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Innovation barriers and high growth firms: Measurement, distance to the frontier and innovation types

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Abstract

High growth firms and reducing innovation barriers figure high on the European innovation policy agenda. In this paper we study the robustness of the perception of innovation barriers when alternative definitions of high growth firms are used. The empirical results show that different definitions of high growth firms lead to substantial different results. We argue that in the light of the available empirical evidence this non-robustness should not come as a surprise and that this negative result has policy implications.

Key words:

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1. Introduction

Both high growth firms and barriers to innovation figure prominently in recent public policy discussions at the EU level. On the one hand it is argued that Europe lacks the ability to generate new high innovative firms such as Google, Microsoft or Apple. Empirical studies show that Europe has a lower number of new large firms (Cohen and Lorenzi, 2000, Philippon and Veron, 2008) and that the average firm growth dynamics are lower in most European countries than in the USA (Bartelsman et al. 2005, Hoffman and Junge, 2006, Bravo-Biosca, 2010). This debate influenced also the Europe 2020 strategy. In fact the measure of the "share of fast growing innovative firms" has been proposed as headline indicator to assess the progress of the whole Europe 2020 Strategy.

On the other hand much innovation policy measures are directed towards alleviating barriers to innovation especially for small and medium sized enterprises both at the member state as on the EU level. It is well known that firm characteristics affect the perception of barriers to innovation. Arundel (1997), Mohnen and Rosa (2000), Baldwin and Lin (2002), Galia and Legros (2004) and Iammarino et al. (2007) show that innovative firms attach higher importance to the hampering factors to innovation than non-innovators. In addition within the group of innovating firms barriers to innovation are considered more relevant by firms having high innovation and R&D intensities. Therefore in the empirical literature the answers are generally considered as firms' assessment of the obstacles and as a measure of their ability to overcome them.

In this paper we bring together these two strands of the literature. Not much is known about the barriers to innovation of high growth firms. The existing literature on barriers to innovation did not consider high growth firms explicitly and concentrates almost exclusively on the perception of barriers among innovative firms (e.g. Mohnen and Rosa 1999) or treats non-innovative firms as an undifferentiated group (Hölzl and Friesenbichler 2009, Iammarino et al. 2007). Thus the extent to which barriers actually hampers or deters innovation activities by high growth firms is largely unknown.

We study the perception of innovation barriers for high growth firms for 18 EU countries grouped by their distance to the technological frontier using Community Innovation Surveys (CIS) for the years 2002-2004 and 2004-2006, and control for a large set of firm characteristics (size, growth and internationalisation status, group affiliation). By using four different definitions of high growth firms we are able to study the robustness of the perceptions of high growth firms.

If we would be able to obtain robust evidence of similar results for different definitions of high growth firms then we would be able to provide strong support for policy measures targeted at high growth firms. However, if our results show that using different definitions of high growth firms leads to sometimes strikingly different results then targeting high growth firms may be not a best idea.

The paper is organized as follows: The next section outlines the relevant literature on high growth firms and innovation barriers and states the research question. Section 3 presents the data and definitions used in the empirical result. Section 4 presents the empirical methodology and the results. Section 5 concludes the paper.

2. Setting the stage

High growth firms moved recently on the radar of both policy makers and researchers. The interest on these firms is motivated by the fact that they are perceived as important drivers of economic dynamics and employment generation. The research on the economic importance of fast growing firms grew out of the controversy regarding the contribution of small firms to job creation. While Birch (1979, 1981) claimed that SMEs contributed a disproportionately large share to overall job creation in the US, Davis, Haltiwanger, and Schuh (1996) challenged these results on the basis of methodological issues. During this discussion it has been observed that it is not the typical small firm that drives job creation among small firms.

Job creation in small size classes is concentrated among a few high growth firms. Thus the attention of some small business and entrepreneurship researchers moved towards these high growth firms. Henrekson and Johansson (2010) provide a survey of 19 studies that use a variety of methods to identify high growth firms. They find despite all differences in method and measurement results that are remarkably robust to the details of definition of high growth firms, countries, time periods and coverage of firms (Henrekson and Johansson, 2010):

1. A few most rapidly growing firms create most new jobs within cohorts of firms of the same age.
2. In relation to aggregate numbers, such as total job growth in the economy, the results are less clear-cut. For some countries (US, UK), studies find that high growth firms are the central driver of overall job generation, while other studies (especially for Scandinavian countries) find more moderate effects.
3. Although most rapidly growing firms are SMEs, there is also an important subset of large high growth firms.
4. High growth firms tend to be younger than the average firm in the industry.

While much is known about the employment generating properties of high growth firms, not much is known about the sources of competitive advantage of high growth firms. Innovation & R&D is one of the leading candidates. R&D and innovation constitute one of the central elements of an flexible entrepreneurial strategy that fosters firm growth. The review of the evidence suggests that innovation success is the driver of growth, not the fact that firms invest in R&D (Coad and Rao, 2008; Hölzl, 2009). In a similar vein Demirel and Mazzuccato (2010) find for the US pharmaceutical industry that it is easier for large firms than for small firms to achieve R&D-led growth and Coad and Rao (2010) again for the US find that R&D increases the variance of growth rates at the firm level. R&D seems to increase the volatility of firm performance. The micro-evidence by Bares, et al. (2006) who study high growth SMEs in the Lorraine region show that high growth firms are characterized by organizational innovation and incremental product innovations and not so much by the creation of new technologies. Most of the evidence regarding high growth firms comes from advanced industrialized countries, where R&D and innovation are important sources of competitive advantage. There are not many cross-country studies regarding high growth and possible differences in the sources of competitive advantage. In one of the few studies Hölzl (2009) shows that the technological and economic position of a country has a substantial influence 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 investment in innovation, while firms more distant from the technological frontier have the possibility to rely on other competitive advantages.

With regard to the sectoral location of high growth the stylized facts show that high growth firms can exist in almost all industries. There is no evidence to support the view that gazelles are overrepresented in high-tech industries. If anywhere, high growth firms are overrepresented in knowledge-intensive service industries (Almus, 2002; Henrekson and Johansson, 2010) and in expanding industries with low mobility costs (Hölzl, 2010). This suggests that being a high growth firm is primarily an economic and not a technological phenomenon (Hölzl, 2009).

However, even the evidence that high growth firms are characterized by a above average innovation activity would not warrant policy interventions. Analyzing the perception of barriers to innovation may provide a good starting point for the discussion about innovation policy towards high growth firms.

Barriers to innovation is an useful concept to understand innovative activity at the firm level and to inform innovation policy about policy priorities. Hadjimanolis (2003) distinguishes

between external and internal barriers to innovation. Internal barriers emerge within firms and are associated with organizational resistance within firms. External barriers to innovation emerge when the firm interacts with other firms, agents or institutions in the innovation system. While the evidence on internal barriers to innovation is of interest to policy makers only evidence on external barriers to innovation provide a rationale for policy intervention (Hölzl and Janger 2011).

It is important to note that many studies on innovation barriers report that innovating firms experience higher innovation barriers than non-innovators and that firms with a high R&D and innovation intensity report the highest barriers to innovation (e.g. Arundel (1997), Mohnen - Rosa (2002), Baldwin - Lin (2002), Galia - Legros (2004), Mohnen - Röller (2005) and)). Therefore innovation barriers should be considered as (innovative) firms' assessment of the obstacles and as a measure of their ability to overcome them. However, the other studies also show that firms with abandoned innovation projects tend to report high innovation barriers especially with regard to economic barriers (Galia – Legros, 2004). And the research by Savignac (2008), D'Este et al. (2008, 2009) and Hölzl and Janger (2010) shows that it is important to distinguish between non-innovators that are not interested in innovation and non-innovators that are deterred by barriers to innovation. These studies show that innovative firms not interested in innovation five very low importance ratings to barriers to innovation, as they are not deterred by these barriers. In contrast non-innovative firms that aspire to be innovative experience barriers in the same way as innovative firms. This result is important for our research. In the case that high growth firms are overproportionally innovation active this would bias our findings towards finding that high growth firms have are affected disproportionately by innovation barriers. By distinguishing barrier-related and non-barrier-related non-innovative firms we are able to correct for this bias.

Our research is concerned with the barriers of innovation experienced by high growth firms. In particular we study the robustness of the results when we change the definition of high growth firms. The expectations regarding the perception of innovation barriers are not clear cut. On the one hand one could argue that high growth firms achieved high growth because they were successful and did not experience high barriers to innovation. On the other hand it could be argued that they overcame substantial barriers thus they would indicate high barriers to innovation. In this respect our analysis is explorative.

However using country variance and existing knowledge about the importance of innovation activities between country groups (technological frontier) allows to conjecture that high growth firms in countries close to the technological frontier should perceive innovation barriers as more relevant than high growth firms in countries more distant to the technological frontier. Our Null hypothesis attached to this conjecture is:

$H0_1$: The sign of coefficients for one high growth definition is the same across all country groups.

This hypothesis is rejected if one country group displays a divergent pattern in terms of the sign of the coefficient. The magnitude of the deviation between the country groups provides evidence on whether high growth firms close to the technology frontier or firms more distant to the technology frontier perceive higher innovation barriers. Our conjecture is that high growth firms in countries close to the technological frontier perceive higher innovation barriers.

The second question relates to the different definitions of high growth firms. Based on the conjecture by Henrekson and Johannson (2010) that argued that for many stylised facts of high growth firms the exact definition of a high growth firm seems to be of minor importance we formulate the null hypothesis that the sign of statistical significant coefficients on the HFG indicator has the same sign:

$H0_2$: The sign of statistical significant coefficients on HGF indicators is the same across the different definitions of high growth firms.

Thus our null hypothesis is that the four different definitions lead to similar results. A rejection of the null hypothesis implies firm characteristics determining the selection into one of the high growth definitions plays a central role mediating the perception of barriers to innovation.

3. Data and Definitions

3.1 Data sources

We use Community innovation Survey (CIS) data for 18 countries. In particular we use the CIS-4 and CIS-2006 waves of the CIS. The Community Innovation Survey is a firm level survey conducted every 2 years in all EU member states, as well as several non-EU countries (e.g. Norway, Iceland).1 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 - Mohnen (2005) 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.

3.2 High growth firms

We use four different definitions of high growth firms in this paper. This is inspired by the fact that befor the publication of the Eurostat-OECD Manual on Business Demography Statistics

(Eurostat-OECD, 2008) a large number of different methods has been used to select high

growth firms. For example, Autio, Arenius, and Wallenius (2000) and Halabisky, Dreessen, and Parsley (2006) defined high growth firms as firms that obtained at least 50 % sales growth during each of three consecutive financial years. Other studies used the Birch Index - a composite measure that takes into account relative and absolute growth -and used a

relative cut-off point and selected the 5 % or 10 % firms with the highest Birch index (e.g.

Schreyer, 2000; Hölzl, 2009; Parker, Storey, and van Witteloostuijn, 2010).
The Birch index is generally used to reduce the impact of firm size on firm growth indicator. Birch (1987) and Schreyer (2000) used a combination of both the relative and absolute growth rates. However, since the publication of the Eurostat-OECD definition of high growth firms and the associated collection of indicators by Statistical Offices in Europe and the OECD has led to a convergence to the indicator proposed by Eurostat and the OECD. In this research we use four different definitions to select rapidly growing firms.

1. HGF(20): We define HGF(20) following a definition that is similar to the Eurostat-OECD definition. Unfortunately the structure of CIS data does not allow to use the OECD-Eurostat definition, as our time frame for computing growth rates is two years instead of the proposed three years. For each enterprise with more than 10 employees we calculate the annualized employment growth rate:

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

$$growth_j = \sqrt[z]{\frac{Employment_{j,t+z}}{Employment_{j,t}}} - 1.$$

HGF(20) are those firms whose annualized growth rate is above 20%.

2. HGF(30): In order to make the restrictions more similar to the OECD-Eurostat definition we make the relative growth requirement stricter by increasing it to 30%. HGF(30) are those firms whose annualized growth rate is above 30%.

3. HGF(TURN) uses the same definition as HGF(20) with the exception that (nominal) turnover is used instead of employment as growth indicator.

4. HGF(Birch) uses the Birch index to select high growth firms. The Birch index is defined as:

$$m = (E_{i,t} - E_{i,t-j})\,(E_{i,t} / E_{i,t-j})$$

We select the top 5% of firms with the highest m as HGF(Birch).

With regard to these high growth definitions it is important to note that the percentage growth approach encompasses all other possible definitions of relative growth. It would not make any difference if another indicator of relative growth (e.g. log differences or the job creation rate) instead of arithmetic annualized growth would be used. Independence of the unit of measurement is a central property of every indicator of relative change (Thornqvist, Vartia, and Vartia, 1985). Only if this property, which implies invariance to size, is violated (as with the Birch index or other indicators that give weight to absolute change) a different set of firms is selected as HGF.

Hölzl (2010) shows that for large firms the Birch Index is similar to an absolute growth requirement. Thus these four definitions of high growth encompass a large number of potential measures of high growth.

We contrast the high growth firms with a selection of firms showing low or negative growth rates between -3% and + 3% p.a. We call these firms *stable firms* and expect them to help us interpreting the effect of firm growth on the perception of innovation barriers.

Table 1: High growth firm shares in the CIS4 qand the CIS 2006

	CIS 4					CIS 2006	
HGF(20)	7587	106283	7.1%		8262	93298	8.9%
HGF(Birch)	5354	106283	5.0%		4731	93298	5.1%
HGF(30)	5967	106283	5.6%		5602	93298	6.0%
HGF(Turn)	19634	106283	18.5%		23037	93298	24.7%

Source: CIS 4 and 2006 data accessed at the safe centre.,

Table 2: Country classification and data availability

Country group 1 (high direct technology intensity):
Belgium (BE)[§], Denmark (DK)[++,+++], Germany (DE)[§], Finland (FI)[++,+++], France (FR)[++], Iceland (IS)[++], Luxemburg (LU)[++,+++], Norway (NO)[++,+++], Sweden (SE)[++,+++], United Kingdom (UK)[§], Netherlands (NL)[§], Austria (AT)[§]

Country group 2 (high indirect technology intensity):
Czech Republic (CZ)[++,+++], Estonia (EE)[++,+++], Hungary (HU)[++,+++], Slovenia (SI)[++,+++], Slovak Republic (SK)[++,+++], Ireland (IE)[+++]

Country group 3 (low direct and indirect technology intensity, with higher GDP per capita):
Spain (ES)[++,+++], Italy (IT)[++,+++], Portugal (PT)[++,+++], Greece (GR)[++,+++]

Country group 4 (low overall technology intensity):

Bulgaria (BG)[++,+++], Lithuania (LT)[++,+++], Latvia (LV)[++,+++], Poland (PL)[§], Romania (RO)[++,+++], Cyprus (CY)[+++], Malta (MT)[+++]

Notes: Availability of Community Innovation Survey (CIS) data at the Eurostat Safe Centre in Luxemburg: [++] CIS 4, [+++] CIS2006; [§] access not allowed by national statistical institute.

3.3 Country groups

We control for country differences by defining groups of countries that have approximately the same position in technological development. Our classification of countries into different groups is based on the research by Reinstaller - Unterlass (2011), who presented a classification of EU countries based on the direct and indirect R&D intensity of each country resulting from an input-output analysis. The direct R&D intensity is the direct investment of the business sector into research and development as shown by the share of R&D in GDP of the business sector in the common STI statistics. The indirect R&D intensity instead captures the R&D embodied in capital goods used in the industries of a country. Together the two indicators provide a rough measure of the level of technological development of a country in terms of its capability to generate new technologies and its ability to use foreign technologies. Reinstaller and Unterlass (2011) use cluster analysis to identify four country groups: The first group of countries has high *direct technology intensity* and the relative share of indirect technology intensity decreases with respect to other country groups. The countries in the second group have high *indirect technology intensity*. Direct R&D intensity in these countries is low, but R&D embodied in imported equipment is high. The countries in the third group have relatively *low levels of both direct and indirect technology intensity but show a relatively high GDP per capita,* pointing to sources of growth different to innovative activity. The fourth group, finally, consists of countries with *low overall technology intensity* both in terms of direct and indirect R&D as well as a low GDP per capita. Table 1 presents the classification of countries and indicates for which countries CIS data could be accessed at the Eurostat Safe Centre in Luxemburg.

3.4 Innovator types

As discussed earlier innovator types are an important control variable to identify the gazelle effect on the perception of innovation barriers. We distinguish four innovator types:

1. We define all firms that introduced a new or significantly improved product or process and/or have ongoing innovation projects as innovators. In order to reduce the heterogeneity within the group of innovators we distinguish two types of innovators:
    i. R&D innovators are the subset of innovative firms which perform own R&D.
    ii. The set of innovators that do not perform own R&D is called non-technological innovators.

    The reason for this distinction is the fact that in comparison to non-technological innovation, R&D activities are generally more costly and uncertain. This is likely to lead to a selection problem, when analyzing barriers to innovation. We expect that R&D innovators have a different perception of obstacles to innovation than non-technological innovators.

2. All other firms are defined as non-innovators. We distinguish:
    i. Barrier-related non-innovators
    ii. Non-interested non-innovators

    The reason for this distinction is the fact that non-interested non-innovators perceive innovation barriers very differently from barrier-related non-innovators (D'Este et al

2008, 2009; Hölzl and Janger 2011). We use the method used by Hölzl and Janger (2011) to distinguish between barrier-related and non-interested innovators and define as barrier-related innovators those non-innovating firms that have an above average intensity of barrier perception and, in addition, gave low ranking to two questions in the CIS that capture the reasons not to innovate ("No need due to prior innovations" and "No need because of no demand for innovations"). The other non-innovators are classified as non-barrier-related non-innovators.

3.5 Barriers to innovation

The community innovation survey differentiates between nine potential barriers to innovation. In this study we consider the five following barriers to innovation out of nine (in brackets we report the original wording of the CIS questionnaire if different):

(i) financial barriers to innovation (Lack of finance from sources outside your enterprise),
(ii) skill barriers to innovation (Lack of qualified personnel),
(iii) lack of information on technology,
(iv) lack of information on markets, and
(v) lack of innovation partners (Difficulty in finding cooperation partners for innovation).

The first barrier belongs to the group of cost barriers, the other four to the group of knowledge barriers. Firms are asked to assess the importance of these barriers using a 4 step scale from high importance over medium to low importance and not relevant. From these answers we construct a binary variable that takes on the value of 1 if the firm considers the degree of importance of the barrier as high or medium. The variable takes on the value of 0 if the firm considers the barrier of low importance or not relevant at all. The rationale for constructing the dependent variable in this way is that we obtain an indicator that discriminates whether firms judge the barrier to be important or not.

4. Econometric methodology and results

The primary goal of the analysis is to uncover systematic differences between firms selected by different definitions of high growth firms Our baseline specification is the following:

Barrier_i = f(HG_i, X, INDUSTRY, COUNTRYGR, INNOTYPE)

The definition of high growth firms (HG), barriers to innovation (Barrier), the country groups(COUNTRYGR) and the innovation types (INNOTYPE) was presented before. X_i denotes additional control variables at the firm level:

1. *Firm size* is measured by the logarithm of employees.
2. We include dummy variables that identify whether the firm is part of a domestic or a foreign corporate group.
3. We include a dummy variable indicating whether the firm is an exporting firm or not.
4. We include a dummy indicating whether the firm had a growth rate between -3% and +3% p.a. We call these firms stable firms and expect that this helps identifying the effect of high growth firms on the perception of innovation barriers.
5. Finally, we employ a number of sectoral control variables. We use a dummy variable indicating whether the firm operates in the manufacturing sector or not. We implement industry dummies following the industrial classification by Peneder (2010 that

distinguishes 5 different sector groups according to their innovation intensity in the country group regressions (see appendix A).

Our dependent variables (innovation barriers) are constructed as binary variables. As we are interested only in the mean effects, we follow the suggestion of Angrist-Pischke (2008) and estimate a linear probability model (LPE) instead of a nonlinear Probit or Logit model. Angrist - Pischke (2008) argue that if one is interested in the mean effect, $E(Y=1|X)$, and not the whole distribution then the LPE with robust standard errors is an appropriate choice. They show that in several empirical applications, there is little difference between marginal effects estimated with limited dependent variables models and linear probability models. Probit and logit estimates would require the computation of marginal effects at the mean.[2]

Table 3 reports the results of the baseline regressions using the HGF(20) definition as indicator of high growth firms. The results are quite similar between CIS 4 and CIS 2006, suggesting that we are able to uncover some regularities in the perception of innovation barriers across firms. However, the explained variation is quite low, indicating that there is much heterogeneity in the sample that we are not able to cover.

The table shows clearly that the most important firm level variables are the innovator types. R&D innovators (13% to 24% higher depending on the innovation barrier and innovation survey), non-technology innovators (5.5% to 17% higher) and barrier-related non-innovators (25% - to 43 % higher) have a significantly higher propensity to assess innovation barriers more relevant than the reference type non-barrier-related non-innovators.

The indicator of interest is the coefficient on HGF(20) we see that the coefficient is in general positive and statistically significant, with exception of the barrier lack of information on markets for the CIS 2006 sample. However, compared the magnitude of the coefficient is low compared to the innovator types variables. Being a high growth firm increases the perception of assessing a barrier as important by 0.5 % to 2.6% . Even if the coefficients are compared to the coefficients of stable firms - that display in general a lower propensity to assess barriers as important as evidenced by the in general negative coefficient – the effect of magnitude is between 0.6 % and 3.5%.

Table 5: Innovation barrier regressions, HGF(20)

[2]Comparisons between marginal effects at the mean from Probit regressions and the results from the LPE showed that there is no qualitative difference in the interpretation of the results.

	CIS 4					CIS 2006				
	financial barriers	skill barriers	lack of information on technology	lack of information on markets	lack of innovation partners	financial barriers	skill barriers	lack of information on technology	lack of information on markets	lack of innovation partners
Firm types										
R&D innovator	0.2037***	0.1997***	0.1332***	0.1299***	0.1301***	0.2374***	0.2316***	0.1646***	0.1737***	0.1389***
Non-technological innovator	0.1319***	0.1580***	0.1263***	0.0931***	0.0545***	0.1604***	0.1719***	0.1273***	0.1144***	0.0767***
Barrier-related non-innovator	0.3436***	0.3288***	0.2608***	0.2500***	0.2598***	0.4319***	0.3681***	0.2974***	0.2838***	0.2621***
Firm-level control variables										
Firm size	-0.0150***	-0.0095***	-0.0089***	-0.0060***	-0.0072***	-0.0102***	-0.0046***	-0.0070***	-0.0104***	-0.0027***
Fast growing firm (y/n)	0.0101***	0.0258***	0.0164***	0.0087***	0.0084***	0.0132***	0.0118***	0.0065**	-0.0073***	0.0056**
Stable firm (y/n)	-0.0284***	-0.0147***	-0.0074***	-0.0142***	-0.0164***	-0.0139***	-0.0069***	0.0009	-0.0052***	-0.0165***
Exporting firm (y/n)	0.0130***	-0.0151***	0.0049***	0.0048***	0.0187***	0.0266***	0.0053***	-0.0024	0.0105***	0.0185***
Part of foreign group (y/n)	-0.0727***	-0.0657***	-0.0516***	-0.0591***	-0.0535***	-0.1169***	-0.0684***	-0.0546***	-0.0489***	-0.0619***
Part of domestic group (y/n)	-0.0067***	-0.0233***	-0.0184***	-0.0196***	-0.0088***	-0.0432***	-0.0497***	-0.0500***	-0.0523***	-0.0243***
Sectoral control variables										
Manufacturing	0.0728***	0.0603***	0.0525***	0.0581***	0.0339***	0.0873***	0.0998***	0.0798***	0.0712***	0.0559***
High innovation intensity	0.0174***	0.0512***	-0.0440***	-0.0026	0.0185***	0.0078	0.0209***	-0.0263***	-0.0178***	0.0233***
Medium-high innovation intensity	-0.0213***	0.0262***	-0.0337***	-0.0060	0.0171***	-0.0106**	-0.0198***	-0.0172***	-0.0356***	0.0151***
Medium innovation intensity	-0.0212***	0.0092***	-0.0378***	-0.0119***	-0.0023	-0.0152***	-0.0063*	-0.0151***	-0.0192***	0.0155***
Medium-low innovation intensity	-0.0426***	-0.0212***	-0.0534***	-0.0434***	-0.0194***	-0.0077*	-0.0278***	-0.0371***	-0.0457***	-0.0129***
Country groups										
Country group 1	-0.1659***	0.0032	-0.0480***	-0.0382***	-0.0909***	-0.1744***	-0.0901***	-0.1588***	-0.1469***	-0.1461***
Country group 2	-0.0960***	-0.0663***	-0.0753***	-0.0581***	-0.0930***	-0.1164***	-0.1576***	-0.1979***	-0.1799***	-0.1544***
Country group 3	-0.0001	0.0096***	0.0481***	0.0227***	-0.0224***	-0.0212***	-0.0741***	-0.0348***	-0.0506***	-0.0819***
Constant	0.6333***	0.6146***	0.4978***	0.4700***	0.5876***	0.7513***	0.6474***	0.6662***	0.7633***	0.6985***
Observations (weighted)	707,373	707,434	707,397	707,392	707,400	340,677	340,652	340,636	340,640	340,646
pseudo R2	0.120	0.075	0.068	0.057	0.063	0.142	0.103	0.087	0.080	0.068
ll	-414859	-450575	-400233	-390456	-381602	-204969	-217856	-203617	-197222	-189942

Source: CIS 4 and 2006 data accessed at the safe centre., *** p<0.01, ** p<0.05, * p<0.1. Country group 1: Belgium, Denmark, Germany, Finland, France, Iceland, Luxemburg, Norway, Sweden; Country group 2: Czech Republic, Estonia, Hungary, Slovenia, Slovak Republic, Ireland; Country group 3: Spain, Italy, Portugal, Greece; Country group 4: Bulgaria, Lithuania, Latvia, Romania, Cyprus, Malta.

The other control variables indicate that manufacturing firms perceive higher innovation barriers than other firms, that are not related to their innovator type (3.4 % to 10% higher). The results for the country groups show that firms located in country group 1 and country group 2 are ceteris paribus less likely to perceive innovation barriers than firms in the reference country group 4. This holds also for country group 3 for the CIS 2006 but not for the CIS 4.

Let us now compare the tree definitions of high growth firms. We estimated the same regressions as before with the only difference the high growth variable. Except for the high growth definition the results were quite robust and did not change the results on innovation types or other control variables in a way that would lead to a need to revise the conclusions on innovation barriers. Therefore we report in Table 3 only the coefficients for high growth firms and stable firms.

The coefficients for HGF(20) are reprinted for reference in the first line. Bold coefficients indicate statistically significant different results (change in sign of the relationship) to the baseline definition of HGF(20). The table shows that the coefficients change sometimes dramatically calling into question the findings from the baseline regressions, that high growth firms report higher innovation barriers.

For lack of technological knowledge we find that for HGF(Birch) the relationship changes in CIS4 sample and in the CIS 2006 sample. For HGF(30) and HGF(Turn) it changesonly inthe CIS2006 sample. For lack of market knowledge we find a change of sign for HGF(30) and HGF(Birch) in the CIS4 sample. In this respect it is important to note that market information changes sign for the HGF(20) between the CIS4 and the CIS 2006 sample. With regard to innovation partners we find only weak changes in sign for CIS4 (HGF-Birch)) but a statistically significant change in CIS 2006 (HGF(30)). For financing barriers we find changes in sign for HG(TURN) and HGF(Birch) in the CIS 2006 sample. For skill barriers the sign of the coefficient changes in the CIS 2006 for HGF(30) and HGF(Birch).

These results imply a rejection of hypothesis $H0_2$ that the signs of statistically significant are identical across the different high growth definitions for all barriers if we pool CIS4 and CIS2006 results. For CIS4 alone we are able to reject $H0_2$ only for “lack of technical

knowledge" and "lack of market knowledge" but not for the other three "barriers" for CIS2006 we observe a non-rejection of the hypothesis $H0_2$ only for the lack of market knowledge. However, these results could be subject to an aggregation bias if high growth firms are clustered in some country groups.

Table 3: Innovation barrier regressions, coefficients for high growth firms.

	CIS 4						CIS 2006				
	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers		lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers
HGF(20)	0.0164***	0.0087***	0.0084***	0.0101***	0.0258***		0.0065**	-0.0073***	0.0056**	0.0132***	0.0118***
stable	-0.0074***	-0.0142***	-0.0164***	-0.0284***	-0.0147***		0.0009	-0.0052***	-0.0165***	-0.0139***	-0.0069***
HGF(30)	0.0024	**-0.0059****	0.0034	0.0115***	-0.0038		**-0.0301*****	-0.0343***	**-0.0253*****	-0.0029	**-0.0121*****
stable	-0.0088***	-0.0153***	-0.0170***	-0.0288***	-0.0173***		-0.0017	-0.0064***	-0.0188***	-0.0157***	-0.0091***
HGF(turn	0.0067***	0.0062***	0.0086***	0.0040**	0.0072***		**-0.0100*****	-0.0143***	0.0029	**-0.0134*****	-0.0009
stable	-0.0077***	-0.0105***	-0.0065***	-0.0266***	-0.0045***		-0.0012	-0.0071***	-0.0096***	-0.0126***	-0.0055**
HGF(Birch)	**-0.0230*****	**-0.0073***	-0.0044	0.0114***	0.0005		**-0.0242*****	-0.0249***	-0.0056	**-0.0102****	**-0.0260*****
stable	-0.0095***	-0.0152***	-0.0173***	-0.0291***	-0.0171***		-0.0007	-0.0052***	-0.0174***	-0.0159***	-0.0092***

Source: CIS 4 and 2006 data accessed at the safe centre., *** p<0.01, ** p<0.05, * p<0.1.
Country group 1: Belgium, Denmark, Germany, Finland, France, Iceland, Luxemburg, Norway, Sweden; Country group 2: Czech Republic, Estonia, Hungary, Slovenia, Slovak Republic, Ireland; Country group 3: Spain, Italy, Portugal, Greece; Country group 4: Bulgaria, Lithuania, Latvia, Romania, Cyprus, Malta.

Table 4: Innovation barriers across country groups: coefficients for high growth firms.

	country group 1					country group 2					country group 3					country group 4				
	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers
HGF(20)	-0.0005	0.0013	0.0074**	0.0027	0.0266***	0.0458***	0.0461***	0.0217***	0.0104	0.0284***	0.0181***	0.0075***	0.0068**	0.0125***	0.0213***	0.0378***	0.0198***	0.0051	-0.0049	0.0466***
stable	-0.0164***	-0.0026	0.0068***	-0.0138***	-0.0182***	-0.0189***	-0.0268***	-0.0310***	-0.0335***	-0.0248***	0.0032*	-0.0153***	-0.0292***	-0.0331***	-0.0113***	0.0133**	0.0018	0.0038	-0.0164**	0.0006
HGF(30)	-0.0358***	**-0.0362***	**-0.0247***	**-0.0155***	**-0.0356***	0.0500***	0.0569***	0.0101	-0.0020	0.0369***	0.0048	-0.0000	0.0151***	0.0234***	-0.0068	0.0544***	0.0195**	0.0336***	**0.0171***	0.0524***
stable	-0.0180***	-0.0043**	0.0051***	-0.0148***	-0.0221***	-0.0203***	-0.0279***	-0.0323***	-0.0344***	-0.0254***	0.0017	-0.0161***	-0.0292***	-0.0333***	-0.0135***	0.0118*	0.0000	0.0063	-0.0137*	-0.0028
HGF(turn	-0.0076***	**-0.0086***	0.0053*	0.0050*	0.0061*	0.0218***	0.0110**	0.0209***	0.0198***	0.0110**	0.0092***	0.0086***	0.0152***	0.0035	0.0069***	0.0137**	0.0188***	**-0.0098***	-0.0277***	0.0216***
stable	-0.0024	-0.0095***	-0.0153***	-0.0296***	0.0120***	-0.0021	-0.0178***	-0.0056	-0.0254***	-0.0163***	-0.0107***	-0.0077***	0.0047***	-0.0224***	-0.0121***	-0.0019	-0.0117	**-0.0391***	-0.0306***	0.0014
HGF(Birch)	0.0085	0.0255***	0.0320***	0.0147**	0.0094	**-0.0194***	**-0.0329***	0.0024	-0.0165	-0.0156	**-0.0568***	**-0.0258***	**-0.0354***	0.0169***	-0.0081	-0.0088	-0.0072	-0.0052	0.0146	0.0372***
stable	-0.0161***	-0.0020	0.0071***	-0.0137***	-0.0203***	-0.0230***	-0.0312***	-0.0327***	-0.0347***	-0.0274***	0.0003	-0.0166***	-0.0306***	-0.0339***	-0.0134***	0.0057	-0.0024	0.0026	-0.0147**	-0.0063
HGF(20)	0.0004	-0.0139	0.0127	-0.0379***	0.0200*	0.0036	-0.0162***	-0.0003	-0.0073	0.0037	0.0131***	-0.0037	0.0067**	0.0354***	0.0163***	0.0095	0.0087	-0.0078	-0.0315***	0.0081
stable	-0.0101*	-0.0240***	-0.0273***	-0.0481***	-0.0400***	0.0014	0.0056	0.0092**	0.0151***	-0.0137***	-0.0045**	-0.0084***	-0.0187***	-0.0088***	-0.0057**	0.0183***	0.0167***	-0.0028	-0.0162***	0.0524***
HGF(30)	0.0396***	0.0151	0.0164	-0.0326**	0.0797***	-0.0347***	-0.0547***	-0.0450***	-0.0247***	**-0.0260***	**-0.0288***	-0.0327***	**-0.0278***	0.0181***	**-0.0082***	0.0038	-0.0105	-0.0279***	-0.0223***	-0.0064
stable	-0.0084	-0.0221***	-0.0277***	-0.0461***	-0.0382***	-0.0013	0.0041	0.0062	0.0144***	-0.0159***	-0.0078***	-0.0099***	-0.0212***	-0.0120***	-0.0082***	0.0171***	0.0142**	-0.0041	-0.0129**	0.0504***
HGF(turn	0.0372***	0.0096	0.0180***	0.0169**	0.0354***	0.0008	-0.0120***	**0.0098**	-0.0178***	0.0065	**-0.0173***	-0.0172***	**-0.0117***	**-0.0174***	**-0.0159***	0.0012	-0.0053	-0.0058	-0.0354***	0.0052
stable	0.0369***	0.0262***	0.0075	-0.0115*	-0.0090	-0.0016	0.0015	0.0174***	0.0090	-0.0217***	-0.0056**	-0.0074***	-0.0112***	-0.0126***	-0.0013	-0.0347***	-0.0402***	-0.0635***	-0.0477***	-0.0782***
HGF(Birch)	0.0954***	0.0318*	0.0375**	**0.0923***	0.0793***	-0.0324***	-0.0217**	-0.0518***	-0.0620***	0.0017	**-0.0210***	-0.0148**	0.0105*	0.0051	**-0.0425***	**-0.0192**	-0.0279***	-0.0118	-0.0296***	-0.0577***
stable	-0.0075	-0.0218***	-0.0273***	-0.0421***	-0.0395***	-0.0004	0.0068*	0.0070*	0.0134***	-0.0141***	-0.0067***	-0.0084***	-0.0192***	-0.0129***	-0.0090***	0.0158***	0.0139**	-0.0021	-0.0122**	0.0483***

Source: CIS 4 and 2006 data accessed at the safe centre., *** p<0.01, ** p<0.05, * p<0.1. Country group 1: Belgium, Denmark, Germany, Finland, France, Iceland, Luxemburg, Norway, Sweden; Country group 2: Czech Republic, Estonia, Hungary, Slovenia, Slovak Republic, Ireland; Country group 3: Spain, Italy, Portugal, Greece; Country group 4: Bulgaria, Lithuania, Latvia, Romania, Cyprus, Malta.

Table 4 presents the country group regressions. Let us first consider Hypothesis $H0_1$ whether the significant coefficients have the sign across the different country groups. Table 5 displays these results. A "R" indicates rejection of the hypothesis for the specific high growth definition. Again we observe differences between the CIS 4 and the CIS 2006 sample and for the different measures of high growth firms.
The results clearly indicate that HGF(20) is the only high growth definition that leads to coefficients of the same sign across the different country groups. The test is quite conservative as coefficients are not compared directly but only statistical significant results with an opposite sign are counted as rejection of the null hypothesis. For high growth definitions other than HGF(20) we observe more often a rejection of the hypothesis. This is especially surprising for HGF(30) as this definition is simply a stricter definition of the HGF(20) definition. Also for HGF(turn) and HGF(Birch) we observe that the null hypothesis is rejected more often than not when we take into account both the CIS 4 and the CIS 206 sample. This results indicates that there is quite some variation across the country groups.

Table 5: Test of $H0_1$; *The sign of coefficients for one high growth definition is the same across all country groups*

	CIS 4						CIS 2006				
	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers		lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers
HGF(20)	-	-	-	-	-		-	-	-	R	-
HGF(30)	R	R	R	R	R		R	-	-	R	R
HGF(turn)	R	R	R	R	-		R	-	R	R	R
HGF(Birch	-	R	R	-	-		R	R	R	R	R

Source: CIS 4 and 2006 data accessed at the safe centre.,

Hypothesis 2 concerns the homogeneity of the sign of the coefficients on the high growth dummy within country groups. Table 6 reports the results. The results are summarized in table 6. A "R" stands for a rejection of the hypothesis. Again the test is conservative as we count as rejection only cases where two statistically significant coefficients of opposite sign are recorded. Except for four cases we do not record a conflicting result for CIS 4 and CIS 2006: lack of technological knowledge for country group 1, financial barriers for country group 2, lack of market knowledge and skill barriers for country group 4. However, in all these four cases the sign of the relationship is different between the CIS4 and the CIS 2006 samples. This result mirrors the fact that in table 4, if we count negative and positive statistically significant results by country group over the CIS samples that there is no country group barrier pair that does have statistically significant results that are only positive or negative.
To sum up the our evidence, we are not able to indicate that the use of different high growth firm measures leads to homogeneous results. In the opposite the heterogeneity of our results suggests that the perception of innovation barriers of high growth firms does not provide a fruitful starting point for innovation policy towards high growth firms. We are not able to identify clear policy priorities that cross the different country groups.

Table 6: Test of $H0_2$; *The sign of statistical significant coefficients on HGF indicators is the same across the different definitions of high growth firms*

	country group 1					country group 2				
	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers
CIS4	-	R	R	R	R	R	R	-	-	-
CIS 2006	-	-	-	R	-	-	-	R	-	R
	country group 3					country group 4				
	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers	lack of technical knowledge	lack of market knowledge	lack of innovation partners	financial barriers	skill barriers
CIS4	R	R	R	-	-	-	-	R	R	-
CIS 2006	R	-	R	R	R	R	-	-	-	-

If we look at the country groups in isolation we observe that we obtain quite homogenous results across the two samples only for HGF(Birch) for country group 1, that is for comparatively large firms – the Birch index is close to absolute growth for large firms - in the countries closest to the technological frontier.
This disappointing results could be due to our research strategy.

1. We pool together all firms in all manufacturing and all service sectors. To the extent that there are important differences between sectors this will mask important results at the sectoral level. But in this respect our results highlight the fact that there is no general tendency in the perception of innovation barriers by high growth firms across the different industries.
2. We are not able to use the original Eurostat-OECD definition of high growth firms that needs a three year period to identify high growth firms. This creates the possibility that our definition collects to a higher extent one time growth firms than the Eurostat-OECD definition. However, Hölzl (2011) shows that for both the Eurostat-OECD definition and the Birch index the post-HGF growth performance is generally quite modest.

[to be completed]

5. Discussion and Conclusions

In this research we estimate innovation barrier regressions for different definitions of high growth firms and compare the coefficients. The results suggest that the perception of innovation barriers is quite heterogeneous using the different definitions and we are not able to come up with conclusive answers.
From a public policy perspective the results do not suggest that high growth firms perceive specific barriers systematically higher or lower than non high growth firms. Our results suggest that further research on the definition of high growth firms and their perception of innovation barriers is warranted, especially at a more disaggregated level.
[to be completed]

References

[to be completed]

Annex 1

1 - Annex 2