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High-growth firms, innovation and the distance to the frontier

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Abstract

This paper studies the differences in the R&D and innovation behaviour of high-growth firms for 16 EU countries. The results confirm that R&D and innovation are important characteristics for high-growth firms in countries close to the technological frontier, but not for high-growth firms in countries further away from the technological frontier.

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1 Introduction

Empirical evidence indicates that a small number of high-growth firms are of central importance to job creation and economic growth (Schreyer, 2000; Henrekson and Johansson, 2010). However, surprisingly little is known about these high-growth firms, perhaps because being a high-growth firm is a temporary stage in the life of a firm. Hölzl (2009) studied the R&D behaviour high growth SMEs with less than 250 employees in 1998 while this note studies high firms of all sizes. High growth firms may be neither small nor young (Henrekson and Johansson, 2010).

The aim of this note is to explore differences in the innovation behaviour of high-growth firms for 16 EU countries and to assess the importance of R&D and innovation measured as innovation sales. These countries are quite different in terms of their general economic and technological development. With regard to R& D the empirical evidence shows that the bulk of R&D expenditure is concentrated in frontier economies. We define frontier economies in terms of average relative GDP levels and average R&D intensities. These are the countries where the comparative advantage is built on knowledge and innovation activities. Non-frontier economies in contrast are countries that still have catch-up potentials with regard to average productivity and R&D intensity. The 'distance to the frontier' approach acknowledges the specific role of 'appropriate institutions' (Aghion and Howitt, 2006) at different stages of development. The emphasis is on the argument that the effectiveness of economic policies is conditional to a country's distance to the world technological frontier. Using a stylised model, Acemoglu et al. (2006) show that high-skilled personnel and technology-intensive firms are more important to economic growth in countries that are close to the technological frontier than for countries further from the frontier. While catch-up countries will profit more from capital accumulation growth strategies, industrial countries close to the technological frontier are required to use an innovation-based strategy. From this quite general perspective we derive the following conjectures, which we test in this paper:

Conjecture 1 B*etween countries: Innovation and R&D are more important to high-growth firms in countries closer to the technological frontier than to high-growth firms in countries further away from the technological frontier.*

Conjecture 2 W*ithin countries: High-growth firms in countries close to the technological frontier are more innovative and tend to have a higher R&D intensity than average-growth firms. Innovation and R&D intensity lose importance as distinguishing features of high-growth and average-growth firms in countries that more distant to the technological frontier.*

2 Data and definitions

The Community Innovation Survey (CIS) is a firm level survey conducted every 4 years in all EU member states, as well as several non-EU countries (e.g. Norway, Iceland). We use

the third survey (CIS3) that covers the period 1998-2000.[1] We consider only organically growing firms and exclude from the sample all firms that grew or shrank through mergers and acquisitions. The sample consists of 16 countries (numbers in brackets indicate the number of observations in the 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).

The CIS aims to provide a sound source of statistical data on innovation by using a stratified sample of companies. 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. Mairesse and Mohnen (2004) provide evidence that the subjective measures of the CIS appear to be consistent with objective measures of innovation, such as the probability of holding a patent and the share in sales of products protected by patents.

Like other studies investigating high-growth firms, we measure growth by an index that helps reduce the bias toward larger fims (absolute growth) and small firms (relative growth rate). Proportional growth is biased towards small firms, as small units are much more likely to exhibit high rates of proportional growth than large firms. It is easier to double the size of the firm for a firm with one employee than for a firm with 500 employees. Absolute growth is the absolute change in size. It is easier for large firms to add 10 employees than for a very small firm. Measuring growth in absolute or relative terms can lead to different results (Almus, 2002; Shepherd and Wiklund, 2009). The index used is a simple combination of proportional and absolute growth (e.g. Schreyer 2000; Ahmad and Gonnard 2007; Coad 2009):

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

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. We use a relative cut-off point and select the top 5 % and 10 % of growing firms as high-growth firms.

In this paper we apply the technology frontier concept at the country level by using GDP per capita and R&D intensity. We control for country differences by defining groups of countries that have approximately the same position in technological development. In this country clustering we loosely follow Verspagen (2007) who provides a spatial hierarchy of technological change for the EU-27 regions. Verspagen's results show some heterogeneity across regions within the same country, however, with the exception of Italy, this is not important for our distinction. The use of country groups reduces the geographical dimension and increases sample size across groups, improving the explanatory power of our analysis.

[1]This data was accessed at the Safe Centre in Luxembourg. We wish to thank Sergiu Parvan at Eurostat. Without his help this study would not have been possible.

We applied the following grouping:

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

When we consider the importance of high-growth firms for job creation, we see that the top 10 % account for more than 60 % of all job creation in all country groups and the top 5 % for more than 45 %. Interestingly, job creation is much more concentrated in the EU-Cont country group (90.3 % for the top 10 % and 84.2 % for the top 5 %) and EU-NMS group (82.1 % and 68.0 %) than in the EU-South group (65.2 % and 47.6%).

We use two measures of innovation behaviour. The first is turnmar, the fraction of turnover due to new or significantly improved products introduced during the 1998 to 2000 period which were new to both the firm and the market. This indicator is a measure of commercial innovation success. It has been used to measure the production of innovation and to identify its determinants and effects on economic performance (e.g. Crepon et al. 1998; Ebersberger et al. 2010). The second indicator is rdint, the intramural R&D expenditures over turnover. This indicator measures the own R&D intensity of a firm. Although R&D is generally considered to be on e of the key driver of innovation and firm performance, it has been difficult to establish a direct relationship between R&D activities and firm growth (Klomp and van Leeuwen, 2001; Coad and Rao, 2008).

3 Results

3.1 Test of conjecture 1

Table 1 presents the results of the t-tests between country groups using the 10 % and the 5 % definition of high-growth firms. The table reports the means for the country groups, the differences and the mean comparison test that allows for unequal variances. We present the results for all high-growth firms and - in order to control for a possible selection bias - for innovative high-growth firms only. When we consider all high-growth firms, we see that only once are we unable to reject the null hypothesis of equal means. This is in the case of share in turnover of products new to the market (turnmar) in the comparison between EU-Cont and EU-South. For R&D intensity (rdint) we observe the following ranking of country groups: EU-Cont > EU-South > EU-NMS. The same result holds for rdint if we only consider innovative high-growth firms. In contrast, for turnmar we obtain the result that high-growth firms in EU-South dominate both firms in the EU-Cont and EU-NMS country groups if we only consider innovative firms' turnmar. Note that when we consider

innovative firms we lose 46.7 % of the high-growth firms in EU-Cont, 51.9 % in EU-South and 62.51 % in EU-NMS.

Table 1: High-growth firms and innovation: Evidence from t-tests between country groups

	top 10 %					top 5 %				
	mean (1)	mean (0)	diff.	sderr	pval	mean (1)	mean (0)	diff.	sderr	pval
(i) all firms										
EU-Cont (1) vs. EU-South (0)										
turnmar	0.084	0.086	-0.002	0.009	0.825	0.098	0.094	0.005	0.014	0.740
rdint	0.027	0.007	0.020	0.002	0.000	0.032	0.008	0.024	0.004	0.000
EU-Cont (1) vs. EU-NMS (0)										
turnmar	0.084	0.042	0.042	0.008	0.000	0.098	0.050	0.049	0.012	0.000
rdint	0.027	0.002	0.025	0.002	0.000	0.032	0.003	0.029	0.003	0.000
EU-South (1) vs EU-NMS (0)										
turnmar	0.086	0.042	0.044	0.007	0.000	0.094	0.050	0.044	0.010	0.000
rdint	0.007	0.002	0.005	0.001	0.000	0.008	0.003	0.005	0.001	0.000
(ii) innovative firms only										
EU-Cont (1) vs. EU-South (0)										
turnmar	0.106	0.136	-0.030	0.012	0.011	0.118	0.141	-0.023	0.017	0.189
rdint	0.033	0.011	0.022	0.003	0.000	0.038	0.012	0.026	0.004	0.000
EU-Cont (1) vs. EU-NMS (0)										
turnmar	0.106	0.098	0.008	0.012	0.525	0.118	0.109	0.009	0.017	0.595
rdint	0.033	0.005	0.028	0.003	0.000	0.038	0.006	0.031	0.004	0.000
EU-South (1) vs EU-NMS (0)										
turnmar	0.136	0.098	0.038	0.012	0.001	0.141	0.109	0.032	0.017	0.060
rdint	0.011	0.005	0.006	0.001	0.000	0.012	0.006	0.006	0.002	0.001

***Notes*:** CIS III micro data (Eurostat); own calculations.

We also control for firm size and sector composition effects by using a matching protocol that excludes high-growth firms for which no comparison with similar firms in terms of firm size and industry was possible. We implemented this using the matching estimator developed by Abadie and Imbens (2006), which allows for exact matching (see next sub-section). The results were qualitatively identical and did not lead to a different interpretation. We therefore do not report them here.

Overall, the results indicate that we are not able to reject conjecture 1 for R&D intensity. High-growth firms in countries closer to the technological frontier are more R&D intensive than high-growth firms in countries more distant to the technological frontier. However, we have to reject conjecture 1 for turnmar. This suggests that non-R&D innovation processes are important for high-growth firms in all country groups, especially in the EU-South. From this, we observe that turnmar is not a good proxy for technological own R&D-based innovation.

3.2 Test of conjecture 2

In order to provide evidence for the second part of hypothesis 1 we also need to apply the matching estimator. Here, we use a more refined matching protocol in order to study whether high-growth firms are different from average-growth firms within the same country group. Our primary use of the estimator is to be sure that we do not 'compare apples to oranges'. The results obtained by Coad and Rao (2010) suggest that the elasticity of the growth of R&D expenditures with restpect to firm growth are around 0.3 to 0.4 for high growth firms. Thus our estimates regarding R&D intensity should be considered to be conservative, as the R&D expenditures grow underproportionally with firm expansion. The matching protocol is as follows:

1. We drop 5 % of the firms that are closest to the high-growth firms from the potential control group, in order to assure that we do not have many matches in the immediate neighborhood of the high-growth firms.

2. The selection of firms in the control group is based on exact matches based on 2-digit industry dummies and the country dummies. In addition we use as covariates the basis of firm size in 1998, both in terms of employment and turnover, whether the firm is part of an enterprise group, export intensity in 1998, and the spatial dimension of the most important market.

3. For each high-growth firm we select up to four firms in the control group (average-growth firms) using the inverted variance of the covariates as the measure of distance. We use a caliper of 0.1 in order to assure that we are comparing similar firms.

4. We then apply a means test using robust standard errors and bias correction based on the formulas proposed by Abadie and Imbens (2006) and implemented in Stata by Abadie et al. (2004).

The results are reported in table 2. We report the results for all firms, as well as for innovative firms only. Table 2 reports the difference between the means, the standard error and the p-value for a simple mean comparison test and the means comparison test using the matching protocol. The results clearly show that the matching protocol makes a difference. The results are more reliable. Except for the EU-NMS country group there is not much difference in the sign and statistical significance between the results using all firms and only innovative firms. If we pool all country groups we only obtain statistically significant results for turnmar. The R&D intensity does not seem to be a distinguishing feature when comparing high-growth firms and average-growth firms. On average, the top 10 % growing firms have a 1.6 percentage points higher share of turnover due to products new to the market. When we consider the country groups in more detail we see that there are significant differences. For EU-Cont we report the highest difference for turnmar. It is around 3 percentage points

Table 2: High-growth firms and innovation: Matching results within country groups

	top 10 %						top 5 %					
	unmatched			matched			unmatched			matched		
	diff.	sderr.	pval	diff.	sderr.	pval	diff.	sderr.	pval	diff.	sderr.	pval
(i) all firms												
all country groups												
turnmar	0,025	0,003	0,000	0,016	0,004	0,000	0,031	0,004	0,000	0,017	0,006	0,003
rdint	0,003	0,001	0,000	0,000	0,001	0,997	0,004	0,001	0,000	0,000	0,001	0,904
EU-Cont												
turnmar	0,047	0,006	0,000	0,031	0,009	0,000	0,068	0,009	0,000	0,044	0,014	0,002
rdint	0,013	0,002	0,000	0,009	0,003	0,001	0,019	0,003	0,000	0,010	0,004	0,007
EU-South												
turnmar	0,036	0,005	0,000	0,022	0,006	0,000	0,041	0,007	0,000	0,020	0,009	0,029
rdint	0,003	0,001	0,000	-0,001	0,001	0,134	0,004	0,001	0,000	-0,002	0,001	0,238
EU-NMS												
turnmar	0,008	0,004	0,062	0,001	0,006	0,897	0,015	0,006	0,007	0,003	0,008	0,718
rdint	-0,001	0,001	0,101	-0,002	0,001	0,001	-0,001	0,001	0,606	-0,002	0,001	0,016
(ii) innovative firms only												
all country groups												
turnmar	0,002	0,006	0,683	0,016	0,007	0,015	0,008	0,008	0,308	0,021	0,010	0,028
rdint	0,001	0,001	0,273	0,000	0,001	0,733	0,003	0,001	0,032	0,000	0,002	0,983
EU-Cont												
turnmar	0,032	0,009	0,001	0,035	0,011	0,002	0,053	0,013	0,000	0,050	0,018	0,005
rdint	0,011	0,003	0,000	0,011	0,003	0,001	0,016	0,004	0,000	0,012	0,005	0,012
EU-South												
turnmar	0,004	0,009	0,633	0,025	0,009	0,008	0,004	0,013	0,770	0,027	0,013	0,048
rdint	0,000	0,001	0,728	-0,003	0,001	0,018	0,001	0,002	0,433	-0,003	0,002	0,142
EU-NMS												
turnmar	-0,017	0,011	0,121	-0,019	0,013	0,154	-0,006	0,014	0,655	-0,020	0,018	0,257
rdint	-0,006	0,002	0,007	-0,005	0,001	0,002	-0,004	0,003	0,110	-0,004	0,002	0,074

***Notes*:** CIS III micro data (Eurostat); own calculations.

for the top 10 % and above 4 percentage points for the top 5 % high-growth firms. In addition, the R&D intensity of high-growth firms is around 1 percentage point higher than for average-growth growing firms. In contrast we see that for both the EU-South and the EU-NMS country groups the R&D intensity carries a negative sign, which is statistically significant for the EU-NMS and once - in the case of the top 10% innovative firms - also for the EU-South. In contrast, turnmar is positive for all country groups but only statistically significant for EU-Cont and EU-South - not for EU-NMS.

Our results strongly confirm conjecture 2. High-growth firms in the EU-Cont country group are much more likely to pursue an R&D-based innovation strategy than high-growth firms in the other country groups. For high-growth firms in EU-South, one can conjecture that they base their competitive advantage more on non-technological innovation, while high-growth firms in the EU-NMS do not primarily pursue innovation-based strategies. Instead,

these are firms which use and modify available blueprints and base their competitive edge on other comparative advantages, such as low-cost labour.

4 Conclusions

Our results confirm the hypothesis that R&D and innovation play a different role for high-growth firms in countries situated at a different distance to the technological frontier. The results also show that high growth firms are only more R&D-intensive than other firms in the same country in frontier economies. For non-frontier economies the results are not statistically significant. In addition, the results strongly suggest that the indicator of innovation sales as measured in the CIS are not well suited as a measure of technological innovativeness for cross-country studies. Further research using different time periods is needed to check the temporal robustness of the econometric results.

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