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Is the R&D behaviour of fast growing SMEs different? Evidence from CIS III data for 16 countries

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Abstract

This paper studies the R&D behaviour of fast growing SMEs using CIS III data for 16 countries. We group the countries into three groups of countries that roughly have the same position in technological development. The first finding of the research is that that R&D is more important to high growth SMEs in countries that are closer to the technological frontier. The second finding is that high growth SMEs are more innovative than non-high-growth SMEs only for countries close to the technological frontier. This suggests that gazelles derive much of their drive from the exploitation of comparative advantages. From a policy perspective this suggest that there are important limits to centralise policies that aim at fostering high growth SMEs.

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1 Introduction

Small and medium sized firms (SMEs) and entrepreneurship figure prominently in policy discussions as the sources of high growth source of dynamism in modern developed and developing economies. Firm size has attracted much attention among policy makers. Many countries have introduced (or are planning to do so) policies that aim at fostering the take up of formal R&D activities in SMEs. However, SMEs are a heterogeneous group of firms. Some of them remain small over their entire life time while others remain SMEs for a small time. This contribution is dedicated to high growth SMEs. High growth firms are a special kind of SMEs. They are rapidly expanding young small and medium sized firms, and have been identified as very important drivers of employment gains (e.g. Birch, 1981, Davidsson et al., 1998, Schreyer, 2000, Henrekson and Johansson. 2008). Gazelles, as they are sometimes called - are the expression of the dynamic and evolutionary nature of entrepreneurial capitalism, where competition is dynamic based on differential productivities, product differentiation and doing things differently. Given the common observation that passing the barrier from existing to growing enterprises is anything but easy for firms - most SMEs either remain small or exit the market sooner or later - it is surprising that relatively little is known about this kind of firms. The best explanation for this is most likely that being a gazelle is a temporary phenomenon in the lifespan of an enterprise. Some firms settle down to remain SMEs, some become large firms, and others fail and disappear. While something is known about the employment creation of Gazelles, not much is known about the R&D behaviour of these high growth firms. Most studies that look at the innovation behaviour of gazelles consider small samples of firms or the firms are selected on the basis of some characteristics (e.g. venture capital financing). We use a representative data set and focus on the following research questions:

1. Are R&D strategies of rapidly growing firms similar across countries close or far away from the technological frontier? In other words we want to know whether innovation and R&D in particular are central to the growth performance of firms in the different EU countries?
2. Are gazelles more R&D active than comparable firms that do not grow that fast?

The paper is structured as follows: in the next section we provide a short literature survey on firm growth and innovation. Section 3 presents the CIS data we use to study the innovation behaviour of gazelles and descriptive statistics. In section 4 we present our results regarding the innovation behaviour of gazelles comparing high growth SMEs across country groups and within country groups. Section 5 provides results based on quantile regression in order to gauge the robustness of our results. Section 6 concludes the paper.

2 Background and hypothesis

The starting point of many studies in the economic literature of firm growth is 'Gibrat's Law' (see Santarelli et al., 2006). Gibrat's Law states that the rate of growth of a firm is independent of the firm's size, and therefore size has no influence on the firm's growth in subsequent periods. This law implies that firm growth rates are essentially random. Thus it stands in stark contrast to strategic management literature that explicitly assumes that firm growth is non-random. The strategic management literature holds that some firms better perform than others, because they adopt more appropriate strategies within a given environmental context. It has since been well established that Gibrat's Law is inconsistent with the empirical evidence. There is much evidence of a slight but statistically negative dependence of growth rate on size when a representative sample of firms is used for analysis. John Sutton refers to this negative dependence of growth on size as a 'statistical regularity' (Sutton, 1997). A number of researchers maintain that Gibrat's Law holds for large firms but not for small and young firms. Caves (1998) concludes that growth is independent of size for firms above a certain size threshold, whilst for smaller firms growth rates decrease with size. On average, younger firms grow faster than other firms, and the smallest firms grow faster than the rest (Schreyer, 2000, Caves, 1998).

A stylised result has emerged recently that regards the distribution of firm growth rates. It has been established for a large number of countries and industries (e.g. Stanley et al., 1996, Bottazzi and Secchi, 2006, Hölzl and Friesenbichler, 2008) across countries and industries seems to follow a tent shaped distribution with a mass of firms concentrated around growth rates marginally different from zero. The tails of the distribution are rather fat, i.e. while most firms do not grow there are a number of outliers on the right and left hand side. Hölzl and Friesenbichler (2008) were able to reproduce these results for both in high and low tech industries, in the old and new member states, for the entire sample and for single industries. This finding is important as it shows that gazelles are primarily an economic not a technological phenomenon. This evidence is confirmed also by Henrekson and Johansson (2008)in their survey of gazelle studies and by Acs, Parsons and Tracy (2008) for the USA.

R&D and innovation are generally acknowledged as the key drivers of firm performance. Catozzella and Vivarelli (2007) show convincingly using Italian CIS data that own R&D is not only relevant for the generation of novel know-how, products and processes but also central ingredients to understand new knowledge. According to the idea of 'absorptive capacity' put forward by Cohen and Levinthal (1989), firms with a low R&D intensity are less able to take advantage from research externalities and the potential spillover pool that is generated by other firms' R&D. Nevertheless, it has been difficult for researchers to find a direct relationship between R&D activity, like for instance R&D staff or expenditures and firm performance. There is vast literature which finds that innovating firms are more productive than non-innovators. Often, a positive effect of innovations on profit margin effect is larger than the growth effect, but in most studies the "likelihood of growing" increases with product innovation (e.g. Geroski and Machin, 1992, Roper, 1997, Freel, 2000, Ahn, 2002). Applying quantile regressions to four sectors with fast changing technologies, Coad and Rao (2006) find that innovation is of much greater importance to high growth firms. Thus available empirical evidence on the relationship between innovation and firm growth is mixed, since innovation is not only a means to growth. This stands in contrast to aggregate evidence, which clearly shows that R&D and innovation lead to higher growth at the level of countries. Are gazelles more innovative than other firms? Per definition, the above average performance of gazelles is due to innovation in a Schumpeterian sense: they combine existing input factors in novel ways and thus produce an innovation that enables them to outperform the market. Similarly, their role in the process of creative destruction seems to be greater than the importance of other firms. If the process of creative destruction works efficiently, fast growing firms can be the agents of dynamic reallocation of resources and decisively contribute to job creation (Henrekson and Johansson, 2008).

When we think about firm growth being embedded in macroeconomic growth processes, we need to take into account that fostering economic growth at the technological frontier may be better served by other firm strategies than those applied to foster economic growth in catch-up countries. The concepts of innovation and imitation are central to the analysis of technology gaps. Whilst backward economies can experience productivity growth by adapting existing technologies, frontier economies can experience productivity growth by pushing the world technological frontier forward. Using a highly stylised model Acemoglu, Aghion and Zililbotti (2006) show that high-skilled personnel and technology intensive firms are more important for economic growth in countries that are close to the technology frontier than for countries far from the frontier. Specifically, Acemoglu, Aghion, and Zilibotti (2006) show that a developing country that is behind the technological frontier will typically pursue a capital accumulation growth strategy ("investment-based growth"). At this development stage, there is less incentive to be highly selective of firms and managers as this is costly. Hence, we observe long-term business relationships between financial market agents and firms, which result in funds flowing to those established firms for capital accumulation purposes. Conversely, industrial countries that are at the technological frontier have a strong incentive for innovation, so they are very selective of firms and managers that can attain this goal. Financial markets will then fund these innovation activities leading to larger productivity gains ("innovation-based growth"). In short: The closer an economy is to the frontier the more important becomes innovation. From this perspective we are able to derive the following hypothesis:

Hypothesis 1 *Given the fact that there is a substantial technological distance between the old member states and the new member states in the European Union we will observe:*

1. *Both innovation input (R&D) and innovation success (share of products new to the market) play a substantially more important role in countries close to the technological frontier than in countries that are further away from the technological frontier.*

2. *The differences between gazelles and non-gazelles is more substantial for countries closer to the frontier than for countries farer away from the frontier.*

This hypothesis states explicitly that high growth strategies are dependent on the economic environment of firms, i.e. relative comparative advantage.

3 Data

3.1 CIS Data

We use Community Innovation Survey (CIS) data for our research. The CIS is a firm level survey conducted every 4 years in all EU member states as well as several other non-EU countries (e.g. Norway, Iceland). Four waves of the innovation survey have been carried out. We use the third survey (CIS3) in this study because it is the most recent CIS available for a large number of countries. CIS-3 covers innovation activity over the period 1998-2000. The data we use for this report was accessed at the Safe centre in Luxembourg. The sample consists of manufacturing firms in 16 countries (numbers in brackets indicate number of observations in our final sample: Austria (321), Belgium (472), Czech Republic (1320), Germany (1326), Estonia (687), Spain (3955), Finland (644), Greece (693), Hungary (912), Italy (5325), Latvia (730), Lithuania (599), Portugal (862), Sweden (710), Slovenia (955) and Slovakia (900) over the period 1998-2000.

Overall the CIS aims to provide a sound source of statistical data on innovation by using a stratified sample of companies: sampling rates differ across countries, and the stratification of the sample (by size-class and sector of activity) should ensure that the samples are representative. CIS data are increasingly being used as a key data source in the study of innovation at the firm level in Europe, Canada and Australia (e.g. Mairesse and Mohnen (2002)). CIS surveys of innovation are often described as 'subjective' because they ask individual firms directly whether they have been able to produce an innovation and to estimate the share of sales that could be ascribed to new or significantly improved products. The assessment of the innovative character of a particular activity is at least partially dependent on the views of the performer. However the evidence provided by Mairesse and Mohnen (2004) suggests that the subjective measures appear to be consistent with more objective measures of innovation, such as the probability of holding a patent and the share in sales of products protected by patents. The main advantage of the CIS data is that it contains detailed information on the innovation behaviour at the firm level in much greater detail than in other datasets. Thus, CIS data provides the possibility to study the innovation behaviour of gazelles in a differentiated and detailed way. The main drawback of the CIS data for the analysis of gazelles activity is that it is a cross sectional dataset. Analysing gazelles, time-series data would allow us to examine further questions, such as, for instance, which fraction of gazelles continues to grow fast, or which role the life cycles of firms plays in the gazelle phenomenon (we cannot look at the previous growth performance of gazelles).

3.2 Identification of high growth firms

Our definition of Gazelles quite closely follows the bulk of firm growth literature. Typically, two principle criteria are used for defining a firm as a gazelle: The firm must be an SME at the base year, and it must display above average growth in a specific period. An important aspect of the definition of gazelles is that being a gazelle is necessarily a temporary phenomenon. In fact, most studies find that there is a high persistence of firm size dynamics, which indicates that the dynamics of the growth processes of most firms are quite limited. However, this does not rule out that firms can have above-average growth rates for quite some time. Successful gazelles transform themselves into larger enterprises and stabilise (size assessed in a sectoral/market perspective), while unsuccessful firms remain small or exit the market. The definition is along the two dimensions 'firm size' and 'growth' that define gazelles, and also includes the choice of an appropriate cut-off point.

Our basic high growth definition is based on the birch index based on employment growth (see Schreyer (2000), Ahmad and Gonnard (2007)) Using this index helps to reduce the bias toward larger films (absolute growth) and small firms (relative growth rate). Our group of high growing firm are the firms that are in the top 10 (5) % and which had a firm size in 1998 of less or equal to 250 employees. It is well known that both relative and absolute measures of growth have their drawbacks. The most prominent indicators of growth in the literature are:

1. Proportional growth: i.e. $(x_{it} - x_{it-1})/(x_{it-1})$, where and are firm size at the beginning and the end of the period under consideration. Proportional growth is biased towards small firms, as small units are much more likely to exhibit high rates of proportional growth than large firms.
2. Absolute growth $(x_{it} - x_{it-1})$ is measured in terms of change in size. It can be considered to result in a bias toward large firms.
3. The third growth indicator used by Birch (1981,1987), Schreyer (2000) and Europe's 500 aims to reduce the impact of firm size on the growth indicator. This indicator is a combination of the proportional and absolute growth indexes. It is defined as:

   $$m = (x_{it} - x_{it-1}) \left(\frac{x_{it}}{x_{it-1}} \right)$$

   where x_{it} and x_{it-1} denote size at the end and at the beginning of the period under consideration. This growth indicator is still dependent on firm size, but has a smaller bias toward firm size than the proportional or absolute measures of growth.

In this study we will use the Birch index to measure firm growth. Gazelles are a dynamic (and temporary) phenomenon. Therefore it is important to consider how firms are allocated to size classes. In the literature on the employment generation of small firms for employment creation this issue played an important role (see Schreyer, 2000, Henrekson and Johansson 2008). We allocate firms to size classes according to a base year. There is no consensus in the literature on how to define the cut-off point in terms of growth. For example, Autio et al. (2000) define gazelles as firms that obtained at least 50 % sales growth during each of three consecutive financial years. Most other studies employ a relative cut-off point and use the top growing 5 % or 10 % of SMEs (see Schreyer, 2000, Parker et al. 2005). We use a relative cut-off methodology for gazelle counts and employ a relative cut-off point of the top 10 % and 5 % of growing SMEs.

3.3 Country groups

The differences between country groups are substantial. We control for country differences by defining groups of countries that roughly have the same position in technological development. In this country-clustering we roughly follow the European Innovation Scoreboard indicator, the map of the structural funds of the EU, or Verspagen 2007 who provides a spatial hierarchy of technological change for the EU-27 regions. Verspagens results show some heterogeneity across regions within the same country, but with the exception of Italy this is not important for our distinction. Thus we decided to apply the following grouping:

1. Continental (EU Cont): Austria, Germany, Luxembourg, Belgium, Sweden, Finland
2. Southern Europe (EU South): Italy, Portugal, Greece, Spain
3. New Member States (NMS): Slovenia, Slovakia, Estonia, Hungary, Czech Republic, Lithuania, Latvia

The classification in different country groups is based on the technological and economic position of countries. The use of country groups reduces the geographical dimension and increases sample size across groups and improves the explanatory power of our analysis.

3.4 Descriptive statistics

Table 1 reports the importance of high growth firms for job creation. Column 1 reports the share of SMEs in the overall job creation. The lowest value is recorded for the more developed new member states, where SMEs account only for 20.1 % of total job creation, while in the Southern member states more 50 % and in the New member states around 45 % of the overall job creation is accounted for by SMEs. Column 2 reports the job creation of the top 10 %. Here the numbers indicate the job creation is more concentrated in the Continental and Northern member states than in the Southern member states, however not in SMEs as column 3 shows. Only around 9.5 % of job overall job creation is accounted for by fast growing firms that where SMEs in 1998. Similar numbers are recorded when we use the stricter 5 % gazelle definition. Interestingly the share of SME job creation by the top 10% high growth SMEs is less concentrated than when no size limit is applied (column 2). These results come with important caveats. Due to the fact that we use quite small samples of firms these results need not be representative to assess the overall contribution to job creation by SMEs. Moreover, this table represents a snapshot of growing firms. Firms expanding rapidly change firm size boundaries quite fast. However, these numbers mirror an important result that has been found in a number of studies, namely that in most economies high growth firms account for an important share of overall job generation, but that these high growth firms need not to be small or even young (Henrekson and Johansson, 2008). Although most gazelles are SMEs there is an important subsection of high growth firms that do not fit SME definitions. For the US Acs, Parsons and Tracy (2008) found that job creation is almost evenly split between small and large gazelles using a size boundary of 500 employees. In this contribution we focus on the high growth SMEs and do not consider high growth non-SMEs.

Table 1: Job creation by SMEs and high growth firms

	Share of Job Creation by				Share of SME Job Creation by
	SMEs	top 10 % overall	top 10 % and SME	top 5% and SME	top 10% SMEs
EU-Cont	17.1%	90.3%	9.5%	9.5%	55.7%
EU-South	53.5%	65.2%	30.8%	21.1%	57.7%
EU-NMS	44.9%	82.1%	34.7%	28.6%	77.4%

Notes: SMEs defined as firms with less than 250 employees in 1995. top 10 % overall are derived by selecting the top 10 % of growing firms by using all firms (SMEs and non-SMEs).

Before turning to our analysis of high growth firms, it is useful to provide some descriptive statistics for R&D and innovation indicators of interest. We consider the following 6 indicators:

turnmar: The fraction of turnover due to new or significantly improved products introduced during the period 1998-2000 that were new to both the firm and the market. It is a measure of commercial innovation success.

turnin: The fraction of turnover due to new of significantly improved products introduced during the period 1998-2000 that were new to the firm but not new to the market.[1]

rdint: Intramural research and experimental development (R&D) in 2000 over turnover in 2000. This is the own R&D intensity.

rdemp: Persons involved in intramural R&D activities in 2000 over employment in 2000. This measures the R&D intensity of the enterprise personnel.

rdext: Acquisition of R&D (extramural R&D) in 2000 over turnover in 2000. This measures the extramural R&D intensity.

rdmac: Acquisition of machinery and equipment that were specifically purchased for use in own innovation activities in 2000 over turnover in 2000.

Table 2 presents descriptive statistics for the six indicators for the three country groups. With regard to turnmar we EU-South records the highest value with on average 6.1 % of turnover due to products new to the market. EU-Cont follows suit with 5.4 %, while in the EU-NMS there are on average 3.8 % of turnover new to the firm. The standard deviations

[1] We cleaned the data in a way so that turnin and turnmar are mutually exclusive.

are considerably larger and the median value is 0 % for all three country groups. With regard to turnin we observe that the EU-NMS has a much lower value than the two country groups. turning to the R&D indicators we see that the EU-Cont countries lead in 3 indicators, while EU-South leads in the acquisition of machinery for innovation purposes. Thus the picture shows a higher average R&D-intensity for EU-Cont than in the other country groups.

Table 2: R&D indicators across country groups

	observations	mean	st.dev.	median
	EU-Cont			
turnmar	3473	5.4%	13.1%	0.0%
turnin	3473	13.1%	21.2%	0.5%
rdint	3473	1.7%	10.0%	0.0%
rdemp	3473	3.8%	9.0%	0.4%
rdext	3473	0.3%	2.0%	0.0%
rdmac	3473	1.0%	4.1%	0.0%
	EU-South			
turnmar	10835	6.1%	16.0%	0.0%
turnin	10835	12.1%	23.2%	0.0%
rdint	10835	0.6%	5.4%	0.0%
rdemp	10835	1.9%	5.7%	0.0%
rdext	10835	0.2%	8.4%	0.0%
rdmac	10835	1.7%	25.0%	0.0%
	EU-NMS			
turnmar	6103	3.8%	12.8%	0.0%
turnin	6103	8.8%	19.3%	0.0%
rdint	6103	0.4%	2.3%	0.0%
rdemp	6103	1.2%	5.2%	0.0%
rdext	6103	0.1%	1.4%	0.0%
rdmac	6103	1.0%	5.3%	0.0%

***Notes*:** All indicators expressed as per cent.

4 Results

4.1 Estimation Strategy

We use two methods in order to study the conjecture that innovation is more important to high growth firms in countries close to technology frontier. The first method is to compare the populations of gazelles between the country groups. The second method compares gazelles to non-gazelles within the country groups. Last we use quantile regression in order to check the robustness of the results.

4.2 Comparison of high growth SMEs between country groups

Table 3 reports the results for the t-tests across country groups using the 10 % and the 5% gazelle definition based on the Birch index. We use both innovative and not innovative firms. The t-tests used control for unequal variances and for independent sample sizes. The table is read as follows. The difference indicates the difference between the means. A positive value indicates that the first country group has a higher value, a negative value conversely that the second country group has a higher average value. For example, for turnmar the difference between EU-Cont and EU-South is 0.010 for the top 10 %, indicating that high growth SMEs in the EU-Cont country group have on average a 1 % higher share of turnover due to products new to the market. This particular difference is not statistically significant. The results provide clear indication that there is a statistical significant difference between the country groups with regard to their own R&D intensity. For rdint, rdemp and to a lesser extent also for rdext we observe the following ranking of country groups:

$$\text{EU Cont} > \text{EU South} > \text{EU NMS}.$$

However, we do not recover this result also for the turnover indicators and the external acquisitions. For the turnover indicators the ranking is the following:

$$\text{EU Cont} = \text{EU South} > \text{EU NMS},$$

while for rdmac we do not observe statistically significant differences across the country groups.

Table 3: High growth firms and R&D: Evidence from t-tests across country groups (all firms)

	top 10 %				top 5 %			
	Difference	St.Error	pval		Difference	St.Error	pval	
				EU-Cont vs EU-South				
turnmar	0.010	0.012	0.421		0.028	0.021	0.174	
turnin	0.011	0.016	0.497		0.023	0.027	0.394	
rdint	0.017	0.004	0.000	**	0.024	0.006	0.000	**
rdemp	0.031	0.006	0.000	**	0.041	0.011	0.000	**
rdext	0.001	0.006	0.890		0.009	0.005	0.081	+
rdmac	-0.012	0.017	0.495		0.016	0.011	0.135	
				EU-Cont vs EU-NMS				
turnmar	0.053	0.012	0.000	**	0.071	0.020	0.001	**
turnin	0.078	0.016	0.000	**	0.091	0.026	0.000	**
rdint	0.021	0.004	0.000	**	0.029	0.006	0.000	**
rdemp	0.042	0.006	0.000	**	0.050	0.010	0.000	**
rdext	0.007	0.003	0.020	**	0.010	0.005	0.047	**
rdmac	0.007	0.005	0.186		0.021	0.011	0.052	+
				EU-South vs EU-NMS				
turnmar	0.043	0.007	0.000	**	0.043	0.009	0.000	**
turnin	0.067	0.010	0.000	**	0.068	0.014	0.000	**
rdint	0.004	0.001	0.000	**	0.005	0.001	0.000	**
rdemp	0.011	0.002	0.000	**	0.009	0.003	0.002	**
rdext	0.006	0.005	0.277		0.001	0.000	0.011	*
rdmac	0.018	0.017	0.269		0.005	0.003	0.100	

***Notes*:** CIS III micro data (Eurostat); Own Calculations. ** indicates statistically significant at the 1 % level, * statistically significant at the 5 % level, + statistically significant at the 10 % level.

This result clearly confirms the conjecture that high growth firms are different across country groups. R&D is more important for countries close to the technological frontier. Table reports results for innovative firms only. However, this results may be subject to some bias, as R&D intensity may be compared in a meaningful way only between innovative firms. Table 4 presents the results for innovative firms only. For the R&D intensity (rdint, rdemp) and rdext we recover largely the same ranking as we obtained when considering all SMEs:

$$\text{EU Cont} > \text{EU South} > \text{EU NMS}.$$

The same holds true for turnmar and rdmac. Thus, the results confirm part 1 of hypothesis 1 in a quite strong way. Overall we find that high growth SMEs in countries close to the technological frontier have a higher propensity to innovate and are more geared towards own R&D, even if we correct for the propensity to innovate. High growth SMEs in countries closer to the technology frontier have higher R&D intensities and also a higher innovation success measured as turnover due to innovation sales.

Table 4: High growth SMEs and R&D: Evidence from t-tests across country groups (only innovative SMEs)

	top 10 %				top 5 %			
	Difference	St.Error	pval		Difference	St.Error	pval	
EU-Cont vs EU-South								
turnmar	-0.004	0.018	0.829		0.014	0.029	0.623	
turnin	-0.022	0.023	0.333		-0.021	0.036	0.549	
rdint	0.022	0.005	0.000	**	0.029	0.008	0.001	**
rdemp	0.038	0.009	0.000	**	0.045	0.014	0.001	**
rdext	-0.001	0.010	0.894		0.011	0.007	0.143	
rdmac	-0.027	0.031	0.384		0.017	0.015	0.267	
EU-Cont vs EU-NMS								
turnmar	0.036	0.019	0.064	+	0.052	0.030	0.084	+
turnin	0.000	0.025	0.993		-0.001	0.037	0.972	
rdint	0.028	0.005	0.000	**	0.036	0.008	0.000	**
rdemp	0.048	0.009	0.000	**	0.050	0.014	0.001	**
rdext	0.008	0.004	0.073	+	0.012	0.007	0.092	+
rdmac	-0.007	0.009	0.409		0.014	0.016	0.407	
EU-South vs EU-NMS								
turnmar	0.040	0.014	0.004	**	0.038	0.019	0.048	*
turnin	0.022	0.019	0.253		0.020	0.026	0.440	
rdint	0.006	0.002	0.000	**	0.007	0.002	0.000	**
rdemp	0.009	0.005	0.045	*	0.005	0.006	0.425	
rdext	0.009	0.009	0.329		0.002	0.001	0.082	+
rdmac	0.019	0.030	0.523		-0.004	0.007	0.622	

Notes: CIS III micro data (Eurostat); Own Calculations. ** indicates statistically significant at the 1 % level, * statistically significant at the 5 % level, + statistically significant at the 10 % level.

4.3 Comparison of high growth SMEs with non-high-growth SMEs within country groups

In order to provide evidence on the second part of hypothesis 1 we need to use a different methodology. We employ a matching estimator in order to study whether gazelles are different from non-gazelles within the same country group.[2] Assuming that SME specificities are similar among SMEs that share certain characteristics, we try to avoid the problem of comparing apples with oranges. This means that instead of simply comparing two groups of observations with each other, matching procedures reduce one group to "statistical twins" (see Heckman et al., 1998, 1999). For each high growth firm, we identified up to four SMEs that are statistically almost alike in a number of criteria:

[2]Matching estimators were designed to examine the effect of a treatment. Since we use observational data, i.e. data that is not randomised, and furthermore identify a subset of the sample as being treated, there is no 'treatment effect' as discussed in the literature. However, by applying a matching estimator, we control for the characteristics that affect both the quasi-treatment and the response. We deem gazelles to be the 'treatment variable', thus using the matching estimator as a tool that produces sophisticated statistics on difference between gazelle and non-gazelle SMEs.

- The selection of SMEs is based on exact matches on 2-digit Nace classifications and the Country dummy. This avoids the problem of comparing SMEs that act in different sectoral or national environments.
- The control group is further selected on the basis of firm size in 1998 whether they are part of an enterprise group, the export intensity (exports over turnover in 1998) as a proxy for the SME's internationalisation, and where the most significant market is (regionally, nationally etc.).
- Furthermore, we use organically growing SMEs only, i.e. we excluded firms that were growing through mergers and acquisitions.

For each gazelle we select up to four firms in the control group (non-gazelles) and then test whether the two sets of firms are different over a number of innovation variables by means of a t-test. y construcing the control group we excluded the 5% firms which were closest to the selected gazelles in terms of growth rates in order to assure that we do not have too much matches in the neighbourhood of the gazelles. Thus the potential control group consists only of firms up to the 85% quantile in terms of growth rates. In addition we imposed a caliper of 0.1 in order to assure that the firms we compare are in fact similar. This implies that for some high growth firms no matches or less than four firms are selected.

Table 5: High growth SMEs and R&D: Matching results over country groups

	top 10 %								
	EU-Cont			EU-South			EU-NMS		
	Difference	pval		Difference	pval		Difference	pval	
turnmar	0.033	0.017	*	0.018	0.014	*	0.006	0.411	
turnin	0.005	0.757		0.030	0.001	**	0.005	0.492	
rdint	0.011	0.013	*	-0.002	0.093	+	-0.001	0.076	+
rdemp	0.015	0.087	+	-0.003	0.128		-0.004	0.154	
rdext	0.003	0.093	+	-0.001	0.320		0.000	0.541	
rdmac	0.009	0.058	+	0.003	0.145		-0.005	0.292	
	top 5 %								
	EU-Cont			EU-South			EU-NMS		
	Difference	pval		Difference	pval		Difference	pval	
turnmar	0.061	0.013	*	0.023	0.043	*	0.004	0.615	
turnin	-0.015	0.405		0.019	0.135		0.012	0.297	
rdint	0.021	0.002	**	0.000	0.883		-0.001	0.495	
rdemp	0.011	0.370		-0.005	0.109		-0.003	0.536	
rdext	0.005	0.234		-0.001	0.434		-0.001	0.006	**
rdmac	0.018	0.032	*	0.000	0.948		-0.005	0.473	

Notes: CIS III micro data (Eurostat); Own Calculations. ** indicates statistically significant at the 1 % level, * statistically significant at the 5 % level, + statistically significant at the 10 % level.

Implementing matching estimators, one has to make an assumption about whether the reaction of SMEs on the treatment is heterogeneous or not. We assume this to hold, i.e. we expect that the effects differ between SMEs, and thus implement an average treatment effect for the treated estimator. We use nearest neighbour matching that estimates the (quasi) average treatment effect on an independent variable, Put differently, we look for differences between each gazelle, which is the (quasi-)treatment, and two similar SMEs (non-treated) in innovation (dependent) variables.

The nearest neighbour matching first computes the differentials of the values of the covariates and, drawing on these results, then assigns similar observations of the treated to the nearest opposite treatment. We then estimate the average difference between the "observed" and the "potential" outcome (for a detailed discussion of the method see Abadie et al. (2004) or Abadie and Imbens (2006)).

Table 6: High growth SMEs and R&D: Matching results for innovative SMEs over country groups

	top 10 %								
	EU-Cont			EU-South			EU-NMS		
	Difference	pval		Difference	pval		Difference	pval	
turnmar	0.070	0.047	*	0.029	0.122		0.001	0.956	
turnin	-0.069	0.002	**	0.011	0.594		0.028	0.328	
rdint	0.024	0.003	**	0.000	0.865		-0.003	0.338	
rdemp	0.006	0.696		-0.012	0.016	*	-0.009	0.349	
rdext	0.006	0.193		-0.002	0.146		-0.004	0.001	**
rdmac	0.019	0.097	+	0.001	0.862		-0.012	0.500	

	top 5 %								
	EU-Cont			EU-South			EU-NMS		
	Difference	pval		Difference	pval		Difference	pval	
turnmar	0.071	0.041	*	0.024	0.206		0.012	0.590	
turnin	-0.064	0.004	**	0.023	0.283		0.024	0.418	
rdint	0.023	0.006	**	-0.004	0.149		-0.004	0.171	
rdemp	0.007	0.653		-0.015	0.002	**	-0.010	0.303	
rdext	0.006	0.210		-0.002	0.262		-0.001	0.092	+
rdmac	0.020	0.084	+	0.002	0.615		-0.015	0.409	

Notes: CIS III micro data (Eurostat); Own Calculations. ** indicates statistically significant at the 1 % level, * statistically significant at the 5 % level, + statistically significant at the 10 % level.

Table 5 provides an overview of the results obtained from the matching estimations for the group using all SMEs. We find that gazelles are more R&D-intensive in the EU Cont countries. In EU-South we find that high growth SMEs are characterized by a below average R&D intensity for the top 10 % high growth SMEs, while there is no statistical difference for the top 5 % high growth SMEs. For both the EU-Cont and EU-South high growth SMEs have a larger turnover share of products new to the market, while for the EU-NMS neither turnmar nor turnin are statistically significant. For the New member states we find a statistically significant negative difference for rdint for the top 10 % and for rdext for the top 5 %.

Table 6 presents the results for innovative SMEs only. Overall, the results are quite similar to the results reported in table 5. Only in the Continental Countries a higher innovation output is characteristic for innovative high growth SMEs compared to innovative low-medium growth SMEs. In the New Member States innovative non-gazelles have a higher external R&D-intensity than the gazelle SMEs, while gazelles in the Southern European countries have a lower share of R&D personnel than innovative non-gazelles. Overall the results using matching estimators suggest that there is a substantial difference between EU-Cont and the other country groups regardless if one considers all SMEs or only innovative SMEs. We largely recover the result from earlier and can state that innovation and R&D-intensity is a distinguishing feature of gazelles in the EU-Cont compared to gazelles in the Southern and the New member states. For the interpretation of the results it is important to note that we compare R&D intensities ex post. This has the implication that we capture largely strategic investment issues and that we are likely underestimate the R&D intensity of fast growing SMEs.

Only in the countries closest to the technological frontier gazelles are characterized by above average R&D intensity. In the other country groups (EU South and New Member States) there is not much difference between gazelles and non-gazelles in terms of R&D intensity and innovation success. Overall, the matching results confirm in strong form that R&D is important for high growth SMEs only if they are located in a country close to the frontier. This confirms part 2 of hypothesis 1.

4.4 Quantile regression

The evidence from the comparisons of means and matching estimators shows that gazelles are different in different geographical areas, that we roughly defined according to their technology intensity: High growth SMEs in countries closer to the technological frontier rely more heavily on new knowledge than SMEs in countries that are further away from the technological frontier and that thus can rely on other sources of comparative advantage. However, unconditional and tests of the equality or difference of means does not provide the full picture that we can outline using CIS data. The estimation of the distribution of firm growth rates produced for all sectors distributions with super-Laplace tails, which exhibits fatter tails when compared to a normal or even a Laplace distribution. This indicates that firm growth is different at the tails of the growth rate distribution. If we want to study firm behaviour at both ends of the distribution we should use a different econometric method than those methods usually employed (e.g. OLS, panel or robust regression) when studying firm growth. Traditional methods aim at identifying average firm behaviour. The great advantage of a quantile regression is that it enables us to consider the entire distribution of firm growth. The quantile regression methodology splits the data into quantiles of the dependant variable, which is the growth rate in our specification. Then we use a series of explanatory variables (e.g. innovation) attempt to describe the influence of the variables in each of the quantiles of growth intensities. Put differently, we try to identify not only the overall influence of an explanatory variable, but also the difference in the influence across growth intensities. Compared to OLS regression, quantile regression is able to provide a more "complete" story of the relationship between variables. As the name quantile regression suggests, it is not limited to regress against averages, and hence it is not limited in its explanatory value, since it also uses information that it obtains from the underlying distribution of the dependent variable (Koenker, 2005).[3]

[3]Quantile regressions have three major advantages when compared to OLS: First, quantile regressions allow us to analyse differences in the relationship between the endogenous and exogenous variables at different points of the conditional distribution of the dependent variable. That is, rather than focusing on a specific moment of the distribution, the linear quantile regression is a statistical method that allows us to study the whole range of values of the dependent variable. Quantile re-

We use quantile regression in order to analyse the determinants of gazelle behaviour. Following the bulk of the literature on firm growth, we use an augmented Gibrat's Law equation to study the determinants of the innovation behaviour of gazelles. The Gibrat's law equation we use is the following:

$$g_i = \alpha + \beta_1 S_{i,t-1} + \beta_2 INN_i + \beta_3 CON_i$$

where g_i is the growth rate indicator (growth rate or Birch index) for firm i, α is an intercept, $S_{i,t-1}$ is the firm size at time t-1, INN_i is a vector of innovation indicators for firm i, CON_i is a vector of control variables and β_1, β_2 and $beta_3$ are the respective coefficient vectors. As the empirical evidence suggests, the explanatory power of such regressions is usually quite low, and it is found that Gibrat's Law is rejected for small firms (e.g. see Sutton, 1997 for a review). Nevertheless such a formulation is useful, as it is often used in the literature. As remarked earlier the literature on innovation finds that the positive effect of innovations on the profit margin effect is substantially larger than the growth effect (e.g. Geroski and Machin, 1992, Roper, 1997, Freel, 2000). Coad and Rao (2006) find that innovation is of much greater importance to high growth companies. In the analysis, we try to explain logarithmic employment growth by using a number of innovation indicators and variables that are more common in mainstream industrial economics. The variables can roughly be split up into three categories that the regression accounts for: innovation input and success at the firm level, the innovation nature of the industry, and firm variables that control for important effects. As innovation indicators specific to the firm we use:

turnmar: The fraction of turnover due to new or significantly improved products introduced during the period 1998-2000 that were new to both the firm and the market.

rdint: Intramural research and experimental development (R&D) in 2000 over turnover in 2000.

We also control for a number of factors at the firm level:

size1: Firm size measured as log employment in 1998.

expint98: Export to sales ratio in the (base) year 1998.

skillint: Skill Intensity (share of staff with tertiary education) in the base year 1998.

gressions allow us to study how one specific quantile of particular interest is correlated with a set of explanatory variables. Extending this analysis to a large number of quantiles, quantile regression allows us to examine how the partial correlation changes across the quantiles. This provides an understanding of the entire shape of the distribution and how it may be shaped by the explanatory variables. Second, the coefficient estimate for the exogenous variable is interpreted in a similar fashion as OLS regression coefficients, namely as the marginal change in the dependent variable due to a marginal change in the exogenous variable conditional on being on the p-th quantile of the distribution. Changing estimated coefficients with varying quantiles is indicative of heteroskedasticity issues (Koenker, 2005). Thrid, estimates of the quantile regression are more robust than those of the ordinary least square regression, where the mean value of the dependent variable is predicted. This is especially true in the presence of outliers as well as for distributions of error terms that deviate from normality.

gp-fo: A dummy variable that indicates whether the firm is part of an enterprise group with foreign headquarters or not.

turninc: Turnover increase by at least 10 % due to a merger of another enterprise or part of it

turndec: Turnover decrease by at least 10 % due to sale or closure of part of the enterprise

Furthermore we control for the innovation nature of the sector and use the following NACE 2 digit averages:

turnmar-nace: Turnover with products that are new to the market - NACE 2 digit industry average.

rdint-nace: NACE 2 digit industry average of R&D intensity.

skillint-nace: NACE 2 digit industry average of skill intensity.

cumulat-nace: NACE 2 digit industry average of how cumulative innovation is in the industry.

basic-nace: NACE 2 digit industry average of how basic innovations are in the industry. The basicness of innovations is measured as higher input of 'new' knowledge from universities and research institutes. Cumulativeness is measured by the value of information from market participants.

The tables 7, 8 and 9 present the results, both quantile and OLS regressions. The quantiles were chosen at 25 % (q25), 50 % (q50), 75 % (q75), 90 % (q90) and 95 % (q95) of the respective distribution of firm growth rates. The tables list coefficients and the p-values for selected variables.

A first result across all regions is the negative influence of size in the base year on firm growth, which increases with the growth rate. Thus, our results suggest a negative relationship between size and growth. Smaller firms grow faster than larger firms. This result is statistically significant across all country groups. Thus one of the results reported in the literature that challenges the law of proportionate effect is strongly confirmed also in this study. Next consider five of the indicators in more detail:

We find that that the turnover share of products new to the market (turnmar) has a exceptional effect on firm growth in continental Europe (table 7) and in Southern Europe (table 8) but less so in the New member States (table 9). For Continental Europe we see that the turnover share of products new to the market increases with higher growth rates. Thus for high growth firms the turnover share of firms new to the market is more important than for firms with lower growth rates. For the Southern country group we do not observe that striking increase in terms of the coefficient. In fact, the coefficient remains for most of the time within the OLS confidence interval. For the New Member States we even observe a slight decline in the importance for the last quantile (q95). The quantile estimates of the turnover share of products new to the market is also in this case all the time largely within the OLS confidence interval. This confirms our result from the previous matching analysis. The turnover share of products new to the market - which can be interpreted as innovation success variable - is of greater importance for high growth firms in the

Continental European country group than for firms in the other country groups.

Next we consider the own R&D intensity (rdint). For the Continental European country group we record a statistical significant coefficient for all quantiles. The magnitude of the coefficient is increasing until the last quantile under consideration (q95). For the Southern European country group and EU-NMS rdint is newer statistically significant. This again confirms the findings from the matching analysis. Only for firms in the Continental country group the own R&D intensity is important to achieve high growth rates.

Table 7: Results of bootstrapped quantile regressions of logarithmic employment growth for EU-Cont

		size1	turnmar	rdint	expint98	skillint	gp-fo	R2
q25	Coeff.	-0.014	0.038	0.164	0.043	0.017	-0.028	0.06
	pval	0.000	0.080	0.054	0.000	0.398	0.012	
q50	Coeff.	-0.016	0.079	0.270	0.035	0.074	-0.015	0.04
	pval	0.000	0.026	0.029	0.000	0.002	0.071	
q75	Coeff.	-0.030	0.291	0.438	0.042	0.128	-0.026	0.08
	pval	0.000	0.000	0.013	0.003	0.000	0.016	
q90	Coeff.	-0.051	0.392	0.618	0.059	0.242	-0.044	0.14
	pval	0.000	0.000	0.001	0.050	0.000	0.013	
q95	Coeff.	-0.070	0.468	0.347	0.106	0.261	-0.089	0.18
	pval	0.000	0.000	0.089	0.004	0.008	0.001	
OLS	Coeff.	-0.050	0.171	0.321	0.092	0.047	-0.026	0.14
	pval	0.000	0.000	0.031	0.000	0.236	0.088	

***Notes*:** CIS III micro data (Eurostat); Own Calculations.

Let us next turn to the export intensity in 1998 (expint98). This indicator is statistically significant except for all quantiles for the Continental country group. The magnitude of the coefficient is increasing for higher growth rates, suggesting that the presence in export markets is important for high growth firms in the OMS. For the Southern OMS we find a positive and statistically significant association only for low growth rates. For high growth rates the coefficient becomes negative, although the coefficient becomes insignificant. For the EU-NMS we find a statistically significant association for all quantiles. The coefficient increases with growth rates.

Next consider the skill intensity (skillint): Here we find an increasing relationship for the Continental and the Southern country groups. The relationship is positive and we record higher coefficients at higher growth rates. For the NMS we surprisingly find a statistically significant negative association of skillint for high growth rates.

Being a foreign affiliate (gp-fo) has a negative effect on growth in the Old Member states (Tables 7 and 8) while the effect is positive and increasing for higher growth rates in the New Member states (9).

5 Conclusions

Small and medium sized firms (SMEs) and R&D figure prominently in policy discussions and are often considered to be the central sources of high growth source of dynamism in modern developed and developing

Table 8: Results of bootstrapped quantile regressions of logarithmic employment growth for EU-South

		size1	turnmar	rdint	expint98	skillint	gp-fo	R2
q25	Coeff.	-0.013	0.034	0.081	0.016	0.087	-0.030	0.03
	pval	0.000	0.000	0.108	0.020	0.000	0.000	
q50	Coeff.	-0.018	0.063	0.099	0.006	0.119	-0.036	0.03
	pval	0.000	0.000	0.329	0.347	0.000	0.000	
q75	Coeff.	-0.036	0.102	0.042	-0.009	0.202	-0.054	0.05
	pval	0.000	0.000	0.753	0.142	0.000	0.000	
q90	Coeff.	-0.057	0.127	0.047	-0.012	0.182	-0.086	0.07
	pval	0.000	0.000	0.868	0.413	0.000	0.000	
q95	Coeff.	-0.085	0.113	0.369	-0.008	0.328	-0.105	0.09
	pval	0.000	0.003	0.310	0.698	0.001	0.000	
OLS	Coeff.	-0.044	0.071	0.141	0.020	0.148	-0.053	0.08
	pval	0.000	0.000	0.288	0.024	0.000	0.000	

Notes: CIS III micro data (Eurostat); Own Calculations.

Table 9: Results of bootstrapped quantile regressions of logarithmic employment growth for EU-NMS

		size1	turnmar	rdint	expint98	skillint	gp-fo	R2
q25	Coeff.	-0.045	0.094	0.178	0.070	-0.105	0.086	0.07
	pval	0.000	0.000	0.241	0.000	0.000	0.000	
q50	Coeff.	-0.044	0.081	0.211	0.085	-0.078	0.091	0.06
	pval	0.000	0.002	0.233	0.000	0.000	0.000	
q75	Coeff.	-0.084	0.091	0.205	0.116	-0.121	0.147	0.08
	pval	0.000	0.068	0.230	0.000	0.000	0.000	
q90	Coeff.	-0.164	0.177	-0.102	0.164	-0.261	0.215	0.15
	pval	0.000	0.000	0.808	0.000	0.000	0.000	
q95	Coeff.	-0.230	0.151	0.117	0.175	-0.429	0.344	0.19
	pval	0.000	0.102	0.892	0.000	0.000	0.000	
OLS	Coeff.	-0.125	0.133	0.311	0.133	-0.213	0.190	0.17
	pval	0.000	0.000	0.006	0.000	0.000	0.000	

Notes: CIS III micro data (Eurostat); Own Calculations.

economies. However, SMEs are a heterogeneous group of firms. Some of them remain small over their entire life time while others remain SMEs for a small time. This contribution concentrated on the innovation behaviour on high growth SMEs. Using a representative data set (CIS 3 data for 19 countries) we found that :

- Fast growing SMEs are quite different across country groups. It has been established that the relative technological position of a country has substantial influences on the success (and choice) of innovation- and R&D-based growth strategies. Firm growth in countries at the technological frontier seems to require firm strategies that focus on R&D. SMEs in catch-up countries are not required to make substantial investments into innovation. Innovation input (R&D) and innovation success (share of products new to the market) are much more important for gazelles in countries close to the technological frontier than in countries that are further away from the technological frontier.
- Furthermore, we try to look into the question "what makes a gazelle" by analysing whether gazelles differ to similar SMEs by comparing

them with a matching estimator. This method allows us to compare gazelles to low growth SMEs that are similar across several dimensions such as country, industry, size in the base year, the location of most significant market etc. Hence this method avoids the problem of comparing apples with oranges. We found that high growth SMEs are more innovative than other SMEs only for countries close to the technological frontier. For the other country groups the results are not statistically significant. This confirms that gazelles derive much of their drive from the exploitation of comparative advantages.

- Finally, we apply quantile regressions as a robustness check. The results confirmed that fast growing SMEs are quite different across country groups. Innovation success (share of products new to the market) and R&D are of central importance for high growth SMEs in countries closer to the technological frontier than in countries that are further away from the technological frontier.

Our results show that R&D is more important to high growth SMEs in countries that are closer to the technological frontier. Our interpretation of this finding is that the distribution of opportunities is different across countries and increasing on the distance to the frontier. At the frontier opportunities are primarily related to innovation while far away from the frontier opportunities are related increasingly to the adoption of known solutions. In fact, we find (relatively speaking) a much lower number of high growth SMEs in the old member states than in the new member states (NMS). With regard to the R&D intensity of SMEs we find that only for countries closest to the technological frontier that high growth firms have a higher innovation intensity (measured by different indicators) than comparable firms that grow less rapidly. From a policy perspective the results suggest that policies to foster high growth SMEs need to take into account the comparative advantage of the economic environment of firms. This implies that there is no single recipe that can be used as blueprint for fostering high growth firms in all Member States. Countries far away from the technological frontier need to choose other priorities than countries close to the technological frontier in order to foster firm growth.

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