0.309	0.283	0.191	0.087	1																								
hg7	SALES	0.342	0.329	0.308	0.215	0.098	0.849	1																							
hg8	SALES	0.343	0.338	0.324	0.240	0.113	0.718	0.845	1																						
hg9	SALES	0.281	0.303	0.319	0.299	0.158	0.433	0.510	0.604	1																					
hg10	SALES	0.149	0.172	0.193	0.233	0.179	0.201	0.237	0.280	0.464	1																				
hg11	Birch Empl.	0.654	0.539	0.436	0.250	0.106	0.335	0.321	0.300	0.212	0.102	1																			
hg12	Birch Empl.	0.667	0.549	0.444	0.255	0.108	0.336	0.322	0.302	0.215	0.103	0.982	1																		
hg13	Birch Sales	0.279	0.245	0.215	0.136	0.058	0.694	0.590	0.498	0.301	0.140	0.340	0.338	1																	
hg14	Birch Sales	0.279	0.245	0.215	0.136	0.058	0.694	0.590	0.498	0.301	0.140	0.340	0.338	1	1																
hg15	Top Empl	0.254	0.308	0.381	0.662	0.637	0.136	0.154	0.176	0.236	0.210	0.166	0.169	0.095	0.095	1															
hg16	Top Empl	0.363	0.440	0.544	0.874	0.445	0.185	0.209	0.235	0.290	0.226	0.237	0.242	0.133	0.133	0.699	1														
hg17	Top Empl	0.450	0.546	0.675	0.852	0.359	0.219	0.245	0.270	0.311	0.224	0.294	0.300	0.159	0.159	0.564	0.807	1													
hg18	Top Empl	0.597	0.726	0.869	0.641	0.270	0.270	0.297	0.315	0.317	0.201	0.391	0.398	0.204	0.204	0.424	0.607	0.752	1												
hg19	Top Sales	0.153	0.177	0.199	0.237	0.174	0.210	0.248	0.293	0.486	0.934	0.106	0.108	0.146	0.146	0.222	0.238	0.233	0.208	1											
hg20	Top Sales	0.213	0.239	0.260	0.285	0.176	0.302	0.356	0.421	0.698	0.665	0.155	0.157	0.210	0.210	0.253	0.287	0.289	0.271	0.696	1										
hg21	Top Sales	0.250	0.275	0.295	0.296	0.167	0.376	0.443	0.524	0.855	0.535	0.189	0.192	0.261	0.261	0.248	0.295	0.310	0.303	0.560	0.804	1									
hg22	Top Sales	0.299	0.315	0.324	0.284	0.142	0.502	0.591	0.699	0.863	0.401	0.239	0.243	0.348	0.348	0.218	0.281	0.311	0.327	0.419	0.602	0.749	1								
hg23	Top Birch Empl.	0.249	0.298	0.365	0.599	0.572	0.132	0.148	0.167	0.215	0.194	0.166	0.169	0.094	0.094	0.670	0.622	0.540	0.410	0.201	0.220	0.218	0.203	1							
hg24	Top Birch Empl.	0.355	0.425	0.519	0.692	0.445	0.181	0.201	0.221	0.263	0.201	0.237	0.242	0.133	0.133	0.638	0.690	0.679	0.585	0.208	0.253	0.261	0.255	0.699	1						
hg25	Top Birch Empl.	0.439	0.526	0.632	0.706	0.359	0.216	0.237	0.257	0.288	0.203	0.294	0.300	0.161	0.161	0.562	0.698	0.727	0.686	0.211	0.262	0.281	0.285	0.564	0.807	1					
hg26	Top Birch Empl.	0.579	0.676	0.741	0.622	0.271	0.262	0.284	0.297	0.299	0.187	0.389	0.397	0.203	0.203	0.426	0.607	0.702	0.752	0.195	0.251	0.282	0.305	0.426	0.609	0.755	1				
hg27	Top Birch Sales	0.100	0.106	0.117	0.126	0.083	0.204	0.230	0.254	0.317	0.372	0.090	0.091	0.146	0.146	0.108	0.118	0.121	0.116	0.368	0.356	0.335	0.303	0.145	0.159	0.157	0.146	1			
hg28	Top Birch Sales	0.141	0.147	0.158	0.161	0.104	0.290	0.325	0.358	0.423	0.420	0.125	0.126	0.210	0.210	0.137	0.153	0.161	0.159	0.419	0.438	0.435	0.412	0.177	0.201	0.204	0.197	0.696	1		
hg29	Top Birch Sales	0.174	0.180	0.190	0.186	0.114	0.358	0.399	0.432	0.478	0.417	0.157	0.159	0.261	0.261	0.152	0.179	0.187	0.189	0.416	0.461	0.477	0.475	0.192	0.225	0.230	0.232	0.560	0.804	1	
hg30	Top Birch Sales	0.217	0.220	0.225	0.200	0.115	0.470	0.514	0.540	0.541	0.371	0.207	0.209	0.348	0.348	0.158	0.193	0.207	0.219	0.373	0.470	0.519	0.553	0.189	0.233	0.246	0.262	0.419	0.602	0.749	1

Source: authors' calculations based on CIS2012 microdata; N=92,926. Pearson correlation; all values are significant at 1% level.

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